OMB Approval Number 2700-0092
Expires 4/30/19

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)
HEADQUARTERS
SCIENCE MISSION DIRECTORATE

RESEARCH OPPORTUNITIES IN SPACE AND EARTH SCIENCES – 2019 (ROSES-2019)

NASA RESEARCH ANNOUNCEMENT (NRA)
SOLICITING BASIC AND APPLIED RESEARCH PROPOSALS

NNH19ZDA001N

CATALOG OF FEDERAL DOMESTIC ASSISTANCE (CFDA) NUMBER: 43.001

ISSUED: MARCH 14, 2019

October 24, 2019. The process for submission of High-End Computing resources has changed. See Section I(d).

July 9, 2019. The POC for Suborbital Reusable Launch Vehicles in Section V(b)iii has been updated, a bullet about purchasing computers with ROSES grant funding has been added to Section IV.(d), and the section of Table 1 on References now includes a link to the FAQ clarifying references to web pages/URLs.

Corrected March 19, 2019: Section V(b)iv "Research Investigations utilizing the International Space Station" has been updated to reflect a number of small changes from the International Space Station Research Integration Office, Section IV(b)ii now warns that digitally signed proposal PDFs must be avoided as they create errors that may prevent submission or review, and Section I(i) Citizen Science has been slightly updated.

FULL (STEP-2) PROPOSALS DUE
STARTING NO EARLIER THAN JUNE 12, 2019
THROUGH NO LATER THAN APRIL 30, 2020

RESEARCH OPPORTUNITIES IN SPACE AND EARTH SCIENCES (ROSES)–2019
EXECUTIVE SUMMARY

This National Aeronautics and Space Administration (NASA) Research Announcement (NRA), Research Opportunities in Space and Earth Sciences (ROSES) – 2019, solicits basic and applied research in support of NASA's Science Mission Directorate (SMD). ROSES is an omnibus NRA, with many individual program elements, each with its own due dates and topics. All together these cover the wide range of basic and applied supporting research and technology in space and Earth sciences supported by SMD. Awards to non-governmental organizations will be made primarily as grants or cooperative agreements and occasionally as contracts as the nature of the work and/or program requirements dictate. Awards to government labs will be made as inter- or intra-agency transfers. The typical period of performance for an award is three years, but some programs may allow up to five years and others specify shorter periods. Organizations of every type, domestic and foreign, Government and private, for profit and not-for-profit, may submit proposals without restriction on teaming arrangements. Note that it is NASA policy that all research involving non-U.S. organizations will be conducted on the basis of no exchange of funds.

This ROSES-2019 omnibus NRA will be available electronically as PDF files, at http://solicitation.nasaprs.com/ROSES2019. Tables 2 and 3 of this NRA, which will be posted at http://solicitation.nasaprs.com/ROSES2019table2 and http://solicitation.nasaprs.com/ROSES2019table3, respectively, provide proposal due dates and hypertext links to descriptions of the solicited program elements in the Appendices of this NRA. To learn of additional new program elements or amendments to this NRA through February 2020, at which time release of a subsequent ROSES NRA is planned, proposers should subscribe to:

(1) The SMD mailing lists (by logging in at http://nspires.nasaprs.com/ and checking the appropriate boxes under "Account Management" and "Email Subscriptions"),
(2) The ROSES-2019 RSS feed for amendments, clarifications, and corrections at http://science.nasa.gov/researchers/sara/grant-solicitations/ROSES-2019/, and
(3) The ROSES-2019 due date Google calendars. Instructions are at https://science.nasa.gov/researchers/sara/library-and-useful-links.

Potential proposers should also be aware of the ROSES FAQ at http://science.nasa.gov/researchers/sara/faqs/ and the *Guidebook for Proposers Responding to a NASA Funding Announcement* (hereafter referred to as the *NASA Guidebook for Proposers* or simply the *Guidebook*).

ROSES–2019 SUMMARY OF SOLICITATION

TABLE OF CONTENTS

Note: Table 2 and Table 3 of this NRA are posted and updated as separate html documents on the web and can be reached either by following the hypertext links above embedded in the electronic version of this document, or at http://solicitation.nasaprs.com/ROSES2019table2 and http://solicitation.nasaprs.com/ROSES2019table3, respectively, or by going to http://solicitation.nasaprs.com/ROSES2019 and following the links there.

Any amendments to the program elements will be indicated as bold and red in Table 2 and Table 3 of this NRA. Potential proposers may receive notification of amendments to ROSES-2019 by signing up for the SMD NSPIRES mailing list and/or by signing up for the ROSES-2019 RSS feed at https://science.nasa.gov/researchers/sara/grant-solicitations/roses-2019/.

RESEARCH OPPORTUNITIES IN SPACE AND EARTH SCIENCES (ROSES)–2019

LIST OF PROGRAM ELEMENT APPENDICES

APPENDIX A. EARTH SCIENCE RESEARCH PROGRAM

RESEARCH OPPORTUNITIES IN SPACE AND EARTH SCIENCES (ROSES)–2019
SUMMARY OF SOLICITATION

I. FUNDING OPPORTUNITY DESCRIPTION

(a) Strategic Objectives of NASA and the Science Mission Directorate

The National Aeronautics and Space Administration (NASA) is chartered in the National Aeronautics and Space Act [51 U.S.C. § 20101 et seq.] with, among other objectives, the expansion of human knowledge of the Earth and of phenomena in the atmosphere and space. Working from this Congressional authorization, U.S. National Space Policy directs NASA to advance fundamental scientific knowledge of our Earth system, Solar System, and the Universe. This direction is manifest in the 2018 NASA Strategic Plan, which includes Strategic Objective 1.1 to understand the Sun, Earth, Solar System, and Universe. Further insight into the Strategic Goals and Objectives of the Science Mission Directorate, from the 2018 NASA Strategic plan and the current version of the Science Plan, are given in the documents at http://science.nasa.gov/about-us/science-strategy/. All program elements in this NASA Research Announcement (NRA) are relevant to NASA's Strategic Goals and Objectives. Each proposal to this NRA demonstrates the relevance of its proposed research to NASA by demonstrating relevance to the particular program element to which it was submitted (further instructions concerning relevance and the other evaluation criteria are provided in Section VI(a) below).

(b) Research Programs of NASA's Science Mission Directorate

The NASA Science Mission Directorate (SMD) pursues NASA's strategic objectives using a wide variety of space flight programs that enable the execution of both remote sensing and *in situ* investigations. These investigations are carried out through the flight of space missions in Earth orbit, as well as to or even beyond objects in the Solar System, and also through ground-based research activities that directly support these space missions. This ROSES NASA Research Announcement (NRA) solicits proposals for both flight investigations, using suborbital-class platforms (including aircraft, balloons, sounding rockets, CubeSats, commercial suborbital reusable launch vehicles, and small International Space Station payloads), and all kinds of ground-based supporting research and technology (SR&T) investigations that seek to understand naturally occurring space and Earth phenomena, human-induced changes in the Earth system, and Earth and space science-related technologies and to support the national goals for further robotic and human exploration of space. These ground-based investigations include, but are not limited to: theory, modeling, and analysis of SMD science data, (together with data from SMD's international and/or interagency partners) development of concepts, techniques and advanced technologies suitable for future SMD space missions; development of methods for laboratory analysis of both extraterrestrial samples returned by spacecraft and terrestrial samples that support or otherwise help verify observations from missions; determination of atomic and composition parameters needed to analyze space data, as well as returned samples from the Earth or space; Earth surface observations and field campaigns that support SMD science missions; development of integrated Earth system models; development of systems for applying Earth science research data to societal needs; and development of applied information systems applicable to SMD objectives and data.

Proposals in response to this NRA should be submitted to the most relevant science program elements described in Appendices A, B, C, D, and E. Table 2 lists these program elements in the order of their calendar deadlines for the submission of proposals, while Table 3 lists them in the order in which they appear in the appendices of this NRA. Questions about each specific program element should be directed to the Program Officer(s) identified in the Summary of Key Information section that concludes each program element description.

In order to pursue NASA's strategic objectives, SMD research and technology development activities are organized into four Programs:

- The Earth Science Research and Applied Sciences Program sponsors integrative research to advance knowledge of and to explore interactions among the major components of the Earth system — continents, oceans, atmosphere, ice, and life — to distinguish natural from human-induced causes of change and to understand and predict the consequences of change.
- The Heliophysics Research Program sponsors research to understand the Sun as a magnetic variable star and its effects on the Earth and other planets and the dynamics of structures in the Solar System.
- The Planetary Science Research Program sponsors research to explore the Solar System to study its origins and evolution, including the origins of life within it.
- The Astrophysics Research Program sponsors research to explore the Universe beyond, from the search for planets and life in other planetary systems to the origin, evolution, structure, and destiny of the Universe itself.

Appendices A, B, C, and D describe program elements of these four science research programs, respectively, while Appendix E describes cross-division program elements relevant to two or more of these science research programs. Each of these appendices is prefaced with an Overview (A.1, B.1 C.1…) that introduces the research program content of that division and lays out important rules that apply to all program elements within that Appendix if not superseded by individual program elements. See section I.(g) regarding order the precedence of these rules.

(c) Significant Changes from Recent ROSES

(i) Proposers should be aware of the following changes from last year:

- Section II.(c) on increasing access to the results of federally funded research links to the Federal Register notice, specifies that manuscripts are to be deposited within one year, and notes that failure to do so "may delay or prevent awarding of funds."
- In Section IV(b)iii in the description of the summary table of work effort it is noted that, unless otherwise stated in an individual program element, person time listed in the table of work effort that is offered at no cost by the proposing organization is assumed to be an estimate of anticipated additional effort that may be provided to the project as needed and is considered voluntary uncommitted effort.
- Section VI.(b) now defines the programmatic considerations that may be considered by the selection official.

- Section VIII now includes a link to information on filing a complaint through the NASA Office of Diversity and Equal Opportunity.
- There have been a number of changes to the program elements within ROSES (see the lists of Program Element Appendices above) including:
- In Appendix A (Earth Science) a new program element for members of a science team for the Global Ecosystem Dynamics Investigation (GEDI) instrument on the International Space Station (ISS) will be solicited as program element A.8, Plankton, Aerosol, Cloud, ocean Ecosystem (PACE) Science Team as program element A.38, and a new program element for Earth Science Research from Operational Geostationary Satellite Systems may be solicited as A.33. Space Archaeology returns as an element in Interdisciplinary Science (A.32). Many programs do not solicit every year so, as always, individual program elements are on their own cadence, some with full text available now (e.g., A.2), some with a bold notice indicating that they will be solicited but dates are currently TBD (e.g., A.6 and A.8), and some with a bold notice indicating that they will not be solicited this year (e.g., A.3-A.5).
- In Appendix B (Heliophysics) Space Weather Science Applications Operations 2 Research has been added as B.7, what was the Flight Opportunities part of Heliophysics Technology and Instrument Development for Science (H-TIDeS) in ROSES-18 has been pulled out and is solicited separately as Heliophysics Flight Opportunities for Research and Technology in B.9.
- In Appendix C (Planetary Science) the new Planetary Science Early Career Award Program will be solicited in C.19, after having been released as draft last year for community comment and The Bepi-Colombo Participating Scientist Program (C.22).
- In Appendix D (Astrophysics) the Astrophysics Data Analysis Program (ADAP) program is not being solicited in ROSES-2019 because it was solicited a second time in ROSES-2018 in order to maintain its normal schedule and due date. See D.16 Second Astrophysics Data Analysis, with proposals due May 17, 2019.
- In Appendix E (Cross Division) the Exoplanets Research Program (E.3) will not be solicited in ROSES-2019, because it was solicited a second time in ROSES-2018 in order to maintain its normal schedule and due dates. See E.5 Second Exoplanets Research, with Step-1 proposals due March 29, 2019. XRP will now be jointly managed by all four science divisions. PIs are now eligible for participation in the NfoLD Research Network, and new language explicitly allows observational proposals searching for biosignatures on exoplanets.
- As always, small changes have been made throughout this document and to program elements, so please read carefully. Other changes will occur throughout the year announced by Amendments, corrections, and clarifications. Subscribe to the NSPIRES mailing lists and the ROSES-2019 RSS feed for updates.
- The 2019 version of the *Guidebook* will not be out at the time of the release of ROSES-2019. It is not anticipated that there will be any significant changes to the *Guidebook* between the 2018 and 2019 versions, but just to avoid any ambiguity, the 2018 version of the *Guidebook* is the one that applies to all proposals until ROSES-2019 is amended to indicate that the new guidebook is in force.

(ii) Individuals who did not propose last year should be aware of the following changes made in recent years:

- New text on the Co-I/Science PI role was added to Section IV(b)(i) last year.
- Section III(a) "Eligibility of Applicants" was updated last year to more accurately reflect NASA policy on participation by non-U.S. organizations.
- The "Micro-purchase Threshold" for grantees was increased from the prior $3K value (from 2 CFR §200.67) to $10K. Therefore, competitive quotes are not required for items or services costing up to $10K if management (at the organization receiving the grant) determines that the price is reasonable.
- Although, in general, Notices of Intent (NOIs) are optional, they are mandatory in a few cases (e.g., D.3 APRA and D.7 SAT). Grants.gov does not include an option to submit a Notice of Intent. For more information on NOIs see Section IV(b)vi.
- Salaries for all participants and overhead from all types of organizations must be included in the NSPIRES web cover page budget and a separately uploaded Total Budget PDF file. This applies to all funded participants, including NASA civil servants. See Section IV(b)iii.
- For all participants and all types of organizations, salaries and overhead may not be included anywhere in the body of the main proposal PDF, this information is to be provided only via the NSPIRES cover pages and the separately uploaded Total Budget PDF. See Section IV(b)iii.
- Awards deriving from ROSES now require that as-accepted manuscript versions of peer-reviewed publications that result from ROSES awards be uploaded into NASA's part of the PubMed Central (PMC) repository called NASA PubSpace, see Section II(c).
- Section I(g) describes which instructions proposers should follow when there are discrepancies among the *ROSES Summary of Solicitation* vs. the *Guidebook* vs. program elements.
- Table 1 indicates that Current and Pending Support is required only for funded Co-Is at or above 10% of that person's time (0.1 FTE).
- Data Management Plans (DMPs) are required along with almost all proposals, see Section II(c) and the FAQ on this subject. For select instrument development programs DMPs are not required under the presumption that no significant research data will be generated. However, if those awards result in peer-reviewed publications, then the data behind figures and tables must be available electronically at the time of publication, ideally in supplementary material with the article. The Agency default is for the data management plan to be put into a required text box on the NSPIRES cover pages, but some program elements (e.g., those in Appendix C) require the DMP to be part of the uploaded proposal PDF and have special instructions. Please read C.1 carefully if proposing to Planetary Science Division programs, including Habitable Worlds (E.4).

(d) NASA-Provided High-End Computing (HEC) Resources

SMD provides a specialized computational infrastructure to support its research community, managed on its behalf by NASA's High-End Computing (HEC) program (see the HEC website at https://www.hec.nasa.gov/). Two major computing facilities are offered: the NASA Center for Climate Simulation (NCCS) at the Goddard Space Flight Center (GSFC), and the NASA Advanced Supercomputing (NAS) facility at the Ames Research Center (ARC).

The HEC program facilities maintain a range of computing systems with significant data storage resources. These offerings are summarized at https://www.hec.nasa.gov/about/overview.html. Augmentation and refreshment of these central systems occur on a periodic basis. The HEC program can also assist in code porting, performance tuning, scientific data visualization, and data transfer.

Any need for computing time and other HEC Program resources for the proposed research must be explicitly justified by completing a two-step request submission process: (1) generate a request form for inclusion with your ROSES proposal (see sections i and ii below); and (2) if selected for funding, submit detailed requirements for evaluation by the HEC Program (see section iii below).

(i) Generate Request for HEC Resources **[Updated October 24, 2019]**

The purpose of this step is to inform science review panels of your computational needs, and if your ROSES proposal is selected, establish eligibility to use HEC resources. First, **Complete and submit a request in the HEC Request Management System (RMS) at https://request.hec.nasa.gov.**~~complete a request form in the HEC eBooks system (https://hec.reisys.com/hec/computing/index.do)~~. The form includes a written justification of how the computational resources would support the investigation as well as a multi-year resource-phasing plan, in annual increments, identifying the computing time and data storage requirements covering the duration of the proposed award period. **Use the "planning date for start of investigation" from the Summary of Key Information for your program element as the start date for your computational project.**

Computing time must be described in the request using Standard Billing Units (SBUs), a common unit of measurement employed by the HEC program for allocating and tracking computing usage across its various architectures. The ~~eBooks~~ **RMS** system has a built-in calculation feature to assist with conversion from processor (CPU) hours to SBUs. SBU Conversion Factors are also available at https://www.hec.nasa.gov/user/policies/sbus.html, or proposers may contact HEC support staff for further assistance calculating SBUs; contact information can be found at https://www.nas.nasa.gov/hecc/support/user_support.html for NAS User Support, and https://www.nccs.nasa.gov for NCCS User Services Group.

(ii) Upload Request for HEC Resources

~~The HEC eBooks system will generate a PDF version of your completed computing request for download, as well as send the PDF via email as an attachment.~~ **Save a PDF copy of your request after submitting it using the button provided in RMS.** During your proposal submission in the NSPIRES system:

- Upload the PDF version of your computing time request as a separate file from your proposal; select "Appendix" as the document type when uploading;
- On the NSPIRES Cover Page

– Check the box indicating that a request for HEC resources is included in the proposal; and
– Enter the HEC Request Number (specified ~~in the email and~~ on the PDF itself).

For proposals submitted via Grants.gov, the resource request should be attached as an appendix to any appropriate location. This requirement for a separate document supersedes the general rule that proposals are made up of only two PDF files: the proposal and the Total Budget.

As they review the proposed investigation, science peer review panels will be asked to consider whether the computing time requested is an appropriate utilization of the highly constrained resources dedicated for each program element under this NRA.

Selection of your ROSES proposal does not also ensure that your HEC request will be fully satisfied, it merely means that your HEC request is eligible to progress to the next step for evaluation by the HEC Program (see section iii below). While you are guaranteed some HEC time, it may differ from your request given resource constraints.

(iii) ~~Submit Detailed Requirements for~~ Allocation of HEC Resources

If your proposal is selected for funding, **your HEC request will be evaluated by the HEC Allocation Authority.** ~~the PI will be prompted by email generated by the HEC eBooks system to log back in to the HEC eBooks system to complete the request process. Principal Investigators (PIs) will be required to submit detailed requirements (e.g., preferred facility/system for where the computational project will be conducted and data security, data transfer, application information, etc.) to be evaluated along with the proposed multi-year phasing plan.~~ The HEC Program will then issue award letters identifying yearly allocations of HEC resources for the duration of the project, which again, may differ from your request due to limited availability of resources. However, PIs will have the opportunity to submit requests to increase or decrease allocations of HEC resources if there are unexpected changes to computational needs. The **RMS** ~~HEC~~ website at **https://request.hec.nasa.gov** provides the mechanism for PIs to formally request changes. Requests for modifications cannot be guaranteed, but SMD will make every attempt to satisfy the needs in the context of the overall set of requirements, resource constraints, and science priorities.

To expedite initiation of new projects where PIs and/or users are foreign nationals (whose accounts will require additional documentation and longer processing), the HEC program will consider providing a minimal allocation to such projects which have been notified of pending funding soon after the PI submits an allocation request ~~in e-Books~~ via the ~~HEC~~ **RMS** website. PIs should identify this foreign national status in their request abstract.

For further information or questions about NASA provided High-End Computing resources please contact Tsengdar Lee at Tsengdar.J.Lee@nasa.gov or 202-358-0860.

(e) Availability of Funds for Awards

Prospective proposers to this NRA are advised that funds are not available for new awards for all of its solicited program elements at the time of its release. The Government's obligation to make awards is contingent upon the availability of sufficient appropriated funds from which payment can be made and the receipt of proposals that NASA determines are acceptable for award under this NRA.

(f) Successor, Resubmitted, Multiple and Duplicate Proposals

PIs holding awards under any program element of any prior NRA are welcome to submit "successor" proposals that seek to continue a previously funded line of research. However, as described in the [*NASA Guidebook for Proposers*](), such successor proposals will be considered with neither advantage nor disadvantage along with new proposals that are submitted for that same program.

Proposers are welcome to resubmit proposals (or tasks) that were not funded under a prior program element or solicitation. Such submissions will be peer reviewed and considered with neither advantage nor disadvantage along with new proposals that are received by NASA. However, some Appendices and/or program elements in ROSES limit submissions in a couple of ways:

The first limitation on submission bars "multiple" proposals to a given program element. Some program elements in Appendix B (Heliophysics), e.g., B.2 H-SR, will not allow a particular individual to be the PI on more than one proposal to those program elements. In such cases, the first proposal identifying a particular PI will be evaluated, but any subsequent proposal to the same program element that identifies the same PI will not be evaluated or considered.

The second limitation bars submission of "duplicate" proposals. Planetary Science will not accept duplicate (the same or essentially the same) proposals submitted to any of its program elements (Appendix C, or its parts of cross-division programs in Appendix E). The first proposal will be evaluated but any other proposals will not be. See C.1 for more information.

In either case, the order of receipt of the proposals will be determined by the time stamp generated automatically by the proposal submission system. Please carefully read the program elements and propose to Heliophysics and Planetary Science with this in mind.

(g) Order of Precedence: The *Guidebook* vs. *ROSES Summary of Solicitation* vs. program elements

Any inconsistency among authorities or agency instructions stated in or referenced in this solicitation shall be resolved by giving precedence in the following order:

1. Statutes and regulations
2. Program elements
3. The *Summary of Solicitation* of the ROSES NRA (i.e., this document)
4. *Guidebook for Proposers Responding to a NASA Funding Announcement*

There may be cases when the instructions in more than one of these documents are contradictory. In cases of contradictions between texts, individual program elements take precedence over this *Summary of Solicitation*, and this *Summary of Solicitation* takes precedence over the *Guidebook for Proposers*.

An example where individual program element may contradict and supersede the *Guidebook* is "letters of affirmation" (sometimes called letters of endorsement). The

Guidebook states that letters that endorse the value or merit of a proposal will not be considered in the evaluation of the proposal, but a few individual program elements in ROSES (e.g., C.17 PMEF, for facility instruments, and E.2 TWSC) do allow such letters of affirmation.

Moreover, this *Summary of Solicitation* may include instructions that are more specific or detailed than the *Guidebook*, and program elements often include instructions that are more specific or detailed than this *Summary of Solicitation* or the *Guidebook*. An example of a case where individual program element differs from this *Summary of Solicitation* is in how Relevance is evaluated. Section VI(a) lays out a general approach to evaluating relevance, but a few individual program elements in Appendix C require explicit statements of relevance through mandatory text boxes on the NSPIRES cover pages.

Finally, answers to questions may appear in FAQs. The FAQ for the ROSES NRA appears at http://science.nasa.gov/researchers/sara/faqs/. Any FAQs for individual program elements will appear under "other documents" on the NSPIRES web page for the program element. FAQs merely present clarification, they do not contradict instructions in the *Guidebook*, *ROSES Summary of Solicitation* or program elements.

Questions about differences between *ROSES Summary of Solicitation* and the *Guidebook* should be directed to sara@nasa.gov. Questions about a difference between either of those and an individual program element, should be directed to the point of contact for the particular program element and cc sara@nasa.gov.

(h) Access to NASA Facilities/Systems

To access NASA facilities and/or systems, award recipients must work with NASA to ensure proper credentialing. For example, for access to High-End Computing (HEC) Resources, this is part of the HEC eBooks system and for physical access to a NASA facility one would work with the badging office at that NASA center. Special restrictions may apply to those who are neither U.S. citizens nor permanent residents, especially those from designated countries. Note, there is a presumption of denial for citizens of, or persons born in, State Sponsors of Terrorism (Column 2 of the NASA Designated Country List). For a current list of designated countries download the PDF at the NASA Export Control Website: https://oiir.hq.nasa.gov/nasaecp/.

(i) Citizen science **[Updated March 19, 2019]**

Citizen science is a form of open collaboration in which individuals or organizations participate voluntarily in the scientific process. Proposers to any ROSES program element are invited to incorporate citizen science and crowdsourcing methodologies into their submissions, where such methodologies will advance the objectives of the proposed investigation. The current SMD Policy on citizen science~~, that~~ describes standards for evaluating proposed and funded SMD citizen science projects. For more information see Section 3 H.R.6414 - Crowdsourcing and Citizen Science Act of 2016, which authorizes federal agencies to utilize crowdsourcing and citizen science and the https://science.nasa.gov/citizenscientists webpage, that provides information about existing SMD-funded projects, including how to sign up for the NASA-SOLVE email listserve.

(j) Science Activation

NASA Science recognizes the importance our content and experts play in advancing human knowledge. SMD created a new program to activate learners of all ages to become more scientifically-literate and create a life-long love of learning. By leveraging community-based organizations across the U.S. and online we can provide new opportunities. If you are a subject matter expert and would like to learn more - visit https://science.nasa.gov/learners. To volunteer as a subject matter expert in this program, submit an application at https://science.nasa.gov/learners/sme-map.

Questions about the program may be submitted to https://science.nasa.gov/contact-science-activation.

II. AWARD INFORMATION

(a) Funding and Award Policies

NASA may support an award as outlined in the proposal budget, or may offer to fund only selected tasks, or all tasks for a shorter duration (e.g., a one-year pilot study), or a combination. Awards may depend on acceptable revised versions of budgets, statements of work, data management plans, or other elements of proposals described in ROSES or in the *NASA Guidebook for Proposers*. Moreover, even after an award letter has been sent or an award has begun, NASA has the authority to suspend or terminate a grant in whole or in part in accordance with 2 CFR 200.338 through 200.340.

The amount of funds expected to be available for new awards for proposals submitted in response to this NRA is given in the Summary Table of Key Information at the end of each program element in the appendices. An estimate of the number of awards that might be made for each program element is also given in this Table, contingent on budget allocation to that program element and availability of funding and presuming the submission of sufficient highly rated proposals.

In all cases, NASA's goal is to initiate new awards as rapidly as possible after the selection of proposals is announced for each program element. However, the workload experienced by NASA, the availability of appropriated funds, and any necessary post-selection negotiations with the proposing organization(s) needed for the award(s) in question can all cause delays. Regarding this last item, every proposer is especially encouraged to submit full and detailed explanations of the requested budget to help expedite the processing of the award, should their proposal be selected.

The ROSES NRA is structured to allow NASA to make the full range of award types: grants, cooperative agreements, contracts, and intra- or interagency transfers. However, most program elements in ROSES exclude contracts because it would not be appropriate for the nature of the work solicited. For example, the research program overviews in A.1, C.1, and E.1 set no contracts as the default so, unless otherwise stated in a program element, contracts are not awarded from proposals to calls in Appendices A, C and E. Where contracts are permitted, the program element will indicate that explicitly. Similarly, most (but not all) of the program elements in Appendices B and D do not award contracts. When new program elements are added by Amendment to this NRA, they may or may not allow contracts. Please read the Research Program Overviews (i.e., A.1, B.1 C.1 etc.) and program elements carefully if planning to propose a contract. If a prospective proposer to a program element that excludes contracts thinks that their work should be a contract, they should communicate with the point of contact for that program element and cc sara@nasa.gov.

The budget narrative need not state the type of award instrument that is anticipated. A NASA awards officer will determine the appropriate award instrument for the selections resulting from this solicitation. Contract awards will be subject to the provisions of the Federal Acquisition Regulations (FAR) and the NASA FAR Supplement (see https://www.nasa.gov/office/procurement/doingbusiness).

(b) Award Period of Performance

The maximum period of performance (duration) for new awards for proposals submitted in response to this NRA is given in the Summary of Key Information that concludes each program element description in the appendices. The maximum period of performance ranges from one year for activities of limited scope to five years for extensive, comprehensive studies. Award durations may be longer in special cases, such as teams of long duration space missions. Whatever the proposed period of performance it must be justified in the proposal. The appropriateness of the proposed period of performance will be evaluated by peer review. NASA may offer to support an award of shorter duration than was proposed.

(c) Increasing Access to the Results of Federally Funded Research

In keeping with the NASA approach for Increasing Access to Results of Federally Funded Research, most proposals to ROSES will be required to provide a data management plan (DMP) or an explanation of why one is not necessary given the nature of the work proposed. Unless otherwise stated, the data management plan will be collected on the NSPIRES web cover pages and limited to 8000 characters. Any program element that doesn't require a DMP via the cover pages will say so explicitly. Regardless of whether a DMP is required, with the proposal, grantees must still meet the mandatory minimum requirement that the data behind figures and tables in peer-reviewed publications be available electronically at the time of release, ideally in supplementary material with the article. The kind of proposal that requires a data management plan is described in the SARA FAQs on this subject. The appendices and individual program elements of ROSES may specify preferred archives and may require more than is outlined here for all proposers or just those that generate certain kinds of data. Please read the individual program elements carefully, especially Appendix C, which has its own instructions in Section 3.6 of C.1 and even templates. Proposers that include a plan to archive data should allocate suitable time and funding for this task. For information about data rights, and other aspects of intellectual property such as invention rights resulting from awards see the file entitled "Award and Intellectual Property Information" under the section called "Grant and Cooperative Agreement Guidance" at https://prod.nais.nasa.gov/pub/pub_library/srba/.

In keeping with the NASA Plan for Increasing Access to Results of Federally Funded Research, awards deriving from ROSES include terms and conditions requiring that as accepted manuscript versions of peer-reviewed publications (hereinafter "manuscripts") that result from ROSES awards be uploaded into NASA's part of the PubMed Central (PMC) repository called NASA PubSpace. The Federal Register notice on this subject specifies that manuscripts are to be deposited within one year of completion of the peer review process. Please note that the NASA research access FAQ says that not doing so "may delay or prevent awarding of funds". This applies only to peer reviewed manuscripts. Patents, publications that contain material governed by personal privacy, export control, proprietary restrictions, or national security law or regulations will not be covered by this requirement. For more details on public access to scientific publications and digital scientific data resulting from NASA-funded research, please see: https://www.nasa.gov/open/researchaccess.

(d) Rephasing of Award Budgets, Family or Medical Leave and No-Cost Time Extensions

Occasionally the schedule for a research project changes, and this will change the phasing of the funding requirement. "Rephasing" funding may be initiated either at the request of the PI or NASA.

In keeping with NASA's policy (in 2 CFR 1800.903), SMD will accommodate all reasonable requests from the PI or Authorized Organization Representative (AOR) to rephase ROSES awards to accommodate a PI's need to care for family and health (e.g., for family or medical leave). In the case of contracts, rephasing will be performed as long as it does not compromise previously agreed upon project goals, timelines, or deliverables associated with a NASA requirement described in the contract.

NASA policy allows grantee-initiated, first time no-cost extensions (NCEs) of up to 12 months. Grantees may use the form at https://www.nssc.nasa.gov/nocostextension to request NCEs. PIs at Government labs should contact their program officer directly.

SMD program officers may engage in active grant management to facilitate carrying forward unobligated funds from one fiscal year to the next fiscal year (carryover). Program Officers may invite the PI to rephase their funding requirement where funds for a year or more are being carried forward. In this way, the awarding of future year funds can more closely align with the timing of project activities. The total funds disbursed over the period of performance would not change, only the fiscal year (FY) in which they arrive.

SMD policy is that work on continuing awards should not be deferred because of a delay in receipt of funds. If an award is rephased, NASA will make every reasonable effort to provide the next fiscal year funding in a timely manner. Honoring commitments and ensuring the continuation of existing projects is a high priority of SMD.

III. Eligibility Information

(a) Eligibility of Applicants

Prospective investigators from any category of organizations or institutions, U.S or non-U.S., are welcome to respond to this solicitation. Specific categories of organizations and institutions that are welcome to respond include, but are not limited to, educational, industrial, and not-for-profit organizations, Federally Funded Research and Development Centers (FFRDCs), University Affiliated Research Centers (UARCs), NASA Centers, the Jet Propulsion Laboratory (JPL), and other Government agencies. Historically Black Colleges and Universities (HBCUs), Hispanic-Serving Institutions, Tribal Colleges, and Other Minority Universities (OMUs), small disadvantaged businesses (SDBs), veteran-owned small businesses, service disabled veteran-owned small businesses, HUBZone small businesses, and women-owned small businesses (WOSBs) are encouraged to apply.

Moreover, NASA recognizes and supports the benefits of having diverse and inclusive scientific, engineering, and technology communities and fully expects that such values will be reflected in the composition of all panels and teams including peer review panels (science, engineering, and technology), proposal teams, science definition teams, and mission and instrument teams.

Participation **in ROSES-funded research** by non-U.S. organizations in this program is welcome, but on a "no exchange of funds" basis. It is NASA policy that each international partner, its sponsoring agency, or its funding/sponsoring institution, covers its own **research** contributions (further information on foreign participation is provided in ROSES FAQ #14 on this topic and the *NASA Guidebook for Proposers*).

NASA does not normally fund research efforts at foreign organizations, whether proposed directly by a foreign organization, or as part of proposals submitted by U.S. organizations. Unless otherwise stated in the program overview or program element, for any research efforts that derive from this NRA, NASA will provide the support for selected U.S. organizations and the sponsoring foreign agency or institution must do the same for their selected organizations.

If a proposal with a non-U.S. partner is selected, NASA will determine whether such participation should be covered by and implemented through an international agreement between NASA and the sponsoring foreign agency or funding/sponsoring institution under which the parties agree to each bear the cost of discharging their respective responsibilities.

NASA funding may not be used for subcontracted foreign research efforts, including travel. The direct purchase of supplies and/or services, which do not constitute research, from non-U.S. sources by U.S. award recipients is permitted.

(b) Number of Proposals and Teaming Arrangements

There is no general restriction on the number of proposals that an organization may submit to this solicitation, or on the teaming arrangements for any one proposal, including teaming with employees of NASA's Centers and the Jet Propulsion Laboratory. However, some Appendices or program elements limit the number of proposals that may be submitted on behalf of an individual PI to a program element or bar duplicate proposals, see Section I(f). Moreover, each proposal must be a single separate, stand-alone, complete PDF document for evaluation purposes, other than the Total Budget and HEC request.

(c) Restrictions Involving China

Proposals must not include bilateral participation, collaboration, or coordination with China or any Chinese-owned company or entity, whether funded or performed under a no exchange of funds arrangement.

In accordance with restrictions in Appropriation Acts, NASA is prohibited from funding any work that involves the bilateral participation, collaboration, or coordination with China or any Chinese-owned company or entity, whether funded or performed under a no exchange of funds arrangement.

Proposals involving bilateral participation, collaboration, or coordination in any way with China or any Chinese-owned company, whether funded or performed under a no exchange of funds arrangement, may be ineligible for award.

For more information please see the ROSES FAQ on the SARA web page at http://science.nasa.gov/researchers/sara/faqs/prc-faq-roses/

As stated in 2 CFR 1800 Appendix A, NASA requires Certifications, Assurances, and Representations, including Certifications and Assurances to implement restrictions in Appropriation Acts, that are applicable to all awards. By submission of a proposal, proposers are certifying that the proposing organization has read and is in compliance with all the Certifications, Assurances, and Representations, including that they are not China or a Chinese-owned company, and that they will not participate, collaborate, or coordinate bilaterally with China or any Chinese-owned company, at the prime recipient level or at any subrecipient level, whether the bilateral involvement is funded or performed under a no exchange of funds arrangement.

An Assurance of Compliance with restrictions in Appropriation Acts herein after referred to as "the Acts" whereas:

(1) NASA is restricted from using funds appropriated in the Acts to enter into or fund any grant or cooperative agreement of any kind to participate, collaborate, or coordinate bilaterally with China or any Chinese-owned company, at the prime recipient level and at all subrecipient levels, whether the bilateral involvement is funded or performed under a no exchange of funds arrangement.

(2) Definition: "China or Chinese-owned Company" means the People’s Republic of China, any company owned by the People’s Republic of China, or any company incorporated under the laws of the People’s Republic of China.

(3) The restrictions in the Acts do not apply to commercial items of supply needed to perform a grant or cooperative agreement.

(4) By submission of its proposal, the proposer represents that the proposer is not China or a Chinese-owned company, and that the proposer will not participate, collaborate, or coordinate bilaterally with China or any Chinese-owned company, at the prime recipient level or at any subrecipient level, whether the bilateral involvement is funded or performed under a no exchange of funds arrangement.

(d) Cost Sharing or Matching

Unless otherwise specified, cost sharing is not required for an institution of higher education or other not-for-profit organization to receive a grant or cooperative agreement, although NASA may accept cost sharing if it is voluntarily offered (see 2

CFR 200.306, 2 CFR 1800.306, *Grants and Cooperative Agreement Manual (GCAM)* 5.6 Funding).

For a commercial organization to receive a cooperative agreement, cost sharing (equal to 50% of the total) is required if the project has commercial applications and profit generating potential. Proposals from commercial organizations for cooperative agreements that do not include cost sharing must demonstrate that potential commercially marketable products are not expected to result from the project. (see references in parenthesis above and 14 CFR §1274.102 (c) 4 and 14 CFR §1274.204, "Costs and Payments" (b) Cost sharing).

Each proposal must include Table of Personnel and Work Effort with names and planned work of all personnel necessary to perform the proposed effort, regardless of whether that work effort requires funding or not. As this is outside of the budget section, any work planned that is not funded by NASA listed in this table is not considered cost sharing as defined in 2 CFR § 200.29. Level of effort estimates for unfunded team members are not intended to represent voluntary committed cost sharing. Collaborators should be listed on the table, but their level of effort may be simply given as "de minimis." See Section IV(b)iii for an example.

IV. Proposal and Submission Information

(a) Proposal Instructions and Requirements

All information needed to apply to this solicitation is contained in this ROSES NRA and in the companion document, the *NASA Guidebook for Proposers*, located at http://www.hq.nasa.gov/office/procurement/nraguidebook. By reference, the latest edition of the *NASA Guidebook for Proposers* is incorporated into this NRA. We also include 48 CFR 1852.235-72 by reference and it appears in the *NASA Guidebook for Proposers*. Proposers are responsible for understanding and complying with its procedures for the successful, timely preparation and submission of their proposals. Proposals that do not conform to its standards may be declared noncompliant and returned without review.

Questions regarding a program element should be directed to the program officer identified in the Summary Table of Key Information at the end of each program element or on the list of program officers on the SARA web page. Any clarifications or questions and answers that are published will be posted on the relevant program element's index page in NSPIRES.

The introductory material, as well as the appendices, of the *NASA Guidebook for Proposers* provides additional information about the entire NRA process, including NASA policies for the solicitation of proposals, guidelines for writing complete and effective proposals, and NASA's general policies and procedures for the review and selection of proposals and for issuing and managing the awards to the institutions that submitted selected proposals. A group of Frequently Asked Questions (FAQs) provides additional miscellaneous information about a variety of the NASA proposal and award processes, policies, and procedures.

NASA is implementing a process to collect demographic data from proposers via NSPIRES for the purpose of analyzing demographic differences associated with its award processes. Information collected will include name, gender, race, ethnicity, and disability status. Submission of this information is voluntary, only available only to NASA's Office of the Chief Scientist in aggregate form, and is not any part of the evaluation or selection process, let alone a precondition of award.

Comments and suggestions of any nature about the *NASA Guidebook for Proposers* are encouraged and welcome and may be directed at any time to the point of contact identified in Section VIII below.

(b) Content and Form of the Proposal Submission

(i) Electronic Proposal Submission

All proposals submitted in response to this ROSES NRA must be submitted electronically by one of the officials at the PI's organization who is authorized to make such a submission; electronic submission by the authorized organization representative (AOR) serves for the proposal as the required original signature by an authorized official of the proposing organization. No hard copy of the proposal is permitted.

Proposers may opt to submit proposals in response to this ROSES NRA via either of two different electronic proposal submission systems: the NASA Solicitation and Proposal Integrated Review and Evaluation System (NSPIRES) at http://nspires.nasaprs.com; see Section IV(b)(iv) below, or Grants.gov at http://www.grants.gov; see Section IV(b)(v) below. The only exceptions are occasional joint calls with the National Science Foundation (NSF) that use the NSF's FastLane system and the Astrophysics Guest Investigator and Guest Observer programs. See Section IV(b)viii on the two-phase process and those program elements for details.

Note carefully the following requirements for submission of an electronic proposal, regardless of the intent to submit via NSPIRES or Grants.gov:

- Every organization that intends to submit a proposal to NASA in response to this NRA, including educational institutions, industry, not-for-profit institutions, the Jet Propulsion Laboratory, NASA Centers, and other U.S. Government agencies, must be registered in NSPIRES. This applies equally for proposals submitted via Grants.gov, as well as for proposals submitted via NSPIRES. Every organization that intends to submit a proposal through Grants.gov must also be registered in Grants.gov, as well as in NSPIRES. Registration for either proposal data system must be performed by an organization's electronic business point-of-contact (EBPOC) in the System for Award Management (https://www.sam.gov/SAM/).
- Any organization requesting NASA funds through the proposed investigation must be listed on the Proposal Cover Page. NASA will not fund organizations that do not appear on the Proposal Cover Page.
- Each individual team member (e.g., PI, Co-Investigators, etc.), including all personnel named on the proposal's electronic cover page, must be individually registered in NSPIRES. This applies equally for proposals submitted via Grants.gov, as well as for proposals submitted via NSPIRES.

- Unless specifically allowed by an individual program element, Co-PIs are not permitted. The use of other team member roles in NSPIRES (described in the *NASA Guidebook for Proposers*) including Co-I/Science PI, Co-I/Institutional PI, and Co-I/Co-PI (only from a non-U.S. organization under specific circumstances), are permitted. Any role with "PI" in the title is subject to the rules, requirements, page limits, etc. laid out for the PI. For more information on rules and expectations regarding the Co-I/Science PI please see SARA FAQ #9.
- Each individual team member (e.g., PI, Co-investigators, etc.), including all personnel named on the proposal's electronic cover page, must confirm their participation on that proposal (indicating team member role) and specify an organizational affiliation. For proposals submitted via NSPIRES, this confirmation is via NSPIRES (see Section IV(b)(iv), below). For proposals submitted via Grants.gov, this confirmation is via "Letters of Commitment" included within the proposal. The organizational affiliation specified on the cover page must be the organization through which the team member would work and receive funding while participating in the proposed investigation. If the individual has multiple affiliations, then this organization may be different from the individual's primary employer or preferred mailing address. Team members are asked to ensure that their contact information in NSPIRES is up to date. Changes can be made using the "Account Management" link on the "NSPIRES Options" page.

Typically, an electronic proposal consists of electronic forms (i.e., the NSPIRES cover pages) and two or more attachments. The electronic forms contain data that will appear on a proposal's cover pages and will be stored with the proposal in the NSPIRES database. A proposal submitted in response to this NRA must have two attachments: the main proposal PDF and the Total Budget PDF. The main proposal PDF contains all ten sections of the proposal listed in Table 1, including the Table of Contents, main Science/Technical/Management section, References, Biographical sketches/CVs, Table of Personnel and Work Effort, Current and Pending Support, any Statements of Commitment or Letters, Budget Justification, Facilities and Equipment, and Detailed Budget (excluding any salary, fringe or overhead). The separately uploaded Total Budget PDF contains the full and complete budget, including salary, fringe and overhead (see Section IV(b)iii). If there is an accompanying HEC request (see Section I(d) above) then a HEC Appendix is uploaded as a separate, third PDF.

Submission of proposals via either NSPIRES or Grants.gov is a two-part process. When the PI has completed entry of the data requested in the required electronic forms and attachment of the allowed PDF attachments, including the Science/Technical/Management section, an official at the PI's organization who is authorized to make such a submission, referred to as the Authorized Organizational Representative (AOR), must submit the electronic proposal (forms plus attachments). Coordination between the PI and his/her AOR on the final editing and submission of the proposal materials is facilitated through their respective accounts in NSPIRES and/or Grants.gov.

(ii) Proposal Format and Contents

All proposals submitted in response to this NRA must include any specified required electronic forms available through either of two proposal submission systems, NSPIRES or Grants.gov. Submission via NSPIRES requires responding to questions on the NSPIRES submission page.

The Science/Technical/Management section and other required sections of the proposal must be submitted as a single, searchable, unlocked PDF file that is attached to the electronic submission using one of the proposal submission systems. Proposers must comply with all format requirements specified in this NRA (see below and Table 1 for a summary) and in the *NASA Guidebook for Proposers*. Only appendices that are specifically requested in the *NASA Guidebook for Proposers* and allowed by this NRA or a program element will be permitted; proposals containing unsolicited appendices may be noncompliant and may be returned without review. The *NASA Guidebook for Proposers* provides detailed discussions of the content and organization of proposals suitable for all program elements in this NRA, as well as the default page limits of a proposal's constituent parts.

Note that some of the program element descriptions in Appendices A through E of this NRA may specify different page limits for the Science/Technical/Management section of the proposal; if so, these page limits will be prominently given in the Summary of Key Information subsection that concludes each program element description. In the event the information in this NRA is different from or contradictory to the information in the *NASA Guidebook for Proposers*, the information in this NRA takes precedence.

Unless otherwise stated in the Appendix or program element, proposals submitted in response to ROSES must follow these rules for formatting: The body text and captions may not, on average across a solid block of text, exceed 15 characters per horizontal inch, including spaces, though text within figures and tables may be smaller if still judged by the reviewers to be readable. Easily read sans serif fonts (e.g., Arial, Helvetica, Verdana) are encouraged but not required. Proposals may not have more than 5.5 lines per vertical inch of text, must have at least one-inch margins, be set for US letter size (8.5x11) paper, and expository text necessary for the proposal may not be located solely in figures, tables, or their captions. Moving images are not allowed unless explicitly permitted by the program element.

Important note on creating PDF files for upload: It is essential that all PDF files generated and submitted meet NASA requirements. This will ensure that the submitted files can be ingested by NSPIRES regardless of whether the proposal is submitted via NSPIRES or Grants.gov. At a minimum, it is the responsibility of the proposer to: (1) ensure that all PDF files are unlocked and that edit permission is enabled – this is necessary to allow NSPIRES to concatenate submitted files into a single PDF document; and (2) ensure that all fonts are embedded in the PDF file and that only Type 1 or TrueType fonts are used. TeX and LaTeX users are strongly cautioned to ensure that their settings conform with the paper size, font size, margins etc., listed above. In addition, any proposer who creates files using TeX or LaTeX is required to first create a DVI file and then convert the DVI file to PDF (via an intermediate Postscript file if necessary). **Do not include any digital signatures in the proposal document, NSPIRES cannot concatenate these PDF files with the cover page, total budget, etc. [Added March 19, 2019]** For more information on creating NSPIRES compliant PDF documents see http://nspires.nasaprs.com/tutorials/PDF_Guidelines.pdf. PDF files that do not meet NASA requirements cannot be ingested by the NSPIRES system; such files may be declared noncompliant and not submitted to peer review for evaluation.

There is a 20 MB size limit for proposals. Large file sizes can impact the time it takes for NASA and peer reviewers to download and access the proposal. In order to increase the ease in reviewing the proposal, the proposer should crop and compress any embedded photos and graphic files to an appropriate size and resolution.

(iii) Table of Work Effort and Redaction of Salary, Fringe and Overhead Costs

Peer reviewers need to see the individual effort that will be spent on the project, whether at the proposing organization or not, whether NASA is paying for it or not. Thus, every proposal must include a Table of Personnel and Work Effort that simply lists all of the planned work commitment, by person or role without any technical details.

Example Table of Personnel and Work Effort

Person and/or Role	Time charged to this proposal	Time not charged to this proposal	Total Time per person/year
PI, Ric Sanchez	3 months/year	N/A	3 months/year
Co-I, Morti Smith	4 months/year	N/A	4 months/year
Co-I, Revolio Clockberg Jr.*	N/A	1.5 months/year	1.5 months/year
Collaborator, Daniella Harmon	N/A	*de minimis*	*de minimis*
Grad Student, Justine Roiland[o]	N/A	12 months/year	12 months/year

* A letter of support is provided from the foreign organization Herpson Polytecknic Universität for Prof. Revolio Clockberg Jr. participating at no cost to this proposal.

[o] The Graduate student from the Citadel is funded by a FINESST award and thus participating at no cost to this proposal.

Note, this table is outside of and is distinct from the budget and the page-limited main part of the proposal and thus, unless otherwise stated in an individual program element, any person time listed in the table of work effort that is offered at no cost by the proposing organization is assumed to be an estimate of anticipated additional effort that may be provided to the project as needed and is considered voluntary uncommitted effort. Descriptions of the work that each team member would be performing must be included in the main part of the proposal, not in this table. The example table shown above presumes a simple case for which all investigators are working the same amount of time on the project each year. The reality is often more complicated, and your table should reflect the best estimate of the amount of time each participant will spend on the project. Templates have been provided for those proposing to Appendix C, and templates have also been provided for a number of program elements in Earth Science (Appendix A) but all are welcome to use them.

Peer reviewers do not need to know salaries or overhead rates to evaluate the cost reasonableness of ROSES proposals. Thus, proposals should not include costs of salary, fringe, or overhead anywhere in the uploaded proposal PDF, including the budget detail or justification sections in the main proposal, which will be seen by peer reviewers. Unless otherwise specified by the program element, all proposers must include all costs, including salary, fringe and overhead of NASA civil servants, all subawards, and any separate Co-I awards in two places outside of the uploaded proposal PDF: the NSPIRES web page budgets and the separately uploaded "Total Budget" PDF file, see below and the walkthrough on this subject. Exceptions to this rule include Phase-2 proposals for the astrophysics observing programs e.g., Neil Gehrels Swift Observatory Guest Investigator (D.5), Fermi Guest Investigator (D.6), NuSTAR Guest Observer (D.9), TESS Guest Investigator (D.10), and NICER Guest Observer (D.11) because those are cost-only proposals (essentially just budgets) that are not peer reviewed. See Section IV(b)(viii).

However, peer reviewers certainly do need to see the costs of everything other than salary, fringe, and overhead. Although quotes are not required, proposers are strongly encouraged to include adequate budget detail and justification both for the peer reviewers to evaluate whether costs of things (other than team members) are reasonable. For example, a TDS3054C Tektronix Digital Oscilloscope that costs ~$17K is needed then the proposal must give this price in the detailed budget and, in the budget justification, explain why such an expensive oscilloscope is needed, when a simple one like a TBS1000 series can be purchased for one tenth the price.

In the budget justification in the main proposal PDF proposers may refer to the time but not costs for a subaward, e.g., "4 months/year are allocated for Co-I Morticia Smith, as can be seen in the Table of Personnel and Work Effort. Dr. Smith will be funded via a subaward to the Citadel. The total cost for that subaward is given in the NSPIRES cover page budget in Section F line 5 and is included in the separately uploaded Total Budget PDF file but is not included here in the proposal."

Almost all ROSES program elements are set up to allow proposers to fill out the NSPIRES web page budgets. These NSPIRES web page budgets are not required for Step-1 proposals. Unless otherwise specified in the ROSES program element, these NSPIRES web page budgets should include all costs, including salary, fringe and overhead of all participants. The full NSPIRES web page budgets will not be seen by peer reviewers. Where more than one organization is involved then the total cost for the Co-I organization is simply given as a single number in row 5, 8, or 9 of Section F (of the NSPIRES cover page budget). When funds are going to Co-I organizations funded directly by NASA, such as NASA centers and other government labs then lines 8 or 9 should be used and customized. Row 10 in Section F is reserved for reporting any subaward that does not have any salary component. Proposers are strongly encouraged to read the FAQs with a walkthrough on this subject.

Almost all ROSES program elements are set up to allow Step-2 (full) proposers to separately upload a "Total Budget" PDF along with their proposal. Unless otherwise specified in the ROSES program element, all proposers are required to include this separate Total Budget PDF. The Total Budget should simply include the full and complete budget from your proposing organization and that of your Co-Is (in whatever is the standard form used by your organizations). This means that proposers need to get this information from their Co-Investigators whether or not they are Civil Servants. Budgets are generally laid out by project year but since NASA Civil Servant salaries must be charged to present fiscal year dollars, proposals that include NASA Civil

Servant salaries may need to phase the funds for NASA Centers by fiscal year. The Total Budget PDF must lay out clearly how much is going to each organization, indicating whether the funds are passing through the proposing organization and which are not. Where the funds are passing through the proposing organization to a Co-I organization, the Total Budget PDF must specify any overhead charged on funds passing through. Such charges never apply to funds sent directly to Co-I organizations such as NASA centers and other government labs. The Total Budget PDF is uploaded in exactly the same way that the proposal PDF is uploaded, but by choosing document type "Total Budget". This Total Budget file will not be seen by peer reviewers. These budget files are not required for Step-1 proposals.

NASA Civil Servant time must be included in the summary table of work effort and all costs for NASA civil servant investigators must be included in the budgets just as it would be for any other team member. In general, it is not anticipated that directed work to NASA Centers will overlap with work proposed via ROSES. However, any questions about whether NASA Civil Servant participation on a ROSES proposal is already covered by directed work and how to present this in a proposal budget should be directed to the appropriate division R&A Lead, a list of which may be found at https://science.nasa.gov/researchers/sara/program-officers-list/.

Proposers from JPL should not include the JPL award fee in the funds requested via ROSES, nor should the budgets of JPL Co-Investigators on proposals from other institutions include the JPL award fee in their budgets. JPL award fees are paid for and accounted for by a different mechanism than that used to fund awards from ROSES.

(iv) Submission of Proposals via NSPIRES, the NASA Proposal Data System

Proposals may be submitted electronically via NASA's Solicitation and Proposal Integrated Review and Evaluation System (NSPIRES). In order to submit a proposal via NSPIRES, this NRA requires that the proposer register key data concerning the intended submission with NSPIRES at http://nspires.nasaprs.com. Potential applicants are urged to access this site well in advance of the Notice of Intent (NOI) and proposal due dates of interest to familiarize themselves with its structure and enter the requested identifier information. Potential PIs should ensure that their organization is also registered in NSPIRES, as it is only an official from the PI's registered organization, not the PI, who can submit a proposal.

It is especially important to note that every individual named on the proposal's electronic Cover Page form (see below) as a proposing team member in any role, including Co-investigators and collaborators, must be individually registered in NSPIRES and that such individuals must perform this registration themselves; no one may register a second party, even the PI of a proposal in which that person is committed to participate. It is also important to note that every named individual must be identified with the organization through which they are participating in the proposal, regardless of their place of permanent employment or preferred mailing address. This data site is secure and all information entered is strictly for NASA's use only.

Every individual identified on the NSPIRES proposal cover page as a team member must indicate their commitment to the proposed investigation through NSPIRES prior to proposal cover page submission. Team members must additionally confirm the organization through which they are participating on this proposal. A team member will receive an email from NSPIRES indicating that he/she has been added to the proposal and should log in to NSPIRES.

- Once logged in, the team member should follow the link in the "Reminders and Notifications" section of his NSPIRES homepage, titled "Need <role> confirmation for proposal <title> for Solicitation <<solicitation number>>." On the "Team Member Participation Confirmation" page, the proposal team member should read language about the Organizational Relationship, then click the "Continue" button.
- If the contact information then displayed on the "Team Member Profile" screen is out of date, the proposal team member should update this information later using the "Account Mgmt" link in the NSPIRES navigation bar across the top. Prior to making that update, however, the team member should follow the on-screen prompts to identify the organization through which he/she is participating on this proposal. Click the "Link Relationship" button to the right side of the "Organizational Relationship" banner. Select the organization from the "Link Proposal to an Association" part of the page. If the correct organization is not displayed here, try using the "Add Association" button to add the organization to this list. Then click the "Save" button at the bottom of the page. If the team member cannot find the organization when searching in the "Add Association" area (i.e., the organization is not registered), type in the formal name in the space provided (or select "Self," if appropriate). Once the organization is selected and the "Save" button is clicked, there is a confirmation page that allows the team member to edit that relationship if it was chosen incorrectly. Click "Continue".
- Note that the organization through which the proposal team member is participating in the proposal might not be the proposal team member's primary employer or primary mailing address. If the address information is accurate (or once it has been edited to be accurate), the proposal team member may log out of NSPIRES.
- NSPIRES will send an email to both the team member and the PI confirming that the commitment was made and the organization was identified. The PI may additionally monitor the status of proposal team member commitments by examining the "Relationship Confirmed" column on the Team Member page of the NSPIRES proposal cover page record. Note that the proposal cannot be submitted until all identified team members have confirmed their participating organizations.

All proposals submitted via NSPIRES in response to this NRA must include a required electronic Cover Page form that is accessed at http://nspires.nasaprs.com/. This form is composed of several distinct sections: a Cover Page that contains the identifier information for the proposing institution and personnel; a Proposal Summary that provides an overview of the proposed investigation that is suitable for release through a publicly accessible archive should the proposal be selected; Business Data that provides the proposed start and end dates, as well as other proposal characteristics; a Budget form that contains a budget summary of the proposed research effort; Program Specific Data that includes required questions specific to ROSES and that particular program element; and Proposal Team that provides the Co-Investigators and other participants in the proposal. This Cover Page form is available for access and submission well in advance of the proposal due dates given in Tables 2 and 3 of this NRA and remains open until the proposal due date for each program element. Unless specified in the program element description itself, no other forms are required for proposal submission via NSPIRES.

The proposer is responsible for assembling the complete proposal document for peer review. The required elements of any proposal submitted in response to this NRA must be submitted as a single, searchable, unlocked PDF document that contains the complete proposal, including the Science/Technical/Management section and budget justification, assembled in the order provided in Table 1 and uploaded as a single attachment. Unless otherwise specified in the program element the only permitted separate attachments are the HEC request, if any, see Section I(d), and the Total Budget file, see Section IV(b)(iii). Documents such as team member biographical sketches, letters of commitment, and current and pending support, as well as the proposal abstract (proposal summary) should not be uploaded to NSPIRES as separate files.

NSPIRES generates error and warning messages as part of the element check concerning possibly missing data. An error (designated by a red X) will preclude proposal submission to NASA by the AOR. A warning (indicated by a ! on a yellow field) is an indication that data may be missing; a warning can be ignored after verifying that the material is included in the single attachment containing the complete proposal. Any actions taken because of warnings are at the PI's discretion.

In addition, it is unnecessary to download the Proposal Cover Page and incorporate it into the Proposal Document. NSPIRES will automatically route the parts of the proposal (Cover Page form, proposal document, and any HEC appendix, but not the Total Budget file) to the reviewers.

Proposers are encouraged to begin their submission process early. Tutorials and other NSPIRES help topics may be accessed through the NSPIRES online help site at http://nspires.nasaprs.com/external/help.do. For any questions that cannot be resolved with the available online help menus, requests for assistance may be directed by email to nspires-help@nasaprs.com or by telephone to (202) 479-9376, Monday through Friday, 8:00 a.m. – 6:00 p.m. Eastern Time.

(v) Submission of Proposals via Grants.gov

Grants.gov may be used in place of NSPIRES to submit proposals in response to almost all program elements this ROSES NRA. Grants.gov is now using the Workspace environment. Grants.gov requires that the PI use Workspace for either online completion of forms or downloading of forms for completion offline, in addition to downloading an instruction package from Grants.gov. Identifying the appropriate application package requires the funding opportunity number for that program element; the Grants.gov funding opportunity number may be found in the Summary of Key Information table at the end of each program element. That number will be of the form NNH19ZDA001N-XXXX where the "XXXX" will be an abbreviation for that program, e.g., NNH19ZDA001N-HSR for Heliophysics Supporting Research. Proposals submitted via Grants.gov must be submitted by the AOR.

Submitting a proposal via Grants.gov requires the following steps:

- Grant researchers (PIs) do not need to register with Grants.gov. However, every individual named in the proposal as a proposing team member in any role, including PI, Co-Investigators, and collaborators, as well as the PI's organization, must be registered in NSPIRES (http://nspires.nasaprs.com) and such individuals must perform this registration themselves; no one may register a second party, even the PI of a proposal in which that person is committed to participate. This data site is secure and all information entered is strictly for NASA's use only.
- Follow Grants.gov instructions provided at the website to download any software tools or applications required to submit via Grants.gov.
- Preview the application package from Grants.gov for either online completion or downloading for completion offline by selecting "Preview" under "Package" for the specific Funding Opportunity at http://www.grants.gov. Each program element described in an appendix of ROSES requires a different application package and has a different Funding Opportunity Number; the Funding Opportunity Number may be found in the Summary of Key Information at the end of the program element description in each appendix of ROSES. Enter the appropriate Funding Opportunity Number to retrieve the desired application package. All ROSES application packages may be found by searching on CFDA Number 43.001.
- Note that Grants.gov proposers must additionally download the "Instructions" zip file, as this includes a proposal summary form and the Program Specific Data form that contains the mandatory data management plan as well as important questions about, for example, China and ITAR.
- When ready to apply, click "Apply" to create, complete, and submit a Workspace. Completing a workspace allows proposers to complete all the required forms online or download PDF versions to be uploaded later.
- Complete the required Grants.gov forms, including the Standard Form 424 Application for Federal Assistance, research and research-related (R&R) Other Project Information, R&R Senior/Key Person Profile, and R&R Budget. Every named individual must be identified with the organization through which they are participating in the proposal, regardless of their place of permanent employment or preferred mailing address.
- Complete the required NASA specific forms including NASA Other Project Information, NASA PI and Authorized Representative Supplemental Data Sheet, and NASA Senior/Key Person Supplemental Data Sheet (this form is only required if there are Senior/Key Persons other than the PI).
- Complete any NASA program-specific form that is required for the specific program element. This form, which is usually required for all ROSES program element submissions, is included as a PDF form within the proposal instruction package downloaded from Grants.gov. The form, once completed, is attached to the NASA Other Project Information form.
- Create a proposal in PDF, including the Science/Technical/Management section and all other required proposal sections (see the *NASA Guidebook for Proposers*). Attach sections as separate PDF documents as prompted by Grants.gov. Do not duplicate materials; if a document must be provided as a separate attachment, do not also include it as part of the proposal narrative PDF file. Even though Grants.gov

permits the attachment of non-PDF documents, NASA requires that all attached documents be PDF files, which conform to the specifications outlined in Section IV (b)(ii) above.

- Because Grants.gov does not support the electronic commitment of team members, statements of commitment from all team members must be provided as letters attached to the proposal application at the place(s) specified by Grants.gov. This statement must include confirmation of both the team member role in the proposed effort (e.g., Co-Investigator, collaborator) and the identification of the organization through which the team member will be participating.

  Here is an example of a statement of commitment: "I acknowledge that I am identified by name as <<role>> to the investigation, entitled <<name of proposal>>, that is submitted by <<name of Principal Investigator>> to the NASA Research Announcement <<alpha-numeric identifier>>, and that I intend to carry out all responsibilities identified for me in this proposal. I understand that the extent and justification of my participation as stated in this proposal will be considered during peer review in determining in part the merits of this proposal. I have read the entire proposal, including the management plan and budget, and I agree that the proposal correctly describes my commitment to the proposed investigation. For the purposes of conducting work for this investigation, my participating organization is <<insert name of organization>>."
- Submit the proposal via the Authorized Organization Representative (AOR); the PI may not submit the application to Grants.gov unless he/she is an AOR.
- Within a few days of submitting the proposal to Grants.gov, the PI and AOR should receive an email verifying submission of the proposal to the NSPIRES system, for review. Any proposer not receiving such a verification should contact the NSPIRES Help Desk.

Potential applicants are urged to access Grants.gov site well in advance of the proposal due date(s) of interest to familiarize themselves with its structure and download the appropriate application packages and tools.

Potential applicants considering employing Grants.gov should pay special attention to program elements that require a Notice of Intent, as Grants.gov does not provide the capability to submit an NOI. See Section IV(b)vi, below.

Additional instructions for formatting and submitting proposals via Grants.gov may be found in the *NASA Guidebook for Proposers*. Instructions for the use of Grants.gov may be found at https://www.grants.gov/web/grants/applicants/workspace-overview.html. Instructions for NASA-specific forms and NASA program-specific forms may be found in the application instructions package. For any questions that cannot be resolved with the available online help menus and documentation, requests for assistance may be directed by email to support@grants.gov or by telephone to (800) 518-4726 twenty-four hours a day, seven days a week, except Federal holidays when the support center is closed.

(vi) Notice of Intent to Propose

The Notice of Intent (NOI) to propose is a brief summary of the planned work by the prospective PI. Such statements are of used to identify expertise needed for the review panel and to avoid inviting panelists who are planning to propose. Where NOIs are used - most of the program elements in Earth Science (Appendix A) and Astrophysics (Appendix D) - they are usually merely encouraged, but not required, for the submission of proposals. However, for some program elements an NOI is not requested e.g., Neil Gehrels Swift, Fermi and TESS Guest Investigator programs and those with rolling submissions such as Rapid Response and Novel Research in Earth Science, and Topical Workshops, Symposia, and Conferences. For other programs, e.g., A.30 AITT, D.3 APRA, and D.7 SAT, an NOI is a required prerequisite for submission of a full proposal. For those program elements where the NOI is mandatory that will be stated clearly in the program element and NOI due dates will be marked "mandatory" in the Tables of due dates. NOIs may be submitted via NSPIRES directly by the PI by 11:59 p.m. Eastern Time on the due date given in Tables 2 and 3 of this NRA; no action by an organization's AOR is required to submit an NOI.

Grants.gov does not provide NOI capability; therefore, when required (or requested) by a program element, NOIs must (or should) be submitted via NSPIRES, whether or not the proposal will be submitted via NSPIRES or Grants.gov. Interested proposers must register with NSPIRES before it can be accessed for use. NSPIRES is open for the submission of NOIs for typically 30 days, starting about 90 days in advance of the due date for the proposals themselves. When NOIs are merely invited and not required, late NOIs may be submitted by email to the main point of contact given in the Summary Table of Key Information at the end of the individual program element.

(vii) The Two-Step Proposal Process

Some ROSES program elements require that proposals be submitted using a two-step process in which the NOI is replaced by a required Step-1 proposal. This Step-1 proposal is an abbreviated presentation of the intended research and, as a proposal, it must be submitted by the Step-1 due date given in Tables 2 and 3 of this NRA by the organization Authorized Organizational Representative (AOR). The Step-1 proposal is a prerequisite for submission of a full Step-2 proposal, but it does not obligate the offerors to submit a Step-2 (full) proposal later.

For some program elements, the purpose of the Step-1 proposal is simply to avoid conflicts in the assembly of the review panel and no response will be provided to proposers. For other program elements, the Step-1 proposal may be evaluated to determine if the anticipated research project exhibits sufficient programmatic relevance and responsiveness to the program element to permit or encourage submission of a full Step-2 proposal. The two-step process can be structured in two ways: 1) Nonbinding two-step process in which a Step-2 proposal may be submitted even if the preceding Step-1 was discouraged or 2) A binding two-step process in which a Step-2 proposal cannot be submitted if it is not "invited" after the evaluation of the preceding Step-1. In any case those who submitted Step-1 proposals will be informed no later than four weeks prior to the Step-2 due date whether they are, or are not, "encouraged" or "invited" to submit a full Step-2 proposal.

The required Step-1 proposal is typically just the contents of the 4000-character limited Proposal Summary field in the cover pages but rarely (e.g., A.2 LCLUC) may require a PDF document upload. In such cases the permitted page length and required contents for the Step-1 proposal will be specified in the program element description. In some cases (e.g., Appendix C, Planetary Science), the team may be adjusted between the Step-1 and Step-2 proposal, but in other cases (e.g., Appendix B, Heliophysics), changes to the team are limited. When a Step-2 proposal is created the team members and their confirmation are carried forward from the Step-1 automatically. However, if a Step-1 team member has changed organizations since confirmation on the Step-1 proposals, this could prevent the submission of the Step-2 proposal. When a confirmed Step-1 team member has changed organizations, the proposer must instruct the team member to update his or her participation confirmation in NSPIRES for the Step-2 proposal and inform the NASA POC immediately.

Please read the program element carefully. Budget data will not be requested as part of the Step-1 proposal. Unlike a Notice of Intent, which may be submitted by an individual, the Step-1 proposal must be submitted by an Authorized Organizational Representative of the proposing organization. Step-2 proposals are to be submitted in full compliance with the *NASA Guidebook for Proposers* discussed in Section IV(a) above. Proposers are encouraged to read the instructions document on Submitting Step-1 proposals that appears under "Other Documents" on the NSPIRES web page of any program element that requires a Step-1 proposal.

At the time of release of this ROSES-2019 NRA, the program elements that solicit proposals using a two-step process include: A few program elements in Earth Science (Appendix A) e.g., A.2 LCLUC, most of the Heliophysics program elements (Appendix B), most program elements in Planetary Science (Appendix C), and the cross-division program elements E.3 Exoplanets Research and E.4 Habitable Worlds.

(viii) The Two-Phase Proposal Process

On occasion, NASA will solicit proposals using a two-phase proposal process for which Phase-1 is a request for an observation to be performed by a NASA space observatory as part of a NASA guest investigator/guest observer program element. Phase-2 is a proposal only for funding from NASA that is not peer reviewed. As such the Phase-2 proposals are not subject to the requirements in Section IV(b)iii to omit salary, fringe and overhead. An NOI may or may not be requested, and the Phase-1 observing request must be submitted to the observatory web page by the proposal due date in Tables 2 and 3 of this NRA. Note the time and mode of proposal submission.

This ROSES NRA contains a number of guest investigator/guest observer program elements in Astrophysics that use the two-phase proposal process: Neil Gehrels Swift Observatory Guest Investigator (D.5), Fermi Guest Investigator (D.6), NuSTAR Guest Observer (D.9), the TESS Guest Investigator Program (D.10), and NICER Guest Observer (D.11).

Phase-1 observing requests for these programs cannot be submitted via either NSPIRES or Grants.gov. They must be submitted via the URL given in the Summary Table of Key Information given at the end of program element description. The Phase-2 proposal for funding must be submitted via NSPIRES by a proposal due date that will be announced when NASA announces the disposition of the Phase-1 observing requests. The process and requirements for the submission of Phase-1 observing requests and Phase-2 proposals may differ for each program element; proposers should read carefully the relevant program element Appendix to this ROSES NRA.

(c) Proposal Submission Due Dates and Deadlines

For each program element, the electronic proposal must be submitted in its entirety by an Authorized Organizational Representative (AOR) no later than the proposal deadline on the appropriate proposal due date given in Tables 2 and 3 of this NRA. Unless stated otherwise in the program element (e.g., Phase-1 proposals in Astrophysics), the proposal deadline is 11:59 p.m. Eastern Time and must be submitted electronically using either NSPIRES or Grants.gov (see Sections IV(b)(i–iii) above).

Proposals (including Step-1 proposals) submitted after the proposal due date and deadline will be labeled "late" by the NSPIRES system and they (and mandatory NOIs) will be handled in accordance with the SMD Policy on Late Proposals. The vast majority of proposals received after the due date are rejected without review. If a late proposal is rejected, it is entirely at the discretion of the proposer whether or not to resubmit it in response to a subsequent appropriate solicitation.

(d) Proposal Funding Restrictions

In addition to the funding restrictions and requirements given in the *NASA Guidebook for Proposers* and the *NASA GCAM*, the following restrictions are applicable to this ROSES NRA.

- The estimated funding and number of proposals anticipated to be funded, as shown in the Summary of Key Information at the end of each program element, are subject to the availability of appropriated funds, as well as the submission of a sufficient number of proposals of adequate merit.
- Unless specifically noted otherwise in the specific ROSES Appendix and/or program element, the proposing PI organization must subaward the funding of all proposed Co-Is who reside at other non-Government organizations, even though this may result in a higher proposal cost because of subawarding fees. Potential exceptions to this rule include, but are not limited to, the awards that stem from the Suborbital-Class Platforms (see Section V). Other rare exceptions will be considered on a case by case basis when requested in the proposal and found to be in the interest of the Government and consistent with appropriate law, regulation, policy, and practice.
- Unless otherwise noted in a program element, SMD will send funds directly to Co-Is at NASA Centers and other U.S. Government organizations, including JPL. Thus, if a proposal submitted by a university has a Government Co-I, the funds will not pass through the university, so the university (or other institution that receives a grant) should not include overhead or any other pass through charges on those funds. Funds for Co-Is who do not work for the Government would pass through the university and those charges may be applied. Regardless of whether a Co-I will be funded through a subaward via the proposing institution or funded directly by NASA, the cover page budget for the proposal must include all funding requested from

NASA for the proposed investigation, including salaries for NASA civil servants, see Section IV(b)iii. Time for Co-Is, costs of procurements (not labor or overhead), and other (non-salary) direct costs (e.g. technical support costs for on-site contractors) at NASA Centers and other U.S. Government organizations must be justified in the proposal's Budget Narrative. No indirect burden from non-governmental organizations should be applied to funds for Co-Is at NASA Centers and other U.S. Government organizations. (See the *NASA Guidebook for Proposers*).

- For most awards (e.g., non-contract awards), allowable costs are governed by 2 CFR Part 200. All proposed costs, including matching or cost sharing, must be allowable, allocable, and reasonable. Funds may only be used for the project. Unless otherwise directed in 2 CFR 200, for changes to the negotiated indirect cost rate that occur throughout the project period, you must apply the rate negotiated for that year, whether higher or lower than at the time of the initial award. All activities charged under indirect costs must be allowed under the cost principles in 2 CFR Part 200. In general, the construction of facilities is not an allowed activity for any of the program elements solicited in this NRA. As described in the GCAM Section 4 (Limitations), facilities are different and distinct from equipment, which may be an allowable expense.
- **Computers are allowable under grants if they are essential for the project. It is no longer required that computers be used exclusively for the project. See ROSES FAQ #27 for more information on this topic. [Added July 9, 2019]**
- Travel, including foreign travel, is allowed as may be necessary for the meaningful completion of the proposed investigation, as well as for publicizing its results at appropriate professional meetings. Proposers from NASA Centers should consult the latest NASA policy document regarding restrictions on travel funding. Note that selection of a proposal and approval of a proposed budget that includes travel for civil servants does not guarantee that a NASA Center has sufficient travel authority to approve the proposed travel under NASA's reduced travel budget.
- In general, proposals for sponsorship of topical conferences, workshops, consortia, or symposia meeting certain criteria are solicited through the ROSES program element E.2 Topical Workshops, Symposia, and Conferences.
- Regardless of whether a conference is sponsored by NASA, individual conference travel by grantees is permitted and proposers from universities, or other eligible non-governmental institutions, may include a budget for travel to conferences and workshops. Proposers from NASA Centers should consult their Center implementing policy on the latest NASA guidance on conference spending and reporting requirements. Note that selection of a proposal and approval of a proposed budget that includes travel for civil servant does not guarantee that a NASA Center has sufficient travel authority under NASA's reduced travel budget to approve the proposed travel.
- Profit for commercial organizations is not allowable under grant or cooperative agreement awards, but is allowable under contract awards. Costs for managing the project may be allowed under a grant. These costs, whether direct charges or part of the indirect cost agreement, must be consistent with 2 CFR 200 Subpart E.

- NASA funding may not be used for subcontracted foreign research efforts. U.S. research award recipients may directly purchase supplies and/or services from non-U.S. sources that do not constitute research, but award funds may not be used to fund research carried out by non-U.S. organizations. However, a foreign national may receive remuneration through a NASA award for the conduct of research while employed either full- or part-time by a U.S. organization. Special restrictions apply to collaboration with China, see Section III(c).
- Travel by a participant in the research investigation, whether for the purpose of conducting the research, for collaboration, or for attending a conference, is considered to be a research expense. NASA conducts its collaborations with foreign institutions on a no exchange of funds basis. NASA funding may not be used for research efforts by foreign organizations at any level. Therefore, NASA funding may not be used for travel expenses by any team member who is not participating as a member of a U.S. organization.
- As noted in the *NASA Guidebook for Proposers*, costs of preparing, publishing, and disseminating the results of NASA funded research (e.g., page charges, open access fees, etc.) may be included in research proposals and are allowable charges against the grant, as long as the charges are levied impartially on all research papers published by the journal.
- Non-NASA U.S. Government organizations should propose based on full-cost accounting, unless no such standards are in effect; in that case such proposers should follow the Managerial Cost Accounting Standards for the Federal Government as recommended by the Federal Accounting Standards Advisory Board. NSPIRES cover pages and uploaded "Total" budgets must include all costs that will be paid out of the resulting award.
- Regardless of whether functioning as a team lead or as a team member, personnel from NASA Centers must propose budgets consistent with the current NASA accounting implementation for the requested year of performance. All NSPIRES cover page budgets must include all costs that will be paid out of the resulting award, including costs of NASA civil servants. Costs that will not be paid out of the resulting award, but are paid from a separate NASA budget (e.g., center management and overhead; CM&O) and are not based on the success of this specific proposal, should not be included in the proposal budget. For example, CM&O should not be included in the proposal budget while other direct charges (including procurements and labor) to the proposed research task should be included. NASA civil servant Co-Is must provide to the proposing organization all costs requested of the ROSES program, so that the proposing organization may correctly complete the cover page budgets in NSPIRES.

V. SUBORBITAL-CLASS INVESTIGATIONS

(a) Overview of Suborbital-Class Platforms

In each SMD Research Program (Earth Science, Heliophysics, Planetary Science, Astrophysics), flight investigations are solicited. Flight investigations solicited through ROSES generally have modest costs and reduced mission assurance requirements appropriate for the specific research program, and these investigations are referred to as suborbital-class investigations. Platforms for flight investigations include aircraft, balloons, sounding rockets, suborbital reusable launch vehicles, CubeSats, and small International Space Station (ISS) payloads. General requirements for proposals to use any of these platforms (except aircraft, see below) are discussed in this section of ROSES.

Requirements for proposals using aircraft are discussed in the description of the Earth Science Research Program found in Appendix A. Moreover, the Aircraft Management Division (AMD https://ad.hq.nasa.gov/) provides capability leadership, oversight, and coordination of NASA's aviation assets, including Unmanned Aircraft Systems (UAS). AMD coordinates functional reviews to ensure high standards of aviation safety and manages NASA's aircraft capability based on mission requirements. Proposals that include flight activities (not normal passenger travel) such as aircraft or helicopter flight services, including Unmanned Aircraft Systems (UAS)/Drones operations or the acquisition or construction of such flight vehicles, must comply with NASA Policy Directive 7900.4. Questions concerning flight compliance requirements may be addressed to Norman Schweizer at norman.s.schweizer@nasa.gov.

Generally, proposals for investigations that are carried out through development, launch, and operation of a short duration orbital experiment, such as one on a CubeSat or ISS-based project, are permitted in any ROSES program element that solicits investigations for use on suborbital-class platforms. In this sense, a CubeSat or an ISS-based investigation is a "suborbital class" investigation, even though it will be placed into orbit. CubeSat or ISS-based "suborbital class" investigations are subject to the same cost constraints to which traditional suborbital investigations are subject.

Proposals for life and microgravity science investigations are not solicited through ROSES. Life and microgravity science investigations are solicited by the Human Exploration and Operations Mission Directorate. For further information, refer to the current "ROSBio" solicitation on NSPIRES.

(b) Points of Contact for Suborbital-Class Platforms

NASA provides some limited avenues for procurement of suborbital launch vehicle services, including: sounding rockets provided by the NASA Sounding Rockets Program Office (SRPO) at the NASA Goddard Space Flight Center/Wallops Flight Facility (NASA/GSFC/WFF), balloons provided by the NASA Balloon Program Office (BPO) at the NASA/GSFC/WFF, and suborbital reusable launch vehicle (sRLV) services provided by the NASA Space Technology Mission Directorate's (STMD) Flight Opportunities Program (FOP). SMD also solicits investigations as CubeSats and as small International Space Station payloads. Regardless of which launch vehicle service is anticipated, all prospective PIs are required to demonstrate the capacity, availability, and commitment of the suborbital-class platform to support their investigation. PIs are strongly urged to discuss prospective investigations with NASA program personnel (see below) prior to submitting their proposal to ensure that probable operational costs are properly anticipated.

(i) NASA-provided Sounding Rocket Services

Information on the capabilities of currently available sounding rocket vehicles is available at http://sites.wff.nasa.gov/code810/vehicles.html. Proposers are encouraged to consider these capabilities in designing their investigations, but the Sounding Rockets Program Office (SRPO) has the final authority in the choice of which vehicle is to be used.

The nominal U.S. launch sites for sounding rockets are White Sands Missile Range (WSMR) in New Mexico, Wallops Island in Virginia, Poker Flat Rocket Range (PFRR) in Alaska, and Reagan Test Site (RTS) in the Kwajalein Atoll. The SRPO also conducts launches from the established non-U.S. launch sites at Andoya, Norway; Kiruna, Sweden (Esrange); or Australia; subject to science community requirements and the availability of SRPO operations funding to conduct the campaign.

Investigators proposing payloads to be flown on sounding rockets should answer the program-specific questions on the NSPIRES proposal cover pages. This information is needed by the SRPO to generate a rough order of magnitude cost estimate for the operational requirements associated with a proposed investigation and is used for planning purposes. The required information includes the envisioned vehicle type, payload mass, trajectory requirements, launch site, telemetry requirements, attitude control, or pointing requirements, and any plans for payload recovery and reuse. Investigators proposing sounding rocket payloads should contact the SRPO to obtain technical information related to SRPO launch vehicle capabilities, services, and the latest planned campaign schedules. Questions concerning sounding rockets may be addressed to:

Giovanni Rosanova
Sounding Rockets Program Office
Code 810
GSFC/Wallops Flight Facility
National Aeronautics and Space Administration
Wallops Island, VA 23337
Telephone: (757) 824-1916 or (757) 824-2202
Email: giovanni.rosanova@nasa.gov

(ii) NASA-provided Balloon Services

Information on the capabilities of current available balloon vehicles is available at http://sites.wff.nasa.gov/code820/operations.html and at http://www.csbf.nasa.gov/balloons.html. Proposers are encouraged to consider these capabilities in designing their investigations, but the Balloon Program Office (BPO) has the final authority in the choice of which vehicles to be used.

The nominal U.S. launch sites for Balloons are Fort Sumner, New Mexico, and at the Columbia Scientific Balloon Facility in Palestine, Texas. The BPO also conducts launches from established non-U.S. launch sites at McMurdo, Antarctica; Alice Springs, Australia; Kiruna, Sweden (Esrange); or Wanaka, New Zealand, subject to science community requirements and the availability of BPO operations funding to conduct the campaign.

Proposers needing investigation unique engineering, flight support systems, and/or technical support services from NASA, such as the Wallops Arc-Second Pointing System (WASP), should contact the BPO directly for an estimate of the Government Furnished Equipment (GFE) cost of the desired support.

Investigators proposing balloon payloads should contact the BPO to obtain technical information related to BPO balloon capabilities, services, and the latest planned campaign schedules.

Questions concerning balloons may be addressed to:

Debora Fairbrother
Balloon Program Office
Code 820, GSFC/Wallops Flight Facility
National Aeronautics and Space Administration
Wallops Island, VA 23337
Telephone: (757) 824-1453
Email: debora.a.fairbrother@nasa.gov

(iii) Suborbital Reusable Launch Vehicles **[POC updated July 9, 2019]**

Suborbital Reusable Launch Vehicles (sRLV) offer newly developed commercial capabilities for the conduct of NASA scientific research and technology advancement.

Proposals to ROSES program elements using sRLVs as platforms must be for complete investigations and must describe a complete suborbital science investigation, including payload construction, vehicle integration, launch and flight operations, data analysis, and publication of results. Proposers interested in using sRLVs as platforms to conduct an Earth or space science investigation must identify a vehicle that can provide the technical capabilities that are required to conduct the proposed investigation.

Proposals using sRLVs as platforms must specify the technical requirements that their investigation places on the vehicle. Proposals for investigations using sRLVs as platforms must provide a description of the instrument; its current status; a clear assessment of what it will take to develop, modify, and integrate the instrument onto the sRLV; and include a plan to provide calibrated, research grade data.

SMD will conduct an sRLV continuing investigation review (CIR) for all sRLV-based projects. The CIR will take place following maturity of the sRLV-based project to the equivalent of a Phase A concept study report or a systems requirement review. A proposal for a sRLV-based project must describe the proposed schedule for CIR and the proposed funding required to reach CIR.

The CIR will include payload description, flight performance assessment, proposed payload configuration and interfaces, mission success criteria, requirements matrix, operational requirements, launch vehicle, and project schedule. Once the sRLV-based project reaches that level of design maturity, the CIR will be held at NASA Headquarters. The SMD Associate Administrator (or designee) is the decision authority for approval to proceed beyond the CIR. It is expected that sRLV-based projects will spend no more than approximately $100K prior to CIR approval.

Proposals for sRLV-based investigations must be submitted to the appropriate ROSES program element, depending on the science to be addressed by the proposed investigation. The proposed sRLV-based investigation must meet the constraints of the program element to which it is being proposed. This explicitly includes any constraints on the areas of science that are solicited, on the available funding, and on the requirement for a complete science investigation.

In addition to the normal evaluation factors specified in Section VI(a) and the *NASA Guidebook for Proposers*, evaluation of the intrinsic merit of sRLV-based proposals shall include the following additional factors:

- The extent that the proposed sRLV offers an advantage (e.g., scientific, technical, or cost) over other suborbital-class platforms (including sounding rockets, balloons, and aircraft);
- The likelihood that the proposed vehicle will be available at the proposed time for flight and that it will be capable of providing the required technical capabilities;
- The feasibility of the proposed technical investigation, including the concept for conduct of the experiment during the suborbital flight and the plans for calibrating and analyzing the data obtained to accomplish the proposed science objectives; and
- The quality of the plans for completing the preliminary design prior to the investigation confirmation review.

The cost to SMD for the flight and all other services provided by the sRLV vendor must be clearly stated in the proposal and included the NSPIRES cover page budget (in Section F, line 10 labeled appropriately) and also the separately uploaded "Total Budget" PDF. See Section IV(b)iii for information about the requirements for the separately uploaded "Total Budget" PDF.

In addition to the factors specified in the *Guidebook*, the evaluation of cost reasonableness of a proposal shall include:

- The affordability to SMD of the proposed vehicle vendor cost for the flight and other required services.

Proposers from Government Laboratories and NASA Centers (including JPL), but not others, may avail themselves of STMD's Flight Opportunities Program (FOP) contracts to sRLV flight service providers. Information on sRLV vehicles, including general vehicle capabilities and contact information for some vendors, is available at https://www.nasa.gov/directorates/spacetech/flightopportunities/flightproviders. Until NASA establishes a policy to sponsor spaceflight participants onboard sRLVs, the FOP will not sponsor participants to fly on commercial balloon or suborbital reusable launch vehicles. The payloads to be flown on FOP-contracted sRLV flights must either be automated or remotely operated. The remote operation capability should be confirmed with the flight operator. For payloads to be flown on FOP contracted sRLV flights, the flight and all other services provided by the sRLV vendor will be procured directly by the FOP rather than through the award. FOP does not currently have a contract to provide parabolic flight.

Investigators proposing FOP-contracted sRLV flight service payloads are strongly urged to discuss prospective investigations with operations personnel in the Flight Opportunities Program and/or a potential vendor to ensure that probable integration, safety and mission assurance, and operational costs are properly anticipated.

Proposals from non-governmental organizations, and government proposers who are not planning to use STMD's Flight Opportunities Program (FOP) contracts to sRLV flight service providers, must include a Letter of Endorsement from a commercial vendor that (i) describes how that vendor's vehicle will meet the investigation requirements and provides technical information on how the vehicle will meet the investigation requirements, (ii) states that the vehicle will be available for use at the time proposed for flight and provides information showing a plan for getting from the current vehicle status to flight status, and (iii) provides a quoted cost for the flight and all other services that are required from the vehicle vendor to enable and conduct the proposed investigation.

Questions concerning potential sRLV investigations may be addressed to:

Paul De León [updated July 9, 2019]
Flight Opportunities Campaign Manager
Mail Stop 213-13
NASA Ames Research Center
Moffett Field, CA 94035
(650) 604-0275
paul.deleon@nasa.gov

(iv) Research Investigations utilizing the International Space Station **[Updated March 19, 2019]**

NASA has determined that there may be payload opportunities for small, suborbital-class space and Earth science research investigations, including both science and technology development, that utilize the International Space Station (ISS). Available external attach points include both zenith and nadir pointing locations and internal attach points include nadir pointing locations. NASA has available ~~annual~~ **regular** external launch opportunities ~~after 2019 on the Japanese HTV launch vehicle and the SpaceX vehicle. NASA also has regular opportunities on a suite of vehicles~~ **and opportunities** to launch pressurized **(internal)** cargo for use in the Window Observational Research Facility (WORF). Information on opportunities and constraints for ISS attached payloads may be found at http://www.nasa.gov/mission_pages/station/research/research_information.html.

Proposals seeking use of the ISS must take advantage of the Station's unique capabilities. Proposals must include a clear and convincing scientific and/or technical argument that use of the ISS is required to produce the needed results in ways that could not be accomplished through the use of other platforms. Investigations that make use of the ISS may be proposed for periods of performance of up to five years.

Proposers interested in using the ISS to conduct an Earth or space science investigation must identify a specific accommodation location that can provide the technical capabilities required to conduct the proposed investigation. The proposal must include a letter of feasibility from the ~~NASA Space Station Payload~~ **ISS Research**

Integration Office, which can take weeks. This letter of feasibility must contain: (1) a preliminary assessment of the feasibility **of the proposed concept and requirements** ~~for proposed provisions~~ for access to and accommodation on the Space Station, (2) identification of any significant challenges or conditional provisions for access and accommodation, and (3) a description of the level of technical interchange or negotiation required to mature the proposed **concept** ~~provisions~~ for access and accommodation **on ISS**. Transportation and accommodation will be provided by NASA at no cost to the proposed research investigation, and costs for transportation to and accommodation on the ISS should not be included in the proposed budget. However, the PI's cost for all accommodation, safety, and other reviews that are conducted and supported by the PI must be included in the PI's proposed investigation budget.

In addition to proposal requirements specified in the appropriate ROSES program element, proposals for investigations utilizing the ISS must provide a description of the instrument; its current status; a clear assessment of what it will take to develop, modify, and integrate the instrument onto the ISS; and include a plan to provide calibrated, research grade data in SI traceable units. Proposals must be for complete investigations that include payload **development,** construction, ISS integration, launch and flight operations, data analysis, and publication of results.

The ISS ~~Customer~~ **Research** Integration Office will provide integration services, launch services, on-orbit operations and services, as well as safety and mission assurance reviews for all ISS investigations.

There is no one due date for Investigations for the ISS, rather proposals must be submitted to the appropriate ROSES program element depending upon the science addressed by the proposed investigation. The proposed investigation must meet the constraints of the program element to which it is being proposed. This explicitly includes any constraints on the areas of science that are solicited, on the available funding, and on the requirement for a complete science investigation.

Investigations proposed for the ISS will be approved for the first year only. During the first year, in addition to beginning the proposed investigation, a detailed transportation and accommodation study will be undertaken with the ISS ~~Customer~~ **Research** Integration Office. Approval for continued funding beyond the first year will be contingent on the ISS Program making a firm commitment for transportation and accommodation on the ISS that is compatible with the requirements of the proposed investigation.

All proposals will be evaluated with respect to the criteria specified in the *NASA Guidebook for Proposers*. In addition to the factors specified in the *Guidebook*, the intrinsic merit of a proposal shall include the following additional factors:

- The extent that the advantages (e.g., scientific, technical, or cost) of the International Space Station's capabilities and location will be utilized; and
- The feasibility of the proposed technical investigation, including the **on-orbit operations** concept ~~for conduct of the experiment during the flight~~ and the plans for calibrating and analyzing the data obtained to accomplish the proposed science objectives.

External accommodations for payloads include Express Logistics Carriers (ELCs) ~~mounted to the ISS truss structure~~, the Japanese Experiment Module-Exposed Facility (JEM-EF), and the Columbus Orbiting Facility-Exposed Facility (COF-EF). Internal accommodations are also available in the pressurized environment via the Window Observational Research Facility (WORF). More detailed information can be found at www.nasa.gov/stationfacilities.

Attached payloads must be certified for transportation and use in a human tended vehicle. External payloads would be required to complete preliminary design review (PDR) approximately 36 months before launch, critical design review (CDR) approximately 24 months before launch, and be delivered for certification and integration approximately nine months before launch. Pressurized cargo for the WORF would be required to complete PDR approximately 12 months before launch, CDR approximately nine months before launch, and be delivered for certification and integration approximately four months before launch.

Investigators proposing ISS payloads are **required to contact the ISS Research Integration Office to begin the technical discussion needed in order to start the ISS technical requirements interface and resource utilization feasibility and accommodation assessment. Only after such feasibility assessment is performed by the ISS Research Integration Office that a signed feasibility letter will be issued to the investigator. The signed ISS feasibility letter must be submitted with any proposal requesting the use of ISS as a science platform to perform any experiment.** ~~strongly urged to discuss International Space Station payload constraints, launch opportunities, and other technical matters with the ISS Research Integration Office~~.

For further information, please contact:

George Nelson
ISS Research Integration Office/OZ
Johnson Space Center
National Aeronautics and Space Administration
Houston, TX 77058
Telephone: (281) 244-8514
Email: George.Nelson-1@nasa.gov

(v) Use of Short Duration Orbital Platforms, including CubeSats

Short duration orbital platforms, such as CubeSats (built in increments of 10-centimeter cubes), have historically been used as teaching tools and technology demonstrations, and now may offer newly developed capabilities for the conduct of NASA scientific research and technology advancement. CubeSats may be built as a single unit (1U), weighing less than 1.33 kg, or combined in units of two, three, six (2x1x3 form factor) and, where allowed (e.g., D.3 APRA), twelve (2x2x3 form factor). Proposers contemplating six or twelve U are strongly encouraged to communicate with the point of contact for the ROSES program element to which they plan to propose to verify that those are solicited and that the costs can be accommodated.

Proposals for science investigations utilizing short duration orbital platforms, such as CubeSats, must be for complete investigations, and must describe a complete science investigation, including CubeSat construction, payload integration and test, launch vehicle integration, communications, mission operations, data analysis, and publication of results.

The CubeSat Launch Initiative (CSLI) program regularly provides launch opportunities for small satellites to fly as secondary (auxiliary) payloads on launch vehicles planned for upcoming U.S. Government missions. Under the CSLI process, an Agency-wide selection recommendation committee considers candidate CubeSats for selection from among those proposed from organizations both internal and external to NASA. At an appropriate time after selection, SMD will provide direction for being considered for manifest on a launch vehicle going to an appropriate orbit.

CubeSats are typically launched as secondary payloads to low-Earth orbit or from the International Space Station. Further, additional commercial opportunities to leave Earth orbit as a secondary payload may arise on future mission launches. Information on the EM-1 stand-alone CubeSat opportunity, can be found by contacting the CubeSat points of contact listed below.

For more information about the CSLI, including previously-selected respondents, see http://www.nasa.gov/directorates/heo/home/CubeSats_initiative.html. For more resources specifically for CubeSat and SmallSats proposers, please see https://www.nasa.gov/smallsat-institute.

As a result of their secondary status, CubeSats are placed into orbits that are dictated by the primary. Therefore, in any given year a finite number of specific orbits (e.g., inclinations and altitudes) will be available for CubeSats, and the types of orbits available will vary from year to year. Thus, CubeSat-based missions requiring very specific orbital parameters may be at a disadvantage for securing a timely launch. Proposals should include the CubeSat Mission Parameters Table (below) and clearly

CubeSat Mission Parameters								
Mission Name	Mass	Cube Size	Desired Orbit		Acceptable Orbit Range	400 km @ 51.6 degree incl. Acceptable – Yes or No	Ready Date	Desired Mission Life
			Altitude					
			Inclination					

indicate both the required and the acceptable range of orbital parameters needed to meet mission objectives. NASA's CubeSats are deployed from the ISS via NanoRacks or from an expendable launch vehicle via a dispenser on contract at the time of manifesting. CubeSats must be compliant with Launch Services Program, Program Level Dispenser and CubeSat Requirements Document (LSP-Req-317.01) and the Compliance and Reference Documents referenced therein. That document may be found at: http://www.nasa.gov/pdf/627972main_LSP-REQ-317_01A.pdf

Investigators proposing CubeSats in response to this solicitation are expected to comply with the requirements of NASA Procedural Requirement (NPR) 7120.8, NASA

Research and Technology Program and Project Management Requirements, and should appropriately tailor these requirements, depending on the project size, complexity, and scope.

Proposals for CubeSat investigations should note the following:

- The cost of launch for a single, ≤ 3U, spacecraft to Low Earth Orbit (LEO) will be covered under the NASA/HEOMD CubeSat Launch Initiative (CSLI) at no cost to the investigation. For this standard case proposers should merely mention (e.g., in the budget justification) that only the standard CSLI-provided launch services are needed and proposers should not include such launch service charges in the budgets of a ROSES proposal.
- Proposals to go beyond LEO, utilize more than one spacecraft, or involve a CubeSat >3U must contact CSLI representatives (see below) to obtain a cost estimate. Proposals shall state explicitly in the budget justification that there are additional costs for launch within the proposed budget, and give those costs in the NSPIRES cover page budget and the separately uploaded Total Budget file. However, such CSLI quoted launch services costs are not in the hands of the proposing organization and overhead must not be charged on those costs.
- The proposed CubeSat investigation must meet the constraints of the program element to which it is being proposed. This explicitly includes any constraints on the areas of science that are solicited, on the available funding, and on the requirement for a complete science investigation.
- Proposals will be evaluated with respect to the criteria specified in the *NASA Guidebook for Proposers*. In addition to the factors specified in the *Guidebook*, the proposal will be evaluated against any additional factors called out in the program element to which it is being proposed.
- Proposals for investigations using CubeSats must satisfy the constraints for a standard CubeSat and the NASA CubeSat deployer.
- Please note that there isn't a 12U deployer on ISS.
- Proposals must specify any constraints placed on the required orbit and orbital lifetime. The likely availability of NASA launches satisfying any constraints in the time period contemplated will be a consideration for the ROSES evaluation. The less stringent the orbital constraints, the more probable it will be that NASA can manifest the CubeSat investigation for launch.
- Proposals must demonstrate knowledge of the requirements for limiting orbital debris and must address how the mission will meet the requirements of NPR 8715.6 for Limiting Orbital Debris.
- Proposals must address the approach to downlink and uplink communications licensing, frequency band selection, and frequency coordination for operations between space and ground within the RF spectrum.
- All costs for preparing, testing, and delivering the CubeSat for launch must be included in the proposal. Launch service charges should be included in the proposal cost request only if they exceed the normal CSLI-provided launch services, as described above.

- Proposals for short duration orbital experiments other than CubeSats must include provisions for access to space as part of the proposal.

Investigators proposing CubeSats are strongly urged to discuss prospective investigations with personnel listed below regarding constraints, launch opportunities, and other technical matters.

For further information on SMD CubeSats, please contact:

Florence Tan
Phone: (202) 358-0058
Email: florence.w.tan@nasa.gov

For further information on CSLI, please contact:
Anne E Sweet,
Launch Services Program Executive,
Phone: 202-358-3784,
Email: anne.sweet-1@nasa.gov

(c) General Guidelines for Suborbital-Class Investigation Proposals

ROSES awards support science investigations and/or technology development utilizing payloads flown on suborbital-class platforms, or as flights of opportunity. Suborbital-class payloads may be recovered, refurbished, and reflown, in order to complete an investigation. A discussion of the plans for management and for reduction and analysis of the data must be given in the proposal. Although most awards are three or four years in duration, a five-year proposal may be accepted to develop a completely new, highly meritorious investigation through its first flight. Please read the individual ROSES program element for program specific requirements.

Budgets are expected to cover complete investigations, including payload development and construction, instrument calibration, launch, data analysis, and publication of results. The number of investigations that can be supported is limited and heavily dependent on the funds available to the relevant research program. Note that NASA does not carry reserves to accommodate any cost overrun incurred by a particular investigation, including the damage and/or loss of the payload owing to a suborbital-class platform system failure. Therefore, failure to achieve the proposed goals within the proposed time and budget could require descoping the initially proposed investigation, delaying it, canceling a particular launch date opportunity, or canceling the investigation altogether. Unlike most other ROSES investigations where the proposing PI organization must subcontract funding to non-Government investigators, funding for suborbital-class investigations will sometimes be split into multiple awards. Please read the individual ROSES Appendix and consult with the POC.

VI. Proposal Review Information

(a) Evaluation Criteria

As stated in the *NASA Guidebook for Proposers*, proposals are ordinarily evaluated on three criteria: intrinsic merit, relevance, and cost. A ROSES proposal that is not relevant is not selectable, no matter what the scores for Merit or Cost, or mean or median of all three criteria scores. Indeed, SMD may return without peer review a proposal deemed to be not relevant. The manner in which SMD evaluates ROSES proposals for relevance, and cost varies from program to program. ROSES proposals may be scored by peer reviewers for all three criteria on a full scale, or the proposal may be scored on a full scale only for merit, with relevance and/or cost evaluated on an abridged scale, or with only comments provided for relevance and/or cost, or the peer review panel may not be asked to comment on relevance and cost at all.

Note the following specific points:

- Some of the program elements discussed in Appendices A through E will give specific factors, based on the solicited research objectives, which will be considered when evaluating a proposal's science and/or technical merits and/or its relevance to program objectives.
- Unless otherwise stated, relevance will be judged by whether the proposal addresses goals and objectives for that ROSES Appendix and/or specific program element, rather than NASA's broader goals. Unless otherwise stated in the program element, relevance of the proposed work is judged based on whether the work proposed is deemed to be relevant, independent of whether or not it includes an overt, clear and direct statement of relevance. That is, unless otherwise stated in the program element, no proposal will be returned as noncompliant for lack of a relevance section or statement, and inclusion of a relevance section or statement is no guarantee that the proposal will be judged relevant. Please read the program elements carefully. See also Section I(h).
- Cost data for U.S. proposals may be evaluated by peer review (for reasonableness) and by NASA program personnel (vs. the available budget). Proposers must follow the budget requirements in Section IV(b)iii and Table 1 of this document. When evaluating the cost reasonableness of the proposals, reviewers will assess whether the proposed level of effort (i.e., labor FTEs) and the proposed other direct costs (i.e., supplies, equipment, travel) are commensurate with those required to accomplish the goals of the investigation. Salary levels, fringe benefit rates, and overhead rates are not part of that evaluation, and will be hidden from peer reviewers.
- Except in rare instances where it is explicitly acknowledged in the program element, neither the existence of proposed voluntary cost sharing nor the lack thereof or the magnitude of such cost sharing will be used as evaluation criteria or as a precondition for award. If voluntary cost sharing is proposed, the proposer should describe, in detail, any proposed cost sharing arrangements (see Section III(d) above). Please note that the Table of Personnel and Work Effort is no longer in the budget section and the *Guidebook* explicitly notes that any planned work commitment not funded by NASA is not considered cost sharing as defined in 2 CFR § 200.29.
- The *NASA Guidebook for Proposers* gives definitions for five adjectival ratings from Excellent down to Poor. NASA may provide decision letters and or evaluations with intermediate scores such as "Excellent/Very Good".

- A NASA awards officer will conduct a pre-award review of risk associated with the proposer as required by 2 CFR 200.205. For all proposals selected for award, the awards officer will review the submitting organization's information available through the Federal Awardee Performance and Integrity Information System (FAPIIS) and the System for Award Management (SAM) to include checks on entity core data, registration expiration date, active exclusions, and delinquent federal debt.
- Prior to making a Federal award with a total amount of Federal share greater than the simplified acquisition threshold, NASA is required to review and consider any information about the applicant that is in the designated integrity and performance system (currently FAPIIS) accessible through the System for Award Management (SAM, https://www.sam.gov/SAM/) (see 41 U.S.C. 2313). An applicant, at its option, may review information in FAPIIS and comment on any information about itself that NASA previously entered and is currently in FAPIIS. NASA will consider any comments by the applicant, in addition to the other information in FAPIIS, in making a judgment about the applicant's integrity, business ethics, and record of performance under Federal awards when completing the review of risk posed by applicants as described in 2 CFR 200.205 Federal awarding agency review of risk posed by applicants.
- For proposal evaluation and other administrative processing, NASA may find it necessary to release information submitted by the proposer to individuals not employed by NASA. Business information that would ordinarily be entitled to confidential treatment may be included in the information released to these individuals. Accordingly, by submission of this proposal, the proposer hereby consents to a limited release of its confidential business information (CBI). Except where otherwise provided by law, NASA will permit the limited release of CBI only pursuant to non-disclosure agreements signed by the assisting contractor or subcontractor, and their individual employees and peer reviewers who may require access to the CBI to perform the assisting contract.

(b) Review and Selection Processes

Review and selection of proposals submitted to this NRA will be consistent with the policies and provisions given in the *NASA Guidebook for Proposers*, the SMD Peer Review Policy and the SMD policy on avoidance of Peer Review Conflicts of Interest.

Although not part of the peer review process, the selection official may take into account programmatic considerations such as impact on current or future missions, balance across subdisciplines, technologies, methodologies, career stage, risk, innovation, types of institutions, and project size (such as funding several small investigations instead of one large one).

Unless otherwise specified, the SMD Division Director responsible for a research program (or a delegate, such as the R&A lead in the Earth Science and Planetary Science Divisions) is its Selection Official.

(c) Selection Announcement and Award Dates

SMD's goal is to announce selections within 150 days of the proposal due date and within 60 days after the conclusion of the peer review. Selections are typically announced between 150 days and 220 days after the proposal due date. Although there are many reasons why selections are not announced earlier, the most common are the uncertainty in the NASA budget at the time selection decisions could be made and the time required to conduct an appropriate peer review and selection process. NASA does not usually announce new selections until the funds needed for those awards are approved through the Federal budget process. Therefore, a delay in the budget process for NASA usually results in a delay of the selection announcement date. After 150 days have passed since the proposal due date, proposers may contact the responsible Program Officer listed at the conclusion of that program element and on the SARA web page (see Section VIII). If the program officer does not respond proposers may send an inquiry to SARA@nasa.gov.

In order to announce selection decisions as soon as is practical, even in the presence of budget uncertainties, the Selection Official may make and announce selection decisions about some proposals and defer decisions on others. If a Selection Official uses this option, then proposers may be told that a proposal has been "selected," "declined," or that a decision has not yet been made. If a decision has not yet been made, then those proposals remain "selectable" and will be considered for a supplemental selection if circumstances allow. Eventually proposers will be notified whether their proposal is selected or is no longer being considered for selection. All proposers will be notified via NSPIRES and provided with a written review (usually the panel evaluation) of the proposal. Proposers may contact the Program Officer for a "debriefing" to gain a better understanding of the evaluation process and the reasoning supporting the decision not to select the proposal, see the SMD Reconsideration Policy for more information.

(d) Processes for Appeals

(i) Reconsideration by SMD

SMD has a process for requesting a debrief and/or reconsideration of the declination of a proposal submitted in response to an SMD NASA Research Announcement and Cooperative Agreement Notices. Reconsideration may be requested if the PI believes that the proposal was not handled correctly. This process may be found at in the SMD Reconsideration Policy document available in the Library section of the SARA website at http://sara.nasa.gov).

(ii) Ombudsman Program

The NASA Procurement Ombudsman Program is available under this NRA as a procedure for addressing concerns and disagreements. The clause at NASA FAR Supplement (NFS) 1852.215-84 ("Ombudsman") is incorporated into this NRA.
The cognizant ombudsman is

Monica Manning
Deputy Assistant Administrator for Procurement
Telephone: 202-358-1050
Email: agency-procurementombudsman@nasa.gov

(iii) Protests

Only contract awards are subject to bid protest, either at the Government Accountability Office (GAO) or with the Agency, as defined in FAR 33.101. The provisions at FAR 52.233-2 (Service of Protest) and NFS 1852.233-70 (Protests to NASA) are incorporated into this NRA. Under both of these provisions, the designated official for receipt of protests to the Agency and copies of protests filed with the GAO is

Jeffrey Cullen
Director of Program Operations
NASA Headquarters
Washington, DC 20546-0001
Telephone: 202-358-1463
Email: jeffrey.m.cullen@nasa.gov

(e) Service as a Peer Reviewer

The success of NASA's research program rests on the quality of peer review. NASA will contact expert investigators and ask them to serve as peer reviewers. Since those whose proposals were selected in prior competitions are highly qualified and may not be submitting a proposal to the current competition, they are highly encouraged to serve on SMD peer review panels. Potential reviewers are encouraged to volunteer to be reviewers by filling out one of the review forms at https://science.nasa.gov/researchers/volunteer-review-panels or by sending an email to one of the program officers or to sara@nasa.gov. It is good experience for early-career scientists, and the influx of new reviewers is healthy for the process.

VII. AWARD ADMINISTRATION INFORMATION

(a) Notice of Award

All proposers will be officially notified via NSPIRES from which they will be able to retrieve their official decision letter and evaluation. If a proposal is selected, the business office of the offeror will be contacted by a NASA Grants Officer from the NASA Shared Services Center (NSSC), who is the only official authorized to obligate the Government. Any costs incurred by the offeror in anticipation of an award will be subject to 2 CFR Section 1800.209 Preaward costs. NASA waives the approval requirement for preaward costs of 90 days or less.

(b) Administrative and National Policy Requirements

This solicitation does not invoke any special administrative or national policy requirements: 2 CFR 200, 2 CFR 1800, 14 CFR 1274, and the Grants and Cooperative Agreement Manual will apply to any awards that derive from this NRA, as applicable. Note that the research terms and conditions have been updated—see Section 5.10.1 of the GCAM for more information. All award requirements are posted at https://prod.nais.nasa.gov/pub/pub_library/srba/index.html.

(c) Award Reporting Requirements

The reporting requirements for awards made through this NRA will be consistent with 2 CFR 1800.902.

Award recipients may also be subject to reporting requirements under the NASA Plan for Increasing Access to Results of Federally Funded Research. Such requirements include reporting of final peer-reviewed manuscripts in annual and final progress reports. In other words, award recipients should report on progress in archiving of data and manuscripts in their progress reports and especially in the final report. All requirements will be identified in the Notice of Award.

If the total value of your currently active grants, cooperative agreements, and procurement contracts from all Federal awarding agencies exceeds $10,000,000 for any period of time during the period of performance of this Federal award, additional reporting requirements will apply. See 2 CFR 200 Appendix XII—Award Term and Condition for Recipient Integrity and Performance Matters.

(d) Compliance with the National Environmental Policy Act

All awards made in response to proposals to this solicitation must comply with the National Environmental Policy Act (NEPA). Thus, proposers are encouraged to plan and budget for any anticipated environmental impacts. While most research awards will not trigger action specific NEPA review, there are some activities, including international actions, that will. The majority of grant-related activities are categorically excluded (from specific NEPA review) as research and development (R&D) projects that do not pose any adverse environmental impact. A blanket NASA Grants Record of Environmental Consideration (REC) provides NEPA coverage for these anticipated activities. The NSPIRES cover pages include questions to determine whether a specific proposal falls within the Grants REC and must be completed as part of the proposal submission process. Activities outside of the bounding conditions of the Grants REC will require additional NEPA analysis. Examples of actions that will likely require NEPA analysis include, but are not limited to: suborbital-class flights not conducted by a NASA Program Office (see Section V); activities involving groundbreaking construction/fieldwork; and certain payload activities such as the use of expendable weather reconnaissance devices (dropsondes). Questions concerning environmental compliance may be addressed to Tina Norwood, NASA NEPA Manager, at tina.norwood-1@nasa.gov or (202) 358-7324.

(e) Acknowledgement of Support for Antarctic Access

For science projects that receive assistance from the U.S. Antarctic Program, this support must be acknowledged in publications. The acknowledgement should include: "Logistical support for this project in Antarctica was provided by the U.S. National Science Foundation through the U.S. Antarctic Program." Any additional requirements will be specified in the program element description.

VIII. Points of Contact for Further Information

General questions and comments about the policies of this NRA may be directed to:

Max Bernstein
SMD Lead for Research
Science Mission Directorate
National Aeronautics and Space Administration
Washington, DC 20546-0001
Email: sara@nasa.gov (preferred)
Telephone: (202) 358-0879

Note: Proposals must not be submitted to this address. Proposals must be submitted electronically, as described in Section IV above.

Specific questions about a given program element in this NRA should be directed to the Program Officer(s) listed in the Summary Table of Key Information at the end of each program element appendix. Up-to-date contact information for program officers can also be found online at the SARA web page's Program Officers List at https://science.nasa.gov/researchers/sara/program-officers-list.

Inquiries about accessing or using the NASA proposal submission web interface located at http://nspires.nasaprs.com should be directed by an email that includes a telephone number to nspires-help@nasaprs.com or by calling (202) 479-9376. This help center is staffed Monday through Friday, 8:00 a.m. – 6:00 p.m. Eastern Time.

Inquiries about accessing or using Grants.gov located at http://www.grants.gov should be directed by an email to support@grants.gov or by calling (800) 518-4726 twenty-four hours a day, seven days a week, except Federal holidays when the center is closed.

Students, faculty or staff in programs receiving NASA financial assistance, such as grant awards from this solicitation, may raise allegations of discrimination, including harassment, by contacting the NASA Office of Diversity and Equal Opportunity. Information on filing a complaint through ODEO may be found at https://missionstem.nasa.gov/filing-a-complaint.html.

IX. Ancillary Information

(a) Announcement of Updates/Amendments to Solicitation

Because this NRA is released far in advance of many of the deadlines given in Tables 2 and 3, additional programmatic information for any of its programs may develop before their proposal due dates. If so, such information will be added as a formal amendment to this NRA no later than 30 days before the proposal due date, or, if that is not possible, the proposal due date will be extended to allow 30 days for proposal submission from the date of the amendment. All amendments are posted on the main ROSES webpage at http://solicitation.nasaprs.com/ROSES2019 (or by going to http://solicitation.nasaprs.com/open and selecting "NNH19ZDA001N"). Also, an RSS feed for amendments, clarifications, and corrections to ROSES can be found in one place (and there is an RSS feed) at http://science.nasa.gov/researchers/sara/grant-solicitations/roses-2019/. NASA SMD will also send an electronic notification of any such amendments to all subscribers of its electronic notification system (see

Section IX(c) below), it is the responsibility of the prospective proposer to check this NRA's homepage for updates concerning the program(s) of interest. Any clarifications or questions and answers that are published will be posted on the relevant program element's web page, which can be found as described above.

(b) Electronic Submission of Proposal Information

On-time electronic submission over the Internet is required for every proposal and mandatory NOI. While every effort is made to ensure the reliability and accessibility of the electronic proposal submission systems (NSPIRES and Grants.gov) and to maintain help centers via email and telephone, difficulty may arise at any point, including with the user's own equipment. Therefore, prospective proposers are urged to familiarize themselves with the submission system(s) and to submit the required proposal materials well in advance of the deadline of the program of interest. Difficulty in registering with or using a proposal submission system is not, in and of itself, a sufficient reason for NASA to consider a proposal that is submitted after the proposal due date (see Section IV(c) above). After submission via NSPIRES, proposers can verify proposal delivery by logging into NSPIRES and selecting "proposals" and "Submitted Proposals/NOIs." Additionally, the proposal PI and the submitting organization's AOR(s) will receive an email from NSPIRES confirming that the submission has been completed.

(c) Electronic Notification of SMD Research Solicitations

SMD maintains an electronic notification system to alert interested researchers of its research program announcements. Subscription to this service is free to all registered users of the NASA proposal database system at http://nspires.nasaprs.com. To add or change a subscription to the electronic notification system, users should login to the database system and select "Account Management" then "email Subscriptions." Owing to the increasingly multidisciplinary nature of SMD programs, this email service will notify all subscribers of (i) all NASA SMD research program solicitations regardless of their type or science objectives; (ii) amendments to all SMD solicitations that have been released for which the proposal due dates have not passed; and (iii) special information that SMD wishes to communicate to those interested in proposing to its sponsored research programs. Altogether, a subscriber may receive 50 - 75 notifications per year. SMD maintains this subscription list in confidence and does not attempt to discern the identity of its subscribers. Regardless of whether or not this service is used, all SMD research announcements may be accessed at http://solicitation.nasaprs.com/open by selecting "NNH19ZDA001N" as soon as they are posted (typically by ~9:00 a.m. Eastern Time on their release date).

Note: Automated spam filtering software may identify SMD's electronic notifications as spam or junk mail. Subscribers are advised to ensure that email received from "NSPIRES-help@nasaprs.com" or "nspires@nasaprs.com" are not identified by any automated email filtering system as unwanted email. Note that the latter address is an outgoing (from NSPIRES) address only; all enquiries should be directed to the former address.

NRAs issued by SMD are synopsized on Grants.gov (http://www.grants.gov) at the time they are released. This ROSES NRA will be synopsized upon its release.

(d) Further Information on SMD Research and Analysis Programs

SMD maintains a website for improving communication with the research community. This site is maintained by the SMD Research Lead, is referred to as the SARA website, and is located at http://sara.nasa.gov. The SARA website contains information related to NASA's Science Research Programs, including the solicitations, selections, an RSS feed for changes to ROSES, and contact information for program officers.

(e) Archives of Past Selections

For more information about the types of research supported by the program elements solicited in previous editions of this NRA and other predecessor NRAs, the titles and abstracts of all investigations selected through previous solicitations (issued after January 1, 2005) are available by solicitation by year at http://nspires.nasaprs.com: click "Solicitations" and then "Closed/Past Solicitations and Selections," choose the year from the pop-down menu, and click the find button to see the abstracts in a PDF file. One can search the grants (only) that resulted from all NASA programs at http://www.research.gov/ by selecting "Search awards" and then using the "Advanced Search" to search for NASA awards only. One can also search the grants (only) that resulted from all NASA programs, but not abstracts at https://www.nssc.nasa.gov/grantstatus.

(f) Meeting Geospatial Standards

NASA pioneered the development of metadata and the accessibility and interoperability of space and Earth science data. When grants result in the development of data that NASA both identifies as geospatial and intends to distribute, then NASA awards will require that documentation (metadata) meet Federal Geographic Data Committee standards. NASA will assure that this documentation is electronically accessible to the Clearinghouse network (http://www.fgdc.gov/dataandservices/) and discoverable through https://www.data.gov/geospatial/.

X. Concluding Statement

Through this ROSES NRA, NASA encourages the participation of the space and Earth science communities in its Science Mission Directorate research and technology programs. These programs, while quite diverse in objectives and types, in fact form the foundation of both the basic and applied research that allows NASA's space and Earth science programs to be properly planned and carried through to the successful interpretation of data and its application to the needs of end users. Comments about this NRA are welcome and may be directed to the point of contact for general questions and comments identified in Section VIII above.

Table 1: Checklist for ROSES-2019 Proposals

This list does not apply to Step-1 proposals. Many items on this checklist may be superseded by the program element and, if there is a difference, the text in the program element takes precedence. The instructions here supersede the *NASA Guidebook for Proposers* if there is a difference, see Section I(g).		
NSPIRES cover pages: Table 1 lists the few aspects that most commonly cause difficulties to proposers. There are many required parts to the cover pages, see the NSPIRES tutorials for guidance.		
	Team	All investigators must indicate participation via NSPIRES, except proposals submitted via grants.gov. If any team member doesn't confirm their participation the AOR will get an error that prevents submission.
	Team	Paid team members may not be collaborators, they should be given a role permitted to receive funds, such as Co-I.
	Team	A critical partner with a sustained, continuing role is a Co-I, not a collaborator, even if unpaid.
	Project Summary	Project Summary (abstract) must be in the 4000-character text box in the NSPIRES cover pages, not the Science/Technical/Management section of the proposal.
	Data manage-ment plan (DMP)	A Data Management Plan (DMP) or explanation of why it is not needed must be provided in the two, 4000-character text boxes in the cover pages, unless otherwise stated in the program element. See Section II(c) and the ROSES FAQ for important information. **Proposers to Appendix C see Section 3.6 of C.1.**
	Budget	List all costs. Include all salary and indirect costs in the NSPIRES cover page budgets.
	Submission	Both the author must "release" the proposal and the AOR must "submit" prior to the due date.
	Other	There are cover page questions that must be answered and there may be other required content, e.g., some program elements in Appendix C collect a relevance statement here, see VI (a).
Proposal document		
Table of contents		First component of proposal. One page only and optional.
Scientific/ Technical/ Management Section		Second component and the main part of the proposal. The sequence for science content here is recommended, but proposers may order the elements as they prefer.
	Length restriction	Typically, 15 pages (except for a Step-1 proposal) and more may be permitted for some (e.g., suborbital) programs and less for others (e.g., C.17 PMEF, E.2 TWSC). Please read the program element and refer to the summary table of key information.
	Format	8.5" x 11.0" paper size

Table 1 Continued: Checklist for ROSES-2019 Proposals

	Format	Single spaced, single column text (unless otherwise specified).
	Format	One-inch margins on all four sides. No reviewable content in margins.
	Format	No more than 5.5 lines per vertical inch
	Format	No more than 15 characters per horizontal inch, including spaces
	Format	Font size 12 consistent with rules above, sans serif font recommended
	Figure Format	Text and content on/in figures must be easily legible without magnification.
	Captions Format	As above. Text necessary for the proposal may not be solely in figures, tables, or their captions.
	Table Format	Text and content on/in Tables must be easily legible without magnification. See also directly above
	Content	Discuss objectives and their significance.
	Content	Discuss perceived impact of the work.
	Content	Discuss relevance of the work to the solicitation. See VI (a)
	Content	Explain the technical approach and methodology.
	Content	Discuss potential sources of uncertainty
	Content	Present mitigation strategy or alternate approach given obstacles
	Content	Present roles of all team members so it's clear what they are doing
	Content	Present a work plan, with milestones, management structure
	Content	Present a data sharing and/or archiving plan in the text only if it is required by program element.
	Special Content	Provide other special requirements of program element, e.g., special statements for participating scientists, team leads, etc.
References: Third component of proposal **[Updated July 9, 2019]**		
	Length	No page limit
	Excluded	No references to documents unavailable to reviewers. **See SARA FAQ 19 for more, including references to web pages.**
Biographical sketches/Curriculum Vitae (CVs): fourth component of proposal		
	Required	One for a PI and each Co-I
	Length restriction	CV for a PI - up to two pages, unless otherwise specified.
	Length restriction	CVs for anyone other than a PI are limited to one page
	Not required	CVs for collaborators are typically not needed, but may be included
Table of Personnel and Work Effort: This is the fifth component of the proposal. Note, location may differ from that given in *Guidebook*. See Section IV(b)iii		
	General	Note this table has been moved from the budget Section. Where names are not known, include the position, such as postdoctoral fellow or technician.

Table 1 Continued: Checklist for ROSES-2019 Proposals

	Required	Names and/or titles of all personnel to perform the proposed effort
	Required	Planned work commitment (e.g., in weeks, months etc.) to be funded by NASA see example in Section IV(b)iii.
	Required	Planned work commitment (e.g., in weeks, months etc.) that will not be funded by NASA, if any see example in Section IV(b)iii. Time commitment included here that is not funded by NASA is not considered cost sharing, as defined in 2 CFR § 200.29.
Current and Pending Support: Sixth component of the proposal, not page limited.		
	Required	Required for the PI and funded team members who are proposed to devote ≥10% of their time to the proposed work.
	Required	For each current project or pending proposal list the level of effort for that one team member (only) per year. Award values are not required.
	Excluded	Do not include Current and Pending for collaborators.
	Discouraged	Current and Pending for students is discouraged.
	Discouraged	Current and Pending for Foreign Co-Is is discouraged.
	Excluded	Do not self-reference this proposal in the current and pending
Statements of Commitment and Letters of Support, feasibility and Endorsement, the Seventh component of the proposal.		
	General	Statements of Commitment by team members have been replaced by an indication of participation via the NSPIRES web interface.
	Statements of Commitment	Statements of Commitment must be included for Grants.gov proposals, since web confirmation of team member participation is not possible via Grants.gov.
	Letter of Endorsement – only permitted in special cases.	In general, not permitted. Special cases include 1) Foreign Co-Is must include letters of endorsement from their government agency or funding/sponsoring institution in their country and 2) Letters from commercial vendor are required for proposals for investigations using sRLVs not contracted by the Flight Opportunities Program. See Section V(b)iii.
	Letter of Support	A letter of support is required from the owner of any facility or resource that is not under the direct control of the PI or a Co-I, acknowledging that the facility or resource is available for the proposed use during the proposed period.
	Letter of feasibility	A letter of feasibility from the NASA Space Station Payload Office must be included with proposals to use ISS.
	Letter of affirmation	In general, letters of affirmation are not permitted for normal research proposals, but letters from the community may be included only where explicitly allowed, e.g., for A.41 Water Resources, C.17 PMEF, and E.2 TWSC.

Table 1 Continued: Checklist for ROSES-2019 Proposals

Budget Justification: The eighth component of the proposal, no page limit overall.		
	General	Please explain in words what is being purchased and why it is reasonable. See the *Guidebook for Proposers*
	Required	Budget Narrative: justify each proposed component of cost, including subcontracts/subawards, consultants, other direct costs (including travel), and facilities and equipment. Give the "basis of estimate;" quotes need not be provided, but the proposal should indicate that the cost was based upon a quote, prior experience, etc.
	Excluded	Do not include any values for salary, fringe, or overhead.
	Optional	Proposers need not specify anticipated award type (i.e., grant vs. contract), see Section II(a)
Facilities and Equipment: The ninth component of the proposal, no page limit.		
	Length restriction	None, as needed
	Excluded content	Does not add scientific or technical information beyond a description of the facilities and equipment, i.e., don't add here what should be in the page-limited scientific/technical Section.
Detailed Budget: The tenth and final component of the main proposal document.		
	Strongly Recommended	Detailed budget, itemizing expenses.
	Strongly Recommended	Separate detailed budget from each subaward organization.
	Excluded	Do not include any $ or % values for salary, fringe, or overhead in this section which is peer reviewed. See the FAQ at https://science.nasa.gov/researchers/sara/faqs#8
PDF Appendices Separate from the main proposal document		
	"Total" Budget Document (separate PDF file attached as document type "Total Budget").	
	Required	Separately uploaded "Total" Budget PDF file see Section IV(b)(iii).
	HEC Appendix Document (separate PDF file attached as document type "Appendix")	
	If necessary	If the Program Specific Data Question on the use of NASA-provided HEC was answered in the affirmative, an appendix document must be provided. See Section I(d) for information.

TABLE 2: PROGRAM ELEMENTS (ORDERED BY PROPOSAL DUE DATE) and TABLE 3: PROGRAM ELEMENTS (ORDERED BY DIVISION/TOPIC) are posted as separate documents on the web at http://solicitation.nasaprs.com/ROSES2019table2 and http://solicitation.nasaprs.com/ROSES2019table3, respectively.

ROSES 2019
TABLE 2: SOLICITED RESEARCH PROGRAMS
(In Order of full/Step-2 proposal due dates) [1]

Appendix	Program Element	NOI/(Step-1) Due Date [2]	Proposal Due Date
C.15	Planetary Protection Research [3]	see C.15 ROSES-2018	
D.2	Astrophysics Data Analysis	See D.16 in ROSES-18	
A.39	Plankton, Aerosol, Cloud, Ocean Ecosystem (PACE) Mission System Vicarious Calibration	See A.48 in ROSES-18	
E.3	Exoplanets Research [3]	See E.5 in ROSES-2018	
A.40	Understanding Changes in High Mountain Asia	04/16/2019	06/12/2019
C.2	Emerging Worlds [3]	04/16/2019 (Step-1)	06/12/2019 (Step-2)
C.5	Exobiology [3]	05/13/2019	06/12/2019
C.6	Solar System Observations [3]	04/16/2019 (Step-1)	06/12/2019 (Step-2)
C.20	Development and Advancement of Lunar Instrumentation Program [3]	04/16/2019 (Step-1)	06/12/2019 (Step-2)
D.13	**System-Level Segmented Telescope Design – Technology Maturation**	**N/A**	**06/13/2019**
A.27	Earth Surface and Interior	05/17/2019	06/14/2019
A.28	GRACE-FO Science Team	05/21/2019	06/14/2019
A.53	**Utilization of L- and S- Band Synthetic Aperture Radar Imagery over North America – Joint NASA and ISRO Airborne Campaign**	**05/20/2019 (mandatory)**	**06/19/2019**
B.11	Heliophysics Data Environment Emphasis	04/18/2019 (Step-1)	06/20/2019 (Step-2)
C.16	Laboratory Analysis of Returned Samples [3]	04/2**5**/2019 (Step-1)	06/25/2019 (Step-2)
A.9	Physical Oceanography	05/30/2019	06/27/2019
D.4	Astrophysics Theory Program	05/02/2019	06/27/2019
A.16	Modeling Analysis and Prediction	05/03/2019	07/02/2019
A.25	The Soil Moisture Active-Passive Mission Science Team	05/15/2019	07/11/2019
C.4	Planetary Data Archiving, Restoration, and Tools [3]	05/09/2019 (Step-1)	07/11/2019 (Step-2)

A.49	**Instrument Incubator Program**	**05/31/2019**	**07/12/2019**
A.38	PACE Science and Applications Team	05/15/2019	07/15/2019
B.4	Heliophysics Guest Investigators Open	05/15/2019 (Step-1)	07/17/2019 (Step-2)
C.10	Cassini Data Analysis [3]	05/16/2019 (Step-1)	07/18/2019 (Step-2)
A.54	**Decadal Survey Incubation Study Teams: Planetary Boundary Layer and Surface Topography and Vegetation**	**06/17/2019**	**08/01/2019**
C.7	New Frontiers Data Analysis [3]	05/30/2019 (Mandatory NOI)	08/01/2019
B.14	**Heliophysics System Observatory Data Support Data Support**	**N/A**	**08/15/2019**
B.8	Heliophysics Technology and Instrument Development for Science	N/A	08/28/2019
A.10	Ocean Salinity Science Team	08/01/2019	08/29/2019
A.37	Global Navigation Satellite System Research	07/31/2019	08/30/2019
A.26	Weather and Atmospheric Dynamics	08/05/2019	09/16/2019
B.2	Heliophysics Supporting Research	08/06/2019 (Step-1)	**10/18/**2019 (Step-2)
A.22	Aura Science Team	N/A	**09/19/2019**
D.5	**Neil Gehrels Swift Observatory Guest Investigator Cycle 16**	**N/A**	**09/26/2019 (Phase-1 via ARK RPS)**
A.36	**Studies with ICESat-2**	**08/01/2019**	**10/08/2019**
C.14	Planetary Science and Technology Through Analog Research [3]	07/25/2019 (Step-1)	10/10/2019 (Step-2)
A.30	Airborne Instrument Technology Transition	08/29/2019 (mandatory NOIs)	10/24/2019
A.11	**Sea Level Change Science Team**	**09/26/2019**	**10/31/2019**
C.11	**Discovery Data Analysis** [3]	08/29/2019 (Step-1)	11/01/2019 (Step-2)
C.24	**Europa Clipper Gravity/Radio Science Team – Lead Scientist**	**10/21/2019 (mandatory NOIs)**	**11/06/2019**
B.9	**Heliophysics Flight Opportunities for Research and Technology**	N/A	**11/08/2019**

D.11	**NICER Guest Observer Cycle 2**	N/A	**11/13/2019 (Phase-1 via ARK RPS)**
A.23	Terrestrial Hydrology	09/26/2019	11/14/2019
A.32	Interdisciplinary Research in Earth Science	10/15/2019	11/15/2019
C.9	**Mars Data Analysis** [3]	**09/20/2019** (Step-1)	**11/20/2019** (Step-2)
C.12	Planetary Instrument Concepts for the Advancement of Solar System Observations [3]	09/20/2019 (Step-1)	11/20/2019 (Step-2)
A.12	**Surface Water and Ocean Topography Science Team**	**10/17/2019**	**11/21/2019**
C.19	Planetary Science Early Career Award Program [3]	N/A	12/02/2019
B.3	**Heliophysics Theory, Modeling, and Simulations**	**10/03/2019 (Step-1)**	**12/10/2019 (Step-2)**
B.13	**Outer Heliosphere Guest Investigators**	**10/24/2019 (Step-1)**	**12/10/2019 (Step-2)**
D.12	**Astrophysics Science SmallSat Studies**	**N/A**	**12/19/2019**
A.33	**Earth Science Research from Operational Geostationary Satellite Systems**	**10/25/2019**	**01/10/2020**
D.10	**TESS Guest Investigator Cycle 3**	**N/A**	**01/16/2020 (Phase-1 via ARK RPS)**
E.4	Habitable Worlds [3]	11/15/2019 (Step-1)	01/17/2020 (Step-2)
C.24	**Europa Clipper Gravity/Radio Science Team – Team Member**	**10/21/2019 (mandatory NOIs)**	**01/24/2020**
D.9	**NuSTAR General Observer Cycle 6**	N/A	01/24/2020 (Phase-1 via ARK RPS)
A.46	**Advancing Collaborative Connections for Earth System Science**	**12/12/2019**	**01/30/2020**
C.25	**Akatsuki Participating Scientist Program**	**11/22/2019 (mandatory NOIs)**	**01/31/2020**
E.6	**Future Investigators in NASA Earth and Space Science and Technology**	**N/A**	**02/04/2020**
C.3	**Solar System Workings** [3]	**11/22/2019**	**02/06/2020**

B.7	**Space Weather Science Applications Operations 2 Research**	**12/16/2019 (Step-1)**	**02/13/2020 (Step-2)**
D.6	**Fermi Guest Investigator Cycle 13**	N/A	02/19/2020 (Phase-1 via ARK RPS)
B.6	**Living With a Star Science**	**12/12/2019 (Step-1)**	**02/27/2020 (Step-2)**
C.8	Lunar Data Analysis [3]	11/26/2019 (Step-1)	02/27/2020 (Step-2)
A.2	Land Cover/ Land Use Change	08/01/2019 (Step-1)	03/03/2020 (Step-2)
C.26	**Mars 2020 Participating Scientist Program**	**01/27/2020 (mandatory NOIs)**	**03/12/2020**
B.15	**Heliophysics System Observatory - Connect**	**01/15/2020 (Step-1)**	**03/13/2020 (Step-2)**
A.29	Rapid Response and Novel Research in Earth Science	N/A	Rolling submissions through 03/27/2020
C.18	Early Career Fellowship Start-Up Program for Named Fellows	N/A	Rolling submissions through 03/27/2020
E.2	**Topical Workshops, Symposia, and Conferences**	N/A	Rolling submissions through 03/27/2020
A.52	**Sustainable Land Imaging - Technology**	**02/05/2020**	**04/14/2020**
E.5	**Applied Information Systems Research**	**01/21/2020 (Step-1)**	**04/17/2020 (Step-2)**
C.23	**Interdisciplinary Consortia for Astrobiology Research**	**01/31/2020 (Step-1)**	**05/15/2020 (Step-2)**
C.17	Planetary Major Equipment and Facilities: Appended proposals	See Program of Interest	
D.8	Nancy Grace Roman Technology Fellowships for Early Career Researchers	See D.3	
A.3	Ocean Biology and Biogeochemistry	Not Solicited This Year	
A.4	Terrestrial Ecology	Not Solicited This Year	
A.5	Carbon Cycle Science	Not Solicited This Year	
A.6	Carbon Monitoring System	**Not Solicited This Year**	
A.7	Biodiversity	Not Solicited This Year	

A.8	**Global Ecosystem Dynamics Investigation (GEDI) Science Team**	**Not Solicited This Year**
A.13	Surface Water and Ocean Topography Calibration and Validation Field Campaigns	**Not Solicited This Year**
A.14	Ocean Surface Topography Science Team	Not Solicited This Year
A.15	Ocean Vector Winds Science Team	Not Solicited This Year
A.17	Cryospheric Science	Not Solicited This Year
A.18	Atmospheric Composition: Upper Atmosphere Research Program	Not Solicited This Year
A.19	Atmospheric Composition: Radiation Sciences Program	Not Solicited This Year
A.20	Atmospheric Composition: Modeling and Analysis Program	Not Solicited This Year
A.21	Tropospheric Composition	Not Solicited This Year
A.24	NASA Energy and Water Cycle Study	Not Solicited This Year
A.31	Earth Science U.S. Participating Investigator	Not Solicited This Year
A.34	New (Early Career) Investigator Program in Earth Science	Not Solicited This Year
A.35	The Science of Terra, Aqua, and Suomi-NPP	Not Solicited This Year
A.41	Water Resources	Not Solicited This Year
A.42	SERVIR Applied Sciences Team	Not Solicited This Year
A.43	Disaster Risk Reduction and Response	Not Solicited This Year
A.44	Health and Air Quality Applied Sciences Team	Not Solicited This Year
A.45	Ecological Forecasting	Not Solicited This Year
A.47	Citizen Science for Earth Systems Program	Not Solicited This Year
A.48	Advanced Information Systems Technology	Not Solicited This Year
A.50	Advanced Component Technology	Not Solicited This Year
A.51	In-space Validation of Earth Science Technologies	Not Solicited This Year
B.5	GOLD-ICON Guest Investigators	Not Solicited This Year
B.10	Living With a Star Strategic Capabilities	**Not Solicited This Year**
B.12	Heliophysics U.S. Participating Investigator	**Not Solicited This Year**
C.13	Maturation of Instruments for Solar System Exploration [3]	Not Solicited This Year

C.17	Planetary Major Equipment and Facilities: Stand-alone proposals	**Not Solicited This Year**	
C.21	Lunar Technology Program	**Not Solicited This Year**	
C.22	Bepi-Colombo Participating Scientists Program	**Not Solicited This Year**	
D.3	**Astrophysics Research and Analysis**	**Not Solicited This Year**	
D.7	**Strategic Astrophysics Technology**	**Not Solicited This Year**	
A.1	Earth Science Research Overview	N/A	N/A
B.1	Heliophysics Research Program Overview	N/A	N/A
C.1	Planetary Science Research Program Overview	N/A	N/A
D.1	Astrophysics Research Program Overview	N/A	N/A
E.1	Cross Division Research Overview	N/A	N/A

Notes:

[1] Amended due dates and new program elements will be indicated with bold red text as ROSES-2019 is amended through the year.

[2] See Sections IV(b)(vi) and IV(b)(vii) of the *Summary of Solicitation* for a discussion of Notice of Intent (NOI) vs. a Step-1 proposal. If NOIs are required by a program in order to be able to submit a proposal, it will be indicated on this table with “(mandatory)”.

[3] Program elements designated with [3] after their name participate in the Planetary Science Early Career Award Program (see C.19).

ROSES 2019
TABLE 3: SOLICITED RESEARCH PROGRAMS
(In Order of Appendices A-E) [1]

Appendix	Program Element	NOI/(Step-1) Due Date [2]	Proposal Due Date
A.1	Earth Science Research Overview	N/A	N/A
A.2	Land Cover/ Land Use Change	08/01/2019 (Step-1)	03/03/2020 (Step-2)
A.3	Ocean Biology and Biogeochemistry	Not Solicited This Year	
A.4	Terrestrial Ecology	Not Solicited This Year	
A.5	Carbon Cycle Science	Not Solicited This Year	
A.6	Carbon Monitoring System	**Not Solicited This Year**	
A.7	Biodiversity	Not Solicited This Year	
A.8	**Global Ecosystem Dynamics Investigation (GEDI) Science Team**	**Not Solicited This Year**	
A.9	Physical Oceanography	05/30/2019	06/27/2019
A.10	Ocean Salinity Science Team	08/01/2019	08/29/2019
A.11	**Sea Level Change Science Team**	**09/26/2019**	**10/31/2019**
A.12	**Surface Water and Ocean Topography Science Team**	**10/17/2019**	**11/21/2019**
A.13	Surface Water and Ocean Topography Calibration and Validation Field Campaigns	**Not Solicited This Year**	
A.14	Ocean Surface Topography Science Team	Not Solicited This Year	
A.15	Ocean Vector Winds Science Team	Not Solicited This Year	
A.16	Modeling Analysis and Prediction	05/03/2019	07/02/2019
A.17	Cryospheric Science	Not Solicited This Year	
A.18	Atmospheric Composition: Upper Atmosphere Research Program	Not Solicited This Year	
A.19	Atmospheric Composition: Radiation Sciences Program	Not Solicited This Year	
A.20	Atmospheric Composition: Modeling and Analysis Program	Not Solicited This Year	
A.21	Tropospheric Composition	Not Solicited This Year	

A.22	Aura Science Team	N/A	**09/19/2019**
A.23	Terrestrial Hydrology	09/26/2019	11/14/2019
A.24	NASA Energy and Water Cycle Study	Not Solicited This Year	
A.25	The Soil Moisture Active-Passive Mission Science Team	05/15/2019	07/11/2019
A.26	Weather and Atmospheric Dynamics	08/05/2019	09/16/2019
A.27	Earth Surface and Interior	05/17/2019	06/14/2019
A.28	GRACE-FO Science Team	05/21/2019	06/14/2019
A.29	Rapid Response and Novel Research in Earth Science	N/A	Rolling submissions through 03/27/2020
A.30	Airborne Instrument Technology Transition	08/29/2019 (mandatory NOIs)	10/24/2019
A.31	Earth Science U.S. Participating Investigator	Not Solicited This Year	
A.32	Interdisciplinary Research in Earth Science	10/15/2019	11/15/2019
A.33	**Earth Science Research from Operational Geostationary Satellite Systems**	**10/25/2019**	**01/10/2020**
A.34	New (Early Career) Investigator Program in Earth Science	Not Solicited This Year	
A.35	The Science of Terra, Aqua, and Suomi-NPP	Not Solicited This Year	
A.36	**Studies with ICESat-2**	**08/01/2019**	**10/08/2019**
A.37	Global Navigation Satellite System Research	07/31/2019	08/30/2019
A.38	PACE Science and Applications Team	05/15/2019	07/15/2019
A.39	Plankton, Aerosol, Cloud, Ocean Ecosystem (PACE) Mission System Vicarious Calibration	See A.48 in ROSES-18	
A.40	Understanding Changes in High Mountain Asia	04/16/2019	06/12/2019
A.41	Water Resources	Not Solicited This Year	
A.42	SERVIR Applied Sciences Team	Not Solicited This Year	
A.43	Disaster Risk Reduction and Response	Not Solicited This Year	
A.44	Health and Air Quality Applied Sciences Team	Not Solicited This Year	
A.45	Ecological Forecasting	Not Solicited This Year	

A.46	**Advancing Collaborative Connections for Earth System Science**	**12/12/2019**	**01/30/2020**
A.47	Citizen Science for Earth Systems Program	Not Solicited This Year	
A.48	Advanced Information Systems Technology	Not Solicited This Year	
A.49	**Instrument Incubator Program**	**05/31/2019**	**07/12/2019**
A.50	Advanced Component Technology	Not Solicited This Year	
A.51	In-space Validation of Earth Science Technologies	Not Solicited This Year	
A.52	**Sustainable Land Imaging - Technology**	**02/05/2020**	**04/14/2020**
A.53	**Utilization of L- and S- Band Synthetic Aperture Radar Imagery over North America – Joint NASA and ISRO Airborne Campaign**	**05/20/2019 (mandatory)**	**06/19/2019**
A.54	**Decadal Survey Incubation Study Teams: Planetary Boundary Layer and Surface Topography and Vegetation**	**06/17/2019**	**08/01/2019**
B.1	Heliophysics Research Program Overview	N/A	N/A
B.2	Heliophysics Supporting Research	08/06/2019 (Step-1)	**10/18/2019** (Step-2)
B.3	**Heliophysics Theory, Modeling, and Simulations**	**10/10/2019 (Step-1)**	**12/10/2019 (Step-2)**
B.4	Heliophysics Guest Investigators Open	05/15/2019 (Step-1)	07/17/2019 (Step-2)
B.5	GOLD-ICON Guest Investigators	Not Solicited This Year	
B.6	**Living With a Star Science**	**12/12/2019 (Step-1)**	**02/27/2020 (Step-2)**
B.7	**Space Weather Science Applications Operations 2 Research**	**12/16/2019 (Step-1)**	**02/13/2020 (Step-2)**
B.8	Heliophysics Technology and Instrument Development for Science	N/A	08/28/2019
B.9	**Heliophysics Flight Opportunities for Research and Technology**	N/A	**11/08/2019**
B.10	Living With a Star Strategic Capabilities	**Not Solicited This Year**	
B.11	Heliophysics Data Environment Emphasis	04/18/2019 (Step-1)	06/20/2019 (Step-2)
B.12	Heliophysics U.S. Participating Investigator	**Not Solicited This Year**	
B.13	**Outer Heliosphere Guest Investigators**	**10/24/2019 (Step-1)**	**12/10/2019 (Step-2)**

B.14	**Heliophysics System Observatory Data Support Data Support**	**N/A**	**08/15/2019**
B.15	**Heliophysics System Observatory - Connect**	**01/15/2020 (Step-1)**	**03/13/2020 (Step-2)**
C.1	Planetary Science Research Program Overview	N/A	N/A
C.2	Emerging Worlds [3]	04/16/2019 (Step-1)	06/12/2019 (Step-2)
C.3	**Solar System Workings** [3]	**11/22/2019**	**02/06/2020**
C.4	Planetary Data Archiving, Restoration, and Tools [3]	05/09/2019 (Step-1)	07/11/2019 (Step-2)
C.5	Exobiology [3]	05/13/2019	06/12/2019
C.6	Solar System Observations [3]	04/16/2019 (Step-1)	06/12/2019 (Step-2)
C.7	New Frontiers Data Analysis [3]	05/30/2019 (mandatory NOIs)	08/01/2019
C.8	Lunar Data Analysis [3]	11/26/2019 (Step-1)	02/27/2020 (Step-2)
C.9	**Mars Data Analysis** [3]	**09/20/2019** (Step-1)	**11/20/2019** (Step-2)
C.10	Cassini Data Analysis [3]	05/16/2019 (Step-1)	07/18/2019 (Step-2)
C.11	**Discovery Data Analysis** [3]	08/29/2019 (Step-1)	11/01/2019 (Step-2)
C.12	Planetary Instrument Concepts for the Advancement of Solar System Observations [3]	09/20/2019 (Step-1)	11/20/2019 (Step-2)
C.13	Maturation of Instruments for Solar System Exploration [3]	Not Solicited This Year	
C.14	Planetary Science and Technology Through Analog Research [3]	07/25/2019 (Step-1)	10/10/2019 (Step-2)
C.15	Planetary Protection Research [3]	see C.15 ROSES-2018	
C.16	Laboratory Analysis of Returned Samples [3]	04/2**5**/2019 (Step-1)	06/25/2019 (Step-2)
C.17	Planetary Major Equipment and Facilities: Appended proposals	See Program of Interest	
C.17	Planetary Major Equipment and Facilities: Stand-alone proposals	**Not Solicited This Year**	

C.18	Early Career Fellowship Start-Up Program for Named Fellows	N/A	Rolling submissions through 03/27/2020
C.19	Planetary Science Early Career Award Program [3]	N/A	12/02/2019
C.20	Development and Advancement of Lunar Instrumentation Program [3]	04/16/2019 (Step-1)	06/12/2019 (Step-2)
C.21	Lunar Technology Program	**Not Solicited This Year**	
C.22	Bepi-Colombo Participating Scientists Program	**Not Solicited This Year**	
C.23	**Interdisciplinary Consortia for Astrobiology Research**	**01/31/2020 (Step-1)**	**05/15/2020 (Step-2)**
C.24	**Europa Clipper Gravity/Radio Science Team – Lead Scientist**	**10/21/2019 (mandatory NOIs)**	**11/06/2019**
C.24	**Europa Clipper Gravity/Radio Science Team – Team Member**	**10/21/2019 (mandatory NOIs)**	**01/24/2020**
C.25	**Akatsuki Participating Scientist Program**	**11/22/2019 (mandatory NOIs)**	**01/31/2020**
C.26	**Mars 2020 Participating Scientist Program**	**01/27/2020 (mandatory NOIs)**	**03/12/2020**
D.1	Astrophysics Research Program Overview	N/A	N/A
D.2	Astrophysics Data Analysis	See D.16 in ROSES-18	
D.3	**Astrophysics Research and Analysis**	**Not Solicited This Year**	
D.4	Astrophysics Theory Program	05/02/2019	06/27/2019
D.5	**Neil Gehrels Swift Observatory Guest Investigator Cycle 16**	**N/A**	**09/26/2019 (Phase-1 via ARK RPS)**
D.6	**Fermi Guest Investigator Cycle 13**	N/A	02/19/2020 (Phase-1 via ARK RPS)
D.7	**Strategic Astrophysics Technology**	**Not Solicited This Year**	
D.8	Nancy Grace Roman Technology Fellowships for Early Career Researchers	See D.3	
D.9	**NuSTAR General Observer Cycle 6**	N/A	01/24/2020 (Phase-1 via ARK RPS)
D.10	**TESS Guest Investigator Cycle 3**	**N/A**	**01/16/2020 (Phase-1 via ARK RPS)**

D.11	**NICER Guest Observer Cycle 2**	**N/A**	**11/13/2019 (Phase-1 via ARK RPS)**
D.12	**Astrophysics Science SmallSat Studies**	**N/A**	**12/19/2019**
D.13	**System-Level Segmented Telescope Design – Technology Maturation**	**N/A**	**06/13/2019**
E.1	Cross Division Research Overview	N/A	N/A
E.2	**Topical Workshops, Symposia, and Conferences**	N/A	Rolling submissions through 03/27/2020
E.3	Exoplanets Research [3]	See E.5 in ROSES-2018	
E.4	Habitable Worlds [3]	11/15/2019 (Step-1)	01/17/2020 (Step-2)
E.5	**Applied Information Systems Research**	**01/21/2020 (Step-1)**	**04/17/2020 (Step-2)**
E.6	**Future Investigators in NASA Earth and Space Science and Technology**	**N/A**	**02/04/2020**

Notes:

[1] Amended due dates and new program elements will be indicated with bold red text as ROSES-2019 is amended through the year.

[2] See Sections IV(b)(vi) and IV(b)(vii) of the *Summary of Solicitation* for a discussion of Notice of Intent (NOI) vs. a Step-1 proposal. If NOIs are required by a program in order to be able to submit a proposal, it will be indicated on this table with "(mandatory)".

[3] Program elements designated with [3] after their name participate in the Planetary Science Early Career Award Program (see C.19).

APPENDIX A. EARTH SCIENCE RESEARCH PROGRAM

A.1 EARTH SCIENCE RESEARCH OVERVIEW

1. Introduction

NASA's Earth Science Research Program supports research activities that address the Earth system and seek to characterize its properties on a broad range of spatial and temporal scales, to understand the naturally occurring and human-induced processes that drive them, and to improve our capability for predicting its future evolution. The focus of the Earth Science Research Program is the use of space-based measurements to provide information not available by other means. NASA's program is an end-to-end one that starts with the development of observational techniques and the instrument technology needed to implement them; tests them in the laboratory and from an appropriate set of *in situ,* surface-, ship-, balloon-, aircraft-, and/or space-based platforms; uses the results to increase basic process knowledge; incorporates results into complex computational models that can be used to more fully characterize the present state and future evolution of the Earth system; and develops partnerships with other national and international organizations that can use the generated information in environmental forecasting and in policy, business, and management decisions.

The scientific documentation underlying the Earth Science Research Program provides a comprehensive background for the science solicited here. The Research Program addresses NASA's Strategic Goal 1.1 to "Understand The Sun, Earth, Solar System, and Universe". (See the most recent *NASA Strategic Plan:* *https://www.nasa.gov/sites/default/files/atoms/files/nasa_2018_strategic_plan.pdf*). In particular, it addresses the more specific Science Goals (see the *Science Plan for NASA's Science Mission Directorate* (hereafter the *NASA Science Plan*), also available at https://smd-prod.s3.amazonaws.com/science-red/s3fs-public/atoms/files/2014_Science_Plan_PDF_Update_508_TAGGED_1.pdf), which are to:

- Advance the understanding of changes in the Earth's radiation balance, air quality, and the ozone layer that result from changes in atmospheric composition;
- Improve the capability to predict weather and extreme weather events;
- Detect and predict changes in Earth's ecosystems and biogeochemical cycles, including land cover, biodiversity, and the global carbon cycle;
- Enable better assessment and management of water quality and quantity to accurately predict how the global water cycle evolves in response to climate change;
- Improve the ability to predict climate changes by better understanding the roles and interactions of the oceans, atmosphere, land, and ice in the climate system;
- Characterize the dynamics of the Earth's surface and interior, improving the capability to assess and respond to natural hazards and extreme events; and
- Further the use of Earth system science research to inform decisions and provide benefits to society.

The most up-to-date description of the Earth Science Research Program may be found in Section 4.2 of the *NASA Science Plan* at http://science.nasa.gov/about-us/science-strategy. The most recent Decadal Survey covering NASA's Earth science activities, *Thriving on our Changing Planet: A Decadal Strategy for Earth Observation from Space*, was released on 1/5/2018 by the National Academies of Science, Engineering, and Medicine (see https://www.nap.edu/catalog/24938/thriving-on-our-changing-planet-a-decadal-strategy-for-earth). This 2017 Decadal Survey now serves as a foundational document for NASA's Earth Science Division (ESD), and includes recommendations for the scopes, foci, and relative budgetary magnitudes of the R&A, Applications, and Technology portions of the ESD program. In addition, the Decadal Survey includes a specific endorsement of the NASA missions making up the 2017 Program of Record (comprehensively defined in the Survey's Appendix A).

NASA's Earth Science Research Program is a major contributor to several interagency efforts within the U.S. Government, most notably the U.S. Global Change Research Program (USGCRP, see http://www.globalchange.gov), to which NASA is the major contributor. This program released its strategic plan in 2012, the National Global Change Research Plan 2012-2021: A Strategic Plan for the U. S. Global Change Research Program (http://www.globalchange.gov/browse/reports/national-global-change-research-plan-2012–2021-strategic-plan-us-global-change). This plan is updated triennially; the most recent such update may be found at https://downloads.globalchange.gov/strategic-plan/2016/usgcrp-strategic-plan-2016.pdf. Similarly, there are interagency programs related to Oceans and the Arctic. In addition, there are several other subgroups of the Committee on the Environment that serve to provide interagency coordination in areas covered by NASA's Earth Science Research Program. NASA's Earth Science Research Program has focused bilateral efforts with other Federal agencies on transitioning knowledge and approaches from research to operations, most notably with the National Oceanic and Atmospheric Administration (NOAA) and the U.S. Geological Survey (USGS).

Research is solicited in four major areas for the Earth Science Research Program: research and analysis (R&A), satellite missions, applied sciences, and enabling capabilities, with R&A containing the bulk of the solicited research. R&A emphasizes the development of new scientific knowledge, including the analysis of data from NASA satellite missions and the development and application of complex models that assimilate these science data products and/or use them for improving predictive capabilities. Within the Earth Science Research Program, the research and analysis activities include those historically coming under R&A, mission science team, interdisciplinary science, and calibration/validation activities.

The applied sciences area supports efforts to discover and demonstrate innovative and practical uses of NASA Earth science observations and research through applications projects carried out in partnership with end user organizations (http://AppliedSciences.nasa.gov/). Applied sciences, thus, serves as a bridge between the data, modeling, and knowledge generated by NASA Earth science and the information required by Government agencies, companies, and organizations to improve their products, services, and decision making.

Enabling capabilities include those programmatic elements with sufficient breadth to contribute to a broad range of activities within the Earth Science Research Program and typically involve the development of some kind of capability whose sustained availability is considered to be important for the Program's future. These include focused activities in support of education; data, information, and management; and airborne science, as well as some broadly-based technology-related elements (others which are very focused towards a single scientific area of the Earth Science Research Program will be solicited through the R&A area).

Most proposals to ROSES-2019 will require a data management plan (DMP) or an explanation of why one is not necessary given the nature of the work proposed. Proposers will satisfy this requirement by responding to the compulsory NSPIRES cover page question about the DMP, unless otherwise specified in a specific program element. The kinds of proposals that require a data management plan are described in the NASA Plan for increasing access to results of Federally funded research and in the SARA DMP Frequently Asked Questions (FAQs) for ROSES. Proposals to instrument development programs (Advanced Information Systems Technology, the Instrument Incubator Program, Advanced Component Technology, and In-Space Validation of Earth Science Technologies) do not require a DMP. Moreover, select calls, such as Advancing Collaborative Connections for Earth System Science (ACCESS), include data requirements in the text that make redundant the cover page DMP. Any proposal intending to submit data products for archival and public distribution by a NASA Distributed Active Archive Center (DAAC) should review guidelines on the Earthdata web site.

The overarching goal of NASA's Earth Science program is to develop a scientific understanding of Earth as a system. Scientific knowledge is most robust and actionable when resulting from transparent, traceable, and reproducible methods, requiring open access to not only the data used in scientific analysis, but the software used to arrive at results as well. Additionally, software developed to be openly accessible, without restrictions on modification and distribution, enables reuse across Federal agencies, reduces overall costs to the Government, removes barriers to innovation, ensures consistency through the application of uniform standards, and facilitates collaboration between agencies and non-Federal institutions. NASA addresses these goals by encouraging the open development, access, and distribution of the source code used to generate, manipulate, and analyze science data and results.

Toward that end, NASA encourages software developed in response to Appendix A program elements be designated, developed, and distributed to the public as Open Source Software (OSS). This includes all software developed with ESD funding used in the production of data products, as well as software developed to discover, access, visualize, and transform NASA data. OSS is defined as software that can be accessed, used, modified, and shared by anyone. The definition of OSS, along with examples of OSS licensing and public code repositories, can be found on the Earthdata web site.

Program elements will give preference to proposals that include a plan for committing software as OSS, beginning at the inception of the proposed work. This plan will include the identification of software components developed as part of the proposed work, and designate a permissive, widely accepted OSS license and a public repository hosting service for these components. Please read the individual appendices and associated amendments carefully and contact the program officers if you have any questions regarding OSS development for a given call.

Contracts will not be issued in response to proposals submitted to the research program elements in Appendix A, unless otherwise noted (e.g., exceptions include calls for flight hardware). Instead, awards to non-governmental organizations will be made in the forms of grants or cooperative agreements, which are most appropriate given the nature of the work solicited. Awards internal to the government will be made through the usual Agency processes.

2. Earth Science Research and Analysis Focus Areas

The Earth Science R&A activity is built around the creation of new scientific knowledge about the Earth system. The analysis and interpretation of data from NASA's satellites form the heart of the R&A program in the Earth Science Research Program, although a full range of underlying scientific activity needed to establish a rigorous base for the satellite data and their use in computational models, including those for assimilation and forecasting, is also included. The complexity of the Earth system, in which spatial and temporal variability exists on a range of scales, requires that an organized scientific approach be developed for addressing the complex, interdisciplinary problems that exist, taking good care that, in doing so, there is a recognition of the objective to integrate science across the programmatic elements towards a comprehensive understanding of the Earth system.

In the Earth system, these elements may be built around aspects of the Earth that emphasize the particular attributes that make it stand out among known planetary bodies. These include the presence of carbon-based life and their associated ecology; water in multiple, interacting phases; a fluid atmosphere and ocean that redistribute heat over the planetary surface; an oxidizing and protective atmosphere, *albeit* one subject to a wide range of fluctuations in its physical properties (especially temperature, moisture, and winds); a solid but dynamically active surface and interior that drive changes in the Earth's shape, orientation, rotation, gravity, and surface and atmospheric composition; and an external environment driven by a large and varying star whose magnetic field also serves to shield the Earth from the broader astronomical environment. The resulting structure is comprised of six interdisciplinary science Focus Areas:

- Carbon Cycle and Ecosystems,
- Water and Energy Cycle,
- Climate Variability and Change,
- Atmospheric Composition,
- Weather, and
- Earth Surface and Interior.

These Focus Areas form the basis around which R&A activity is solicited for the Earth Science Research Program. Given the interconnectedness of these science Focus Areas, research that crosses individual Focus Areas is also sought, and a number of specific cases of such connectivity will be identified in some of the specific research opportunities identified below. In particular, several instrument science teams for NASA satellite missions are solicited through this NRA. These can contribute to scientific advances in several areas, and potential investigators may want to look carefully at all such teams for opportunities that may be relevant to them. In addition, there are several cross-cutting elements included within this appendix, most notably one that solicits proposals that address rapid response to significant Earth system events, as well as truly novel work that doesn't easily fit the active ROSES-2019 elements this year or in the recent past (Rapid Response and Novel Research in Earth Science – program element A.29).

Several elements solicited in prior years are not being solicited this year, but have program-specific ROSES-2019 elements for completeness, as well as to provide potential proposers with plans about the anticipated dates of the next solicitation.

- Ocean Biology and Biogeochemistry (program element A.3);
- Terrestrial Ecology (program element A.4);
- Carbon Cycle Science (program element A.5);
- Biodiversity (program element A.7);
- Ocean Surface Topography Science Team (program element A.14);
- Ocean Vector Winds Science Team (program element A.15);
- Cryospheric Science (program element A.17);
- Atmospheric Composition: Upper Atmosphere Research Program (program element A.18);
- Atmospheric Composition: Radiation Sciences Program (program element A.19);
- Atmospheric Composition: Modeling and Analysis (program element A.20);
- Atmospheric Composition: Tropospheric Composition Program (program element A.21);
- NASA Energy and Water Cycle Study (program element A.24);
- U.S. Participating Investigator (program element A.31);
- New (Early Career) Investigator Program in Earth Science (program element A.34);
- The Science of Terra, Aqua, and Suomi-NPP (program element A.35);
- Studies with ICESat-2 (program element A.36);
- The Plankton, Aerosol, Cloud, Ocean Ecosystem (PACE) Mission System Vicrarious Calibration (program element A.39)
- Earth Science Applications: Water Resources (program element A.41):
- SERVIR Applied Sciences Team (program element A.42);
- Earth Science Applications: Disaster Risk Reduction and Response (program element A.43);
- Health and Air Quality Applied Sciences Team (program element A.44);
- Ecological Forecasting (program element A.45);
- Citizen Science for Earth Systems Program (program element A.47);
- Advanced Information Systems Technology (program element A.48);
- Advanced Component Technology (program element A.50);
- In-Space Validation of Earth Science Technologies (program element A.51); and
- Sustainable Land Imaging – Technology (program element A.52).

Elements for which it has not yet been decided whether or not to solicit during the period of applicability of ROSES-2019 are not included in this list, but are included by focus area and/or program component later in Appendix A. Note that not all elements which have been solicited in previous ROSES are included this year; some will reappear in future solicitations at an appropriate time that should allow for smooth transition between the currently funded tasks and those that would come out of the next solicitation.

2.1 Carbon Cycle and Ecosystems

The carbon cycle, which encompasses the flow and transformation of carbon between reservoirs, is the backbone that sustains life on planet Earth. The cycling of carbon dioxide and methane into the atmosphere contributes to the planetary greenhouse effect and global climate. Organic and inorganic carbon flow through ecosystems as part of food webs, and interact with the climate system. Earth’s carbon cycle and ecosystems are subject to human intervention and environmental changes on an unprecedented scale, in both rate and geographical extent. This has the potential to impact ecosystem services, which provide a wide variety of essential goods to human societies. Our ability to ameliorate, adapt to, or benefit from these rapid changes requires fundamental knowledge of the responses of the carbon cycle and terrestrial and marine ecosystems to global change. Also required is an understanding of the implications of these changes for food production, biodiversity, sustainable resource management, and the maintenance of a healthy, productive environment.

The Carbon Cycle and Ecosystems Focus Area addresses: (1) the distribution and cycling of carbon among the active terrestrial, marine, and atmospheric reservoirs and (2) ecosystems as they are affected by human activity, as they change due to their own intrinsic biogeochemical dynamics, and as they respond to climatic variations and, in turn, affect climate. Research activities focus on providing data and information derived from remote sensing systems to answer the following science questions:

- How are global ecosystems changing?
- What changes are occurring in global land cover and land use, and what are their causes?
- How do ecosystems, land cover and biogeochemical cycles respond to and affect global environmental change?
- What are the consequences of land cover and land use change for human societies and the sustainability of ecosystems?
- What are the consequences of climate change and increased human activities for coastal regions?
- How will carbon cycle dynamics and terrestrial and marine ecosystems change in the future?

Frequent, repeat observations from space, at both moderate and high spatial resolutions, are required to address the heterogeneity of living systems. Complementary airborne and *in situ* observations, intensive field campaigns and related process studies, fundamental research, data and information systems, and modeling are employed to interpret the satellite observations and answer the science questions.

The goal of the Carbon Cycle and Ecosystems Focus Area is to:

- Quantify, understand, and predict changes in Earth's ecosystems and biogeochemical cycles, including the global carbon cycle, land cover, and biodiversity.

Anticipated products and payoffs include:

- Assessments of ecosystem response to climatic and other environmental changes and the effects on food, fiber, biodiversity, primary productivity, and other ecological goods and services;
- Quantitative carbon budgets for key ecosystems along with the identification of sources and sinks of carbon dioxide and other greenhouse gases;
- Documentation and prediction of land-cover and land-use change, as well as assessments of consequences to society and for resource sustainability;
- Understanding of ecosystem interactions with the atmosphere and hydrosphere leading to comprehensive modeling of the exchange of gases, aerosols, water, and energy among the components of the Earth system; and
- Improved representations of ecosystem and carbon cycling processes within global climate models leading to more credible predictions of climate and other Earth system functions.

Interdisciplinary collaborations with other Earth Science Research Program Focus Areas include:

- Work with the Water and Energy Cycle Focus Area on land-atmosphere exchanges of water and energy and the effects of land-cover and land-use change on water resources;
- Work with the Atmospheric Composition Focus Area on surface emissions and atmospheric transport of trace gases and aerosols and on measurement of carbon-containing greenhouse gases;
- Work with the Climate Variability and Change and Weather Focus Areas on air-sea CO_2 exchange and to share the observations of climate, weather, ecosystems, and land cover that are needed to drive Earth system models; and
- Coordinate with the Earth Surface and Interior Focus Area to advance and/or exploit radar, lidar, and hyperspectral remote sensing technologies for surface properties.

The ROSES elements most closely directed towards the Carbon Cycle and Ecosystems Focus Area that are or may be soliciting proposals in ROSES-2019 are:

- Land-Cover and Land-Use Change (program element A.2);
- Carbon Monitoring System (program element A.6); and
- GEDI Science Team (program element A.8).

Topics relevant to the Carbon Cycle and Ecosystems Focus Area that are actively or potentially soliciting in ROSES-2019 include the following program elements:

- Atmospheric Composition: Aura Science Team (program element A.22);
- SMAP Science Team (program element A.25);
- Rapid Response and Novel Research in Earth Science (program element A.29);
- Airborne Instrument Technology Transition (program element A.30);

- Interdisciplinary Research in Earth Science (program element A.32);
- Earth Science Research from Operational Geostationary Satellite Systems (program element A.33);
- PACE Science and Applications Team (program element A.38);
- High Mountain Asia Team (program element A.40);
- Advancing Collaborative Connetions for Earth System Science (program element A.46);
- Instrument Incubator Program (program element A.49); and
- Topical Workshops, Symposia, and Conferences (program element E.2).

2.2 Climate Variability and Change

Climate change is one of the major themes guiding Earth System Science today. NASA is at the forefront of quantifying forcings and feedbacks of recent and future climate change. Our comprehensive end-to-end program ranges from global high-resolution observations to data assimilation and model predictions. Recently, the Climate Variability and Change Focus Area has directed its research toward addressing five specific questions:

- How is global ocean circulation varying on interannual, decadal, and longer time scales?
- What changes are occurring in the mass of the Earth's ice cover?
- How can climate variations induce changes in the global ocean circulation?
- How is global sea level affected by natural variability and human-induced change in the Earth system?
- How can predictions of climate variability and change be improved?

Climate-variability and change research is now not just a global issue, but also a research problem that directly impacts regional to local environments. In fact, local-to-regional anthropogenic-induced changes are having global impacts whose magnitudes are expected to increase in the future. Climate models have moved toward higher and higher spatial resolution as computer resources have improved. During the next decade, climate models are expected to approach the spatial resolution of weather and regional models as more details of Earth System processes are incorporated.

The oceans are a major part of the climate system and a unique NASA contribution to climate science is the near-global coverage of observations from space of selected ocean properties every two to ten days. Additionally, NASA provides observations of the vast expanses of polar ice, including both ice sheets and sea ice, on the temporal and spatial scales necessary to detect change and sampling of the other critical elements of the climate system that link climate to other Focus Areas, such as cloud distribution, snow cover, surface temperatures, humidity characteristics, etc.

NASA makes substantial investments to characterize and understand the nature and variability of the climate system. As part of those investments, NASA maintains an active research program to utilize data from satellites to both improve our understanding of these components of the Earth system and the interactions between them and to assess how satellite observations can be used to improve predictive capability. Current capabilities include global measurements of sea-surface topography, ocean-vector winds, ice topography and motion, and mass movements of the Earth’s fluid envelope and cryosphere.

Understanding interactions within the climate system also requires strong modeling and analysis efforts. The climate system is dynamic and complex, and modeling is the only way we can effectively integrate the observations and current knowledge of individual components fully to characterize current conditions and underlying mechanisms, as well as to project the future states of the climate system. This modeling requires a concerted effort both to improve the representation of physical, chemical, and biological processes and to incorporate observations into climate models through data assimilation and other techniques. The ultimate objective is to enable a predictive capability of climate change on time scales ranging from seasonal to multidecadal.

The ROSES elements most closely directed towards the Climate Variability and Change Focus Area that are or may be soliciting proposals in ROSES-2019 are:

- Physical Oceanography (program element A.9);
- Ocean Salinity Science Team (program element A.10);
- Sea Level Change Science Team (program element A.11);
- SWOT Science Team (program element A.12);
- SWOT Calibration/Validation Field Campaigns (program element A.13); and
- Modeling, Analysis, and Prediction (program element A.16).

Topics relevant to the Climate Variability and Change Focus Area that are actively or potentially soliciting in ROSES-2019 include the following program elements:

- Carbon Monitoring System (program element A.6);
- Atmospheric Composition: Aura Science Team (program element A.22);
- SMAP Science Team (program element A.25);
- GRACE-FO Science Team (program element A.28);
- Rapid Response and Novel Research in Earth Science (program element A.29);
- Airborne Instrument Technology Transition (program element A.30);
- Interdisciplinary Research in Earth Science (program element A.32);
- Earth Science Research from Operational Geostationary Satellite Systems (program element A.33);
- GNSS Research (program element A.37);
- High Mountain Asia Team (program element A.40);
- Advancing Collaborative Connetions for Earth System Science (program element A.46);
- Instrument Incubator Program (program element A.49); and
- Topical Workshops, Symposia, and Conferences (program element E.2).

2.3 Atmospheric Composition

Changes in atmospheric composition affect air quality, weather, climate, and critical constituents, such as ozone and aerosol particles. Atmospheric exchange links terrestrial and oceanic pools within the carbon cycle and other biogeochemical cycles. Solar radiation affects atmospheric chemistry and is, thus, a critical factor in atmospheric composition. Atmospheric composition, in turn, affects incoming solar and outgoing long wave radiation. Atmospheric composition is central to Earth system dynamics, since the atmosphere integrates surface emissions globally on time scales from weeks to years and couples several environmental issues. NASA's research for furthering our understanding of atmospheric composition is geared to providing an improved prognostic capability for such issues (e.g., the recovery of stratospheric ozone and its impacts on surface ultraviolet radiation, the evolution of greenhouse gases and their impacts on climate, the impact of clouds and aerosol particles on the Earth's energy budget and the evolution of aerosols and tropospheric ozone and their impacts on climate and air quality). Toward this end, research within the Atmospheric Composition Focus Area addresses the following science questions:

- How is atmospheric composition changing?
- What trends in atmospheric composition and solar radiation are driving global climate?
- How does atmospheric composition respond to and affect global environmental change?
- What are the effects of global atmospheric composition and climate changes on regional air quality?
- How will future changes in atmospheric composition affect ozone, climate, and global air quality?

NASA expects to provide the necessary monitoring and evaluation tools to assess the effects of climate change on ozone recovery and future atmospheric composition, improved climate forecasts based on our understanding of the forcings of global environmental change, and air quality forecasts that take into account the feedbacks between regional air quality and global climate change. Achievements in these areas via advances in observations, data assimilation, and modeling enable improved predictive capabilities for describing how future changes in atmospheric composition affect ozone, climate, and air quality. Drawing on global observations from space, augmented by airborne, balloon, and ground-based measurements, NASA is uniquely poised to address these issues. This integrated observational strategy is furthered via studies of atmospheric processes using unique suborbital platform-sensor combinations to investigate, for example: (1) the processes responsible for the emission, uptake, transport, and chemical transformation of ozone and precursor molecules associated with its production in the troposphere and its destruction in the stratosphere; and (2) the formation, properties, and transport of aerosol particles in the Earth's troposphere and stratosphere, as well as aerosol particle interaction with clouds. NASA's research strategy for atmospheric composition encompasses an end-to-end approach for instrument design, data collection, analysis, interpretation, and prognostic studies.

No ROSES element exclusively focused on the Atmospheric Composition Focus Area that are or may be soliciting for proposals in ROSES-2019.

Topics relevant to the Atmospheric Composition Focus Area are actively or potentially soliciting in ROSES-2019 include the following program elements:

- Carbon Monitoring System (program element A.6);
- Atmospheric Composition: Aura Science Team (program element A.22);
- Rapid Response and Novel Research in Earth Science (program element A.29);
- Airborne Instrument Technology Transition (program element A.30);

- Interdisciplinary Research in Earth Science (program element A.32);
- Earth Science Research from Operational Geostationary Satellite Systems (program element A.33);
- PACE Science Team (program element A.38);
- High Mountain Asia Team (program element A.40);
- Advancing Collaborative Connections for Earth System Science (program element A.46);
- Instrument Incubator Program (program element A.49); and
- Topical Workshops, Symposia, and Conferences (program element E.2).

2.4 <u>Water and Energy Cycle</u>

Earth is a unique, living planet in our Solar System due to the abundance of water and the vigorous cycling of that water throughout its global environment. The global water cycle represents the transport and transformation of water within the Earth system, and, as such, distributes fresh water over the Earth's surface. The water cycle operates on a continuum of time and space scales and exchanges large amounts of energy as water undergoes phase changes and is moved from one part of the Earth system to another. Through latent heat release from condensation and sublimation, the water cycle is a major driving agent of global atmospheric circulation. Clouds play a critical role in modulating the flow of energy into and out of the Earth system, while at the same time modulating the continuous supply of solar energy that keeps the water cycle in motion. So, while the water cycle delivers the hydrologic consequences of climate changes, the global water cycle is both a consequence of, and influence on, the global energy cycle.

The global water and energy cycles maintain a considerable influence upon the global pathways of biogeochemical cycles. The cycling of water and energy and nutrient exchanges among the atmosphere, ocean, and land help determine the Earth's climate and cause much of the climate's natural variability. Natural and human-induced changes to the water and energy cycle have major impacts on industry, agriculture, and other human activities. For example, increased exposure and density of human settlements in vulnerable areas amplify the potential loss of life, property, and commodities that are at risk from intense precipitation events. Improved monitoring and prediction of the global water and energy cycle enable improved knowledge of the Earth system that must be nurtured to proactively mitigate future adversities. Current and forthcoming projections of such impacts will remain speculative unless fundamental understanding is assimilated into global prediction systems and effective decision-support tools applicable to local conditions.

The Terrestrial Hydrology Program resides exclusively within the Water and Energy Cycle Focus Area. Other programs (Radiation Sciences, Weather and Atmospheric Dynamics, and Land-Cover Land-Use Change) which contribute to this focus area are shared with other focus areas (Atmospheric Composition, Weather, and Carbon Cycle and Ecosystems, respectively). In brief, the Water and Energy Cycle Focus Area seeks to address the topics discussed above by enhancing our understanding of the transfer and storage of water and energy in the Earth system. For the water cycle, the Focus Area's emphasis is on atmospheric and terrestrial stores, including seasonal snow cover. Permanent snow and ice, as well as ocean dynamics, are studied within the

Climate Variability and Change Focus Area. The Water and Energy Cycle Focus Area aims to resolve all fluxes of water and the corresponding energy fluxes involved with water changing phase.
In addition to the study of the individual components of the water and energy cycle, this Focus Area places a high priority on integrating these components in a coherent fashion as is pursued by the NASA Energy and Water Cycle Study (NEWS), for which more information can be found at https://wec.gsfc.nasa.gov. NEWS has been established to create a mechanism to export and import information, results, and technology to and from other U.S. agencies and international partners concerned with the study and observation of water and energy cycles, such as the Global Energy and Water Cycle Exchanges project (GEWEX; http://www.gewex.org/).

All of the Focus Area's activities should enhance the community's ability to answer these research questions:

- How are global precipitation, evaporation, and the cycling of water changing?
- What are the effects of clouds and surface hydrologic processes on Earth's climate?
- How are variations in local weather, precipitation, and water resources related to global climate variation?
- What are the consequences of land cover and land use change for human societies and the sustainability of ecosystems?
- How can weather forecast duration and reliability be improved?
- How can prediction of climate variability and change be improved?
- How will water cycle dynamics change in the future?

Pursuit of answers to these questions should lead to research products, such as satellite data and model outputs, that are useful to activities sponsored by the Applied Sciences Program, in particular, the Applications areas of water resources, disasters, and ecological forecasting (see Section 3 for more details on the Applied Sciences Program). Ultimately, Water and Energy Cycle Focus Area-sponsored activities will lead to the fulfillment of its goal: "Models capable of predicting the water cycle, including floods and droughts, down to tens of kilometers resolution."

The ROSES elements most closely directed towards the Water and Energy Cycle Focus Area that are or may be soliciting for proposals in ROSES-2019 are:

- Terrestrial Hydrology (program element A.23); and
- SMAP Science Team (program element A.25).

Topics relevant to the Water and Energy Cycle Focus Area that are actively or potentially soliciting in ROSES-2019 include the following program elements:

- Carbon Monitoring System (program element A.6);
- SWOT Science Team (program element A.12);
- SWOT Calibration/Validation Field Campaign (program element A.13);
- Atmospheric Dynamics (program element A.26);
- GRACE-FO Science Team (program element A.28);
- Rapid Response and Novel Research in Earth Science (program element A.29);
- Airborne Instrument Technology Transition (program element A.30);

- Interdisciplinary Research in Earth Science (program element A.32);
- Earth Science Research from Operational Geostationary Satellite Systems (program element A.33);
- GNSS Research (program element A.37);
- High Mountain Asia Team (program element A.40);
- Advancing Collaborative Connetions for Earth System Science (program element A.46);
- Instrument Incubator Program (program element A.49); and
- Topical Workshops, Symposia, and Conferences (program element E.2).

2.5 Weather

The Weather Focus Area represents the cooperation among NASA programs for Atmospheric Dynamics, Weather Forecast Improvement, and Ocean and Land Remote Sensing. It has strong ties to other Focus Areas, especially Climate Variability and Change and Water and Energy Cycle, and it has a supporting role in Carbon Cycle and Ecosystems and the Atmospheric Composition Focus Areas.

The Weather Focus Area is primarily designed to apply NASA scientific remote sensing expertise to the problem of obtaining accurate and globally distributed measurements of the atmosphere and the use of these measurements in retrievals, research, and operational weather forecast models in order to both enhance our understanding of weather systems and their role(s) in the Earth system, as well as to improve and extend U.S. and global weather prediction. This Focus Area is implemented in coordination with other U.S. agencies' programs and it is guided by the question from the 2003 Earth Science Enterprise Strategy:

- How can weather forecast duration and reliability be improved?

NASA sponsored research continues to gain new insight into weather and extreme-weather events by the utilization of data obtained from a variety of NASA- and partner satellite platforms and hurricane field experiments. Major numerical weather prediction (NWP) centers both outside (European Centre for Medium Range Weather Forecasts (ECMWF) and in the U.S. – NOAA/National Centers for Environmental Prediction (NCEP), NASA Global Modeling and Assimilation Office (GMAO), and the U.S. Navy – have shown notable improvements from the assimilation of Atmospheric Infrared Sounder (AIRS) data into their operational forecast systems.

An extra benefit of AIRS data assimilation at NWP centers is its use in establishing readiness to assimilate data from other current and future operational instruments, as has been demonstrated for the Crosstrack Infrared Sounder (CrIS) on the Suomi National Polar-orbiting Partnership (NPP) and Joint Polar Satellite System-1 satellite slaunched in October 2011 and November, 2017, respectively. Recent advancement in the Nation's operational geostationary capability, especially the Advanced Baseline Imager (ABI) and Geostationary Lightning Mapper (GLM) on the Geostationary Operational Environmental Satellite (GOES) – R series are of interest to the Weather Focus Area. Currently NASA is prioritizing on assimilating all-sky radiance into GEOS-5 to take advantage of the GPM data.

The study and analysis of the dynamics of the atmosphere and its interaction with the oceans and land is also an important component of the Weather Focus Area. Improvement of our knowledge of weather processes and related phenomena is crucial in gaining a better understanding of the Earth system. Applying NASA Scientific remote sensing data such as from the Global Precipitation Measurement (GPM) mission, GOES, ATMS, SMAP, and CYGNSS could lead to improved retrieval algorithms, increased knowledge of atmospheric dynamical processes, and assimilation of these measurements into NASA's research investigations, cloud and climate models, and quasi-operational weather models should improve global weather prediction, climate change studies, and information on the interactions within the Earth System.

Two major investments in the Weather Forcus Area form the integrator and transition centers of research results in this area. Through collaborations in the Joint Center for Satellite Data Assimilation (JCSDA) (https://www.star.nesdis.noaa.gov/jcsda/), observations from Suomi-NPP were assimilated into the operational weather forecast systems in a record seven months after the satellite launch. Observation impact analyses conducted with NASA Goddard Earth Observing System model, version 5 (GEOS-5) in the NASA Global Modeling and Assimilation Office, showed that, in concert with other observations, the Advanced Technology Microwave Sounder (ATMS) and CrIS have made positive impacts on a global integrated forecast metric.

On the short time scale, the NASA Short-term Prediction Research and Transition (SPoRT) (http://weather.msfc.nasa.gov/sport/) program is an end-to-end research-to-operations (R2O) activity focused on improving weather forecasts through the use of unique high-resolution, multispectral observations from NASA and NOAA satellites, nowcasting tools, and advanced modeling and data assimilation techniques. The SPoRT program has established a successful R2O paradigm in which the end-users (mainly forecasters at NOAA/NWS forecast offices and National Centers) are involved in the entire process. SPoRT also partners with universities and other Government agencies to develop new products that are transitioned to applicable end user decision support systems. SPoRT has recently succeeded in broadening its activities to other National Weather Service (NWS) Regions and its active participation in NOAA Proving Ground activities and Testbeds.

The ROSES element most closely directed towards the Weather Focus Area that are or may be soliciting for proposals in ROSES-2019 are:

- Weather and Atmospheric Dynamics (program element A.26); and

Topics relevant to the Weather Focus Area that are actively or potentially soliciting in ROSES-2019 include the following program elements:

- Carbon Monitoring System (program element A.6);
- Atmospheric Composition: Aura Science Team (program element A.22);
- SMAP Science Team (program element A.25);
- Rapid Response and Novel Research in Earth Science (program element A.29);
- Interdisciplinary Research in Earth Science (program element A.32);
- Earth Science Research from Operational Geostationary Satellite Systems (program element A.33).
- High Mountain Asia Team (program element A.40);

- Advancing Collaborative Connetions for Earth System Science (program element A.46);
- Instrument Incubator Program (program element A.49); and
- Topical Workshops, Symposia, and Conferences (program element E.2).

2.6 Earth Surface and Interior

The Earth Surface and Interior Focus Area promotes the development and application of remote sensing to better understand core, mantle, and lithospheric structure and dynamics, and interactions between these processes and Earth's fluid envelopes. ESI studies provide the basic understanding and data products needed to inform the assessment, mitigation, and forecasting of natural hazards, including phenomena such as earthquakes, tsunamis, landslides, and volcanic eruptions. These investigations also exploit the time-variable signals associated with other natural and anthropogenic perturbations to the Earth system, including those associated with the production and management of natural resources. Space-based remote sensing is vital to forecasting in the solid Earth sciences, providing a truly comprehensive perspective for monitoring the entire solid Earth system. ESI seeks to address the questions:

1. What is the nature of deformation associated with plate boundaries and what are the implications for earthquakes, tsunamis, and other related natural hazards?
2. How do tectonic processes and climate variability interact to shape Earth's surface and create natural hazards?
3. How does the solid Earth respond to climate-driven exchange of water among Earth systems and what are the implications for sea-level change?
4. How do magmatic systems evolve, under what conditions do volcanoes erupt, and how do eruptions and volcano hazards develop?
5. What are the dynamics of Earth's deep interior and how does Earth's surface respond?
6. What are the dynamics of Earth's magnetic field and its interactions with the rest of Earth's systems?
7. How do human activities impact and interact with Earth's surface and interior?

ESI's Space Geodesy Program (SGP) produces observations that refine our knowledge of Earth's shape, rotation, orientation, and gravity, advancing our understanding of the motion and rotation of tectonic plates, elastic properties of the crust and mantle, mantle-core interactions, solid Earth tides, and the effects of surface loading resulting from surface water, ground water, glaciers, and ice sheets. SGP infrastructure enables the establishment and maintenance of a precise terrestrial reference frame that is foundational to many Earth missions and location-based observations.

Modeling, calibration, and validation are essential components in advancing the above solid-Earth science objectives. ESI views natural laboratories as a critical component for the validation and verification of remote sensing algorithms. For example, NASA joins with the National Science Foundation (NSF) in support of the Geodetic Facility for the Advancement of Geoscience (GAGE) initiative to maintain and operate a set of foundational geodetic capabilities that are essential for current research efforts to measure Earth changes with unprecedented spatial and temporal resolution, enabling advances in our understanding of tectonic processes; earthquakes and tsunami;

magmatic processes; landslide hazards; continental water storage; atmospheric, ice sheet and glacier dynamics; and interactions among these components of the Earth system.

Among the many activities carried out by ESI are the following:

- Geodetic and thermal imaging of the precise metrology of Earth's surface and its changes through GNSS, lidar, radar constellations, and optical arrays, coupled with geopotential field measurements to understand the dynamics of the Earth's surface and interior;
- Development of a stable terrestrial reference frame, highly precise realization of topography and topographic change, and understanding of changes in the Earth's angular momentum and gravity fields, which can be applied to issues such as sea-level change, polar mass balance, and land subsidence;
- Use of gravitational and magnetic observables for studying the inner dynamics of the Earth, as well as for studies of how the ionosphere responds to changes in the Earth's surface; and
- Improved forecasts and early warnings for earthquakes, tsunamis, landslides, and volcanic eruptions through the use of a broad range of Earth surface remote sensing and space geodesy approaches.

The ROSES element most closely directed towards the Earth Surface and Interior Focus Area that are or may be soliciting for proposals in ROSES-2019 is:

- Earth Surface and Interior (program element A.27).

Topics relevant to the Earth Surface and Interior Focus Area that are actively or potentially soliciting in ROSES-2019 include the following program elements:

- Carbon Monitoring System (program element A.6);
- Sea Level Change Science Team (program element A.11);
- Atmospheric Composition: Aura Science Team (program element A.22);
- SMAP Science Team (program element A.25);
- GRACE-FO Science Team (program element A.28);
- Rapid Response and Novel Research in Earth Science (program element A.29);
- Airborne Instrument Technology Transition (program element A.30);
- Interdisciplinary Research in Earth Science (program element A.32);
- Earth Science Research from Operational Geostationary Satellite Systems (program element A.33);
- GNSS Research (program element A.37);
- High Mountain Asia Team (program element A.40);
- Advancing Collaborative Connetions for Earth System Science (program element A.46);
- Instrument Incubator Program (program element A.49); and
- Topical Workshops, Symposia, and Conferences (program element E.2).

2.7 Cross-Cutting and Interdisciplinary

There are several cross-cutting and interdisciplinary elements in ROSES-2019, all of which have been identified as related elements to specific research focus areas in Sections 2.1 through 2.6 (and also briefly summarized in the overview to Section 2). These elements, all of which are being actively solicited in ROSES-2019 or are being evaluated for possible solicitation, are:

- *GRACE FO Science Team (program element A.28)* - This ROSES element seeks proposals that will advance the development of new methods, algorithms, and models for the exploitation of gravity field observations to be made by GRACE, GRACE-Follow on (FO), and future space based gravity field missions for the broad spectrum of Earth system science challenges. This solicitation also seeks the development of techniques and algorithms capable of bridging gravity field observation across different gravity missions.
- *Rapid Response and Novel Research in Earth Science* (program element A.29) – This program element allows for two types of proposals not normally solicited through ROSES – (a) immediate research activity to take advantage of a target of opportunity due to an unforeseen event in the Earth system, and (b) exceptionally novel and innovative ideas to advance Earth remote sensing that do not fit within ESD's current slate of solicitations and or programs;
- *Airborne Instrument Technology Transition (program element A.30)* – This announcement seeks to upgrade mature instruments developed under NASA's Instrument Incubator Program (IIP – see Appendix A.49 for details on this program), or by similar NASA or externally-supported (e.g., corporate, other federal agency, internal institution funding) programs or activities. This opportunity provides for engineering activities leading to the integration of instruments to airborne platforms that will deploy them as part of organized airborne science campaigns that typically involve multiple instruments and/or platforms. The goal is to upgrade existing operating instruments to campaign-ready airborne configuration(s). Management of the tasks selected in response to these Airborne Instrument Technology Transition calls is carried out in conjunction with the Earth Science Technology Office (ESTO).
- *Interdisciplinary Research in Earth Science (program element A.32)* - This solicitation is for new and successor interdisciplinary research investigations within NASA's Interdisciplinary Research in Earth Science (IDS) program. Proposed research investigations will meet the following criteria: a) offer a fundamental advance to our understanding of the Earth system; b) be based on remote sensing data, especially satellite observations, but including suborbital sensors as appropriate; c) go beyond correlation of data sets and seek to understand the underlying causality of change through determination of the specific physical, chemical, and/or biological processes involved; d) be truly interdisciplinary in scope by involving traditionally disparate disciplines of the Earth sciences; and e) address at least one of the specific themes listed in any particular IDS solicitation.
- *Earth Science Research from Operational Geostationary Satellite Systems (program element A.33)* – This announcement is to provide an opportunity for the earth science research community to develop additional products from the new

generation of operational geostationary satellites (e.g., Japan's Himawari, NOAA's Global Operational Environmental Satellites, …) beyond those produced by the operational agencies that implement them. These products could be for earth system parameters not produced by those agencies, or could use algorithms different from those currently used. The element also allows for the use of currently produced and/or future operational geostationary satellite data to address research questions till now addressed only with low earth orbit (LEO) satellites.

- *GNSS Research (program element A*.37) – This announcement seeks innovative approaches to the development of GNSS remote sensing techniques and algorithms to advance NASA's Earth Science program as described in Appendix A.1; the National Academy of Sciences, Engineering, and Medicine Decadal Survey, *Thriving on Our Changing Planet: A Decadal Strategy for Earth Observation from Space* (2018) (https://www.nap.edu/catalog/24938), and NASA's *Challenges and Opportunities for Research in ESI (CORE) Report* (2016) (http://go.nasa.gov/2hmZLQO). Proposals that develop new processing and analysis approaches; improve positioning, navigation, and timing (PNT) using GNSS and Regional Navigation Satellite Systems (RNSS) signals; and develop truly multi-GNSS capabilities are encouraged. Potential areas of consideration include, but are not limited to, rapid characterization of transient processes, probing of ionospheric structure, improvements to the international terrestrial reference frame, leveraging Signals of Opportunity (SoOp), GNSS reflectometry for recovery of Earth surface or atmospheric characteristics, and GNSS radio occultation for recovery of atmospheric structure.
- *PACE Science and Applications Team (program element A*.38) – This announcement solicits for the next phase of a science team for the planned Plankton, Aerosol, Cloud, Ocean Ecosystem (PACE) mission, which is to include an ocean color sensor and one or more aerosol/cloud polarimeters, in order to produce data to maintain a time series of critical climate and Earth system variables;
- *High Mountain Asia Team (program element A*.40) - This solicitation funds investigations into High Mountain Asia's (HMA's) glaciers, snow, permafrost, and precipitation to improve our understanding of regional changes, water resources, and induced impacts, while furthering NASA's strategic goals in Earth system science and societal applications. Through expanded knowledge of the processes controlling change in HMA, the program intends to improve regional forecasts and address vulnerabilities in human and biogeophysical systems.

3. Applied Sciences

The Applied Sciences Program supports efforts to discover and demonstrate innovative and practical uses of NASA Earth science data, knowledge, and technology. The program (http://AppliedSciences.NASA.gov/) develops applications knowledge and understanding of how Earth science can be applied to serve society, increasing the benefits of the nation's investments in NASA Earth science. The Program funds applied science research and applications projects to enable near-term uses of Earth science, transition applied knowledge to public and private organizations, and integrate Earth science and satellite observations as inputs to organizations' decision-making and services. The projects are carried out in partnership with end user organizations. The Program, thus, serves as a bridge between the data and knowledge generated by NASA Earth science and the information needs and decision making of Government agencies, companies, regional associations, international organizations, not-for-profit organizations, and others.

The Program's applications themes align with the U.S. Group on Earth Observations (USGEO) Societal Benefit Areas, with current emphasis on Water Resources, Health and Air Quality, Disasters, and Ecological Forecasting. Applied Sciences projects leverage products, knowledge, and outcomes of Research and Analysis activities described in Section 2.

There are no ROSES elements primarily focused towards Applied Sciences that are or may be soliciting for proposals in ROSES-2019.

Topics relevant to the Applied Sciences Program that are actively or potentially soliciting in ROSES-2019 include the following program elements:

- Carbon Monitoring System (program element A.6);
- GEDI Science Team (program element A.8);
- Sea Level Change Team (program element A.11);
- SWOT Science Team (program element A.12);
- Atmospheric Composition: Aura Science Team (program element A.22);
- SMAP Science Team (program element A.25);
- GRACE-FO Science Team (program element A.28);
- Rapid Response and Novel Research in Earth Science (program element A.29);
- Airborne Instrument Technology Transition (program element A.30);
- Earth Science Research from Operational Geostationary Satellite Systems (program element A.33);
- GNSS Research (program element A.37);
- PACE Science and Applications Team (program element A.38);
- High Mountain Asia (program element A.40);
- Advancing Collaborative Connections for Earth System Science (program element A.46);
- Instrument Incubator Program (program element A.49); and
- Topical Workshops, Symposia, and Conferences (program element E.2).

4. Technology

Advanced technology plays a major role in enabling Earth research and applications. The Earth Science Technology Program (ESTP) enables previously infeasible science investigations, improves existing measurement capabilities, and reduces the cost, risk, and/or development times for Earth science instruments.

As the implementer of the ESTP, the Earth Science Technology Office (ESTO) performs strategic technology planning and manages the development of a range of advanced technologies to enable new science observations or reduce the cost of current observations. ESTO employs an open, flexible, science-driven strategy that relies on competitive solicitations and peer-review to produce a portfolio of cutting-edge technologies for NASA Earth science endeavors. This is done through:

- Planning investments by careful analyses of science requirements
- Selecting and funding technologies through competitive solicitations and partnership opportunities
- Actively managing the progress of funded projects
- Facilitating the infusion of mature technologies into science measurements

Needs for advanced technology development are based on Earth science measurement and system requirements articulated in chapter 4 of the *Science Plan for NASA's Science Mission Directorate* (https://smd-prod.s3.amazonaws.com/science-red/s3fs-public/atoms/files/2014_Science_Plan_PDF_Update_508_TAGGED_1.pdf) and the most recent Decadal Survey covering NASA's Earth science activities, *Thriving on our Changing Planet: A Decadal Strategy for Earth Observation from Space*, which was released on 1/5/2018 by the National Academies of Science, Engineering, and Medicine (see https://www.nap.edu/catalog/24938/thriving-on-our-changing-planet-a-decadal-strategy-for-earth). This 2017 Decadal Survey now serves as a foundational document for NASA's Earth Science Division (ESD), and includes recommendations for the scopes, foci, and relative budgetary magnitudes of the R&A, Applications, and Technology portions of the ESD program.

The Earth Science Technology Office (http://esto.nasa.gov) maintains several program lines through which technology investments are regularly competed through ROSES, and that cover a range of technology readiness levels (TRLs). Currently, the Instrument Incubator Program will be solicited in ROSES-2019:

- Instrument Incubator Program (program element A.49): The Instrument Incubator Program (IIP) funds technology development that leads directly to new Earth observing instruments, sensors, and systems. From concept through field demonstrations and infusion, IIP developments yield smaller, less resource intensive, and easier-to-build flight instruments.

Other ESTO programs that are periodically solicited are NOT being solicited in ROSES-2019:

- AIST (program element A.48): The Advanced Information Systems Technology program advances information systems that are used to process, archive, access, visualize, and communicate science data The Instrument Incubator Program funds technology development that leads directly to new Earth observing instruments, sensors, and systems. From concept through field demonstrations and infusion, IIP developments yield smaller, less resource intensive, and easier-to-build flight instruments;
- ACT (program element A.50): The Advanced Component Technology program develops a broad array of components and subsystems for instruments and observing systems;
- InVEST (program element A.51): The In-Space Validation of Earth Science Technologies program provides a path for some new technologies to be validated in space prior to use in science mission; and
- SLIT (program element A.52): The Sustainable Land Imaging Technology

Program - The Sustainable Land Imaging Technology program develops technologies leading to new SLI instruments, sensors, systems, components, data systems, measurement concepts, and architectures in support of the nation's future SLI activities.

5. Enabling Capability

Enabling capabilities include those programmatic elements that are of sufficient breadth that they contribute to a broad range of activities within the Earth Science Research Program. They typically involve the development of some kind of capability whose sustained availability is considered to be important for the Earth Science Research Program's future. These include focused activities in support of education; data, information, and management; and airborne science, as well as some broadly-based technology-related elements (others which are very focused towards a single scientific area of the Earth Science Research Program will be solicited through the research and analysis area).

5.1 Education

The Earth Science Research Program recognizes its essential role in NASA's mission to inspire the scientists and engineers of tomorrow. The Earth system science concept pioneered by NASA is changing not only how science research is conducted, but also the way Earth and space science education is taught at elementary through postgraduate levels, as well as the way space exploration is presented to the public by the media and informal learning communities.

In 2015, SMD announced selections from the Science Education Cooperative Agreement Notice. These organizations (https://science.nasa.gov/science-activation-team) are collaborating with SMD in the execution of its science education efforts. The desired outcome is to increase the overall coherence of the SMD science education program leading to more effective, sustainable, and efficient utilization of SMD science discoveries and learning experiences to meet overall SMD science education objectives. Fundamental to achieving this outcome is to enable NASA scientists and engineers to engage more effectively with learners of all ages. In addition, SMD is moving away from mission-by-mission products and services and towards aggregating efforts into science-based disciplines aligned with SMD Divisions.

The Earth Science Research Program will continue its management of the Global Learning and Observations to Benefit the Environment (GLOBE) Program (https://www.globe.gov/) and oversight of the GLOBE Implementation Office that is responsible for the coordination of the worldwide community in relation to GLOBE science, education, evaluation, communication, and other common functions. It will also continue to oversee the GLOBE Data and Information System. ESD welcomes proposals that incorporate the use of GLOBE observations, where appropriate. Observations can be accessed via the GLOBE Visualization System (https://vis.globe.gov/GLOBE/) and the GLOBE Advanced Data Access Tool (ADAT; https://datasearch.globe.gov/).

5.2 Graduate and Early-Career Research

The NASA Earth Science Division recognizes the importance of workforce enrichment. To this end, the Earth Science Division sponsors the Earth component of the Future Investigators in NASA Earth and Space Science and Technology (FINESST) program, which replaces the NASA Earth and Space Science Fellowship (NESSF) program. FINESST supports graduate student-designed research projects that contribute to SMD's science, technology, and exploration goals. Previous awardees of NESSF will be able to submit renewal proposals to a NESSF renewal solicitation for the 2019/2020 and 2020/2021 school years for a maximum of three years of total support (see NESSF19R for the 2019/2020 school year). FINESST and NESSF are currently solicited outside of ROSES with applications typically due each year in February for new awards and March for renewals. For 2019 the due dates are March 11 and March 15, respectively.

The New (Early Career) Investigator Program in Earth Science (program element A.34), which is directed towards scientists and/or engineers within six years of their receipt of a Ph.D. degree, is solicited every three years. It is not being solicited in ROSES 2019.

5.3 Data and Information Management

NASA's space observation capabilities are a central part of the Agency's contribution to Earth system science, along with the science information systems that compile and organize observations and related data for research purposes. The Earth Science Research Program has established a number of strategic principles for the development and deployment of its observing and information systems, recognizing the importance of providing active and informed stewardship for the large volumes of data that are returned to Earth every day. The broad range of uses to which the data are put and the large and diverse user community require multiple temporal and spatial scales, emphasize the need for having a range of data products, and place stringent requirements on NASA for its data processing, archival, and data dissemination activities. These products and services will be variously useful to multiple classes of users, from sophisticated scientific users to other Government and private sector entities that use NASA's information for policy and resource management decisions and including scientifically attentive members of the public who utilize data and information for general information and recreation.

Two program elements related to Data and Information Management have been solicited periodically by the Earth Science Division in recent years – The Advancing Collaborative Connections for Earth System Science (ACCESS, program element A.46), the Making Earth System Data Records for Use in Research Environments (MEaSUREs, most recently solicited in ROSES 2017 as program element A.43), and . Citizen Science for Earth Science Program (program element A.47). The only one of these solicited in ROSES 2019 is ACCESS (program element A.46).

Unless otherwise specified, any data proposed to be analyzed in response to Appendix A program elements from any source, including NASA and other satellite data, ancillary data, and data from commercial sources, must use publicly available data, in the sense that they are openly accessible. Commercial data need not be free, but it must be purchasable by all potential investigators. Proposals that utilize any data that is not, or not yet, publicly available will *not* be considered unless permitted by the call for proposals or associated Frequently Asked Questions. Please read the individual appendices and associated amendments to ROSES carefully and contact the program officers if you have any questions regarding whether a restricted dataset is permissible for a given call.

Data, model results and other information created is subject to NASA's Earth Science Data policy (see http://science.nasa.gov/earth-science/earth-science-data/data-information-policy/ for the policy). All data will be released along with the source code for algorithm software, coefficients, and ancillary data used to generate products.

5.4 High-End Computing, Networking, and Storage

High-end computing, networking, and storage are critical enabling capabilities for Earth system science. Satellite observations must be converted into scientific data products through retrieval and/or data assimilation processes. Long-term data sets must be synthesized together and become a physically consistent climate-research quality data set through reanalysis. These data products, in turn, provide initial and boundary conditions, validation and verification references, and internal and external constraints to the models that describe the behavior of the Earth system. None of the above will be possible without advanced techniques in high-end computing, networking, and storage.

SMD recognizes the need of such an enabling capability and maintains the high-end computing, networking, and storage within its programs. Computing resources are provided through various program elements. Over the past several years, computational resources have become significantly constrained. Starting in ROSES-2016, SMD began implementing a more rigorous resource allocation process. Proposals should include up to a one-page justification (not counted against the technical proposal page limit) for the computational resource requirement and this will be used during the proposal evaluation and selection processes. This justification should include how the computational resources may support the investigation and a multiyear resource-phasing plan, in annual increments, identifying the computing system and facility location where the computational project will be accomplished for the duration of the proposed award period. Proposers to this NRA must follow the instructions in Section I(d) of the *Summary of Solicitation* of this NRA to request computing resources, including explicit descriptions of computing resource needs.

NASA also supports computational science research and development, including parallelization of codes to an advanced computing architecture for the advancement of Earth system modeling and data assimilation.

In ROSES-2019, no program elements specifically targeted towards High End Computing, Networking, and Storage will be solicited.

5.5 NASA Earth Exchange

For large-scale global high-resolution Earth science data analysis and modeling projects, especially in areas of land surface hydrology, land cover, land use, carbon management, and terrestrial ecosystems, NASA encourages using the new NASA Earth Exchange (NEX) collaboration facility. The NEX facility includes a state-of-the-art Earth system modeling and data analytics system for the use of remote sensing data from

NASA and other agencies. It is supported by a world-class supercomputing and data storage system. Much of the global Landsat, MODIS, AVHRR and related data have been staged online for easy access. NEX (http://nex.nasa.gov) represents a scientific collaboration platform to deliver a complete work environment, in which users can explore and analyze large Earth science data sets, run modeling codes, collaborate on new or existing projects, and share results.

Since it is a unique platform for large-scale data analyses that cannot be easily accommodated by a single Principal Investigator (PI) or small research group-based data analysis system, PIs who require the use of such a system are encouraged to register on the NEX Website at https://nex.nasa.gov/nex/auth/register/. Proposals should include a section that justifies the need for using NEX, specifies the data storage and processing needs, and includes a data management plan as described above in Section 1. The resource availability will be considered during the proposal review and selection process.

Proposals that involve the use of NEX must be submitted to the appropriate ROSES program element depending on the science addressed by the proposed investigation. Additional constraints and requirements for proposals to use NEX are available at https://nex.nasa.gov/nex/resource_updates.

In ROSES-2019, no program elements directed towards the enhancement of NEX are being solicited.

5.6 Airborne Science

The Earth Science Research Program airborne science program provides access to airborne platforms that can be used to obtain measurements of the Earth. Airborne platforms may be used to test new measurement approaches, collect detailed *in situ* and remote sensing observations that are needed to better document and test models of Earth system processes, and/or provide calibration/validation information for satellites. Airborne platforms can also be an important part of training the next generation of scientists, because students can be engaged in all aspects of scientific investigations, from sensor development, through utilization, to completing analysis of data obtained.

Aircraft have proven to be of significant value in Earth system science research, particularly for investigation into atmospheric processes. NASA makes use of several existing aircraft, including the NASA-owned DC-8, G-III, GV, ER-2, and P-3B, as well as several independently owned aircraft, including, but not limited to, those operated by other Federal agencies and commercial aircraft providers. Proposers that utilize commercial aircraft service providers must ensure real time position tracking of the aircraft and provide flight reports after the completion of flights. Information regarding the utilization and reporting requirements of airborne assets to support proposals can be found at https://airbornescience.nasa.gov/.

Proposals that require the acquisition of new airborne data may be submitted in response to other active ROSES elements, unless otherwise specified in the element. In any such cases, proposers are encouraged to contact the program manager indicated prior to submitting such proposals.

The NASA Headquarters science concurrence is provided by the manager of the NASA Research Program under which the grant or contract is issued. User fees are paid by the investigator's funding source’s research program or directly from the investigator's grant funds.

Any airborne science experiment using NASA assets, personnel, instruments, or funds, must be in compliance with NASA Policy Directive 7900 and NASA Procedural Requirement Series 7900. It is NASA policy that when utilizing other than NASA aircraft, including foreign owned or leased aircraft, those aircraft are subject to the same compliance requirements.

A.2 LAND-COVER/LAND-USE CHANGE FOR EARLY CAREER SCIENTISTS

NOTICE: This program element uses a two-step proposal process (see section 4.3), with required Step-1 proposals due August 1, 2019. Step-2 proposals must be submitted by March 3, 2020.

1. The LCLUC Program

The Land-Cover/Land-Use Change (LCLUC) program is developing interdisciplinary approaches combining aspects of physical, social and economic sciences, with a high level of societal relevance, using remote sensing tools, methods, and data. One of its stated goals is to develop the capability for periodic satellite-based inventories of land cover and monitoring and characterizing land-cover and land-use change. The program focuses on analysis at global to regional scales, taking advantage of the synoptic capability afforded by satellite remote sensing and with the understanding that land-use change occurs locally. Additional information on the NASA LCLUC program can be found at http://lcluc.hq.nasa.gov or contact Dr. Garik Gutman, the Land-Cover/Land-Use Change Program Manager, see Section 5, below.

2. Scope of the current solicitation: Land-cover and land-use changes

This solicitation will contribute to NASA's general goal of developing a new generation of scientists capable of undertaking integrated earth science research.

The NASA LCLUC program supports research at the intersection of physical and social science involving the use of remotely sensed data. The program encourages the development of early career scientists that excel in this area of research. There is a growing community within academia, including students, that is engaging in interdisciplinary research of societal relevance. This solicitation aims to help build the next generation of experts, which will contribute to the goals of the NASA LCLUC program. The eligible proposers (both PI and Co-Is) should have their Ph.D. degree awarded no earlier than 2014, so that at the time of submission of the full proposal (March 2020) a proposer would be no more than 6 years after the Ph.D. degree. No restriction on the time after Ph.D. is imposed on collaborators (See Section 4.2).

The identification of a Co-I/Science PI is permissible only for cases in which the institution does not allow research or un-tenured faculty to lead proposals. No Co-Principal Investigators are permitted. Up to two paid Co-Is are allowed to enhance the interdisciplinary character of the proposal and their role must be clearly explained. Unpaid Co-Is are discouraged. Students and postdoctoral fellows may participate as supported team members. Regional collaborations are encouraged, and the proposed research may include up to three Collaborators. Proposers are strongly encouraged to read the *Guidebook for Proposers* at http://www.hq.nasa.gov/office/procurement/nraguidebook/, particularly Appendix B for the definitions of team member roles like Collaborator vs. Co-Investigator.

This particular solicitation is directed at early career scientists and aims to stimulate more interdisciplinary research proposals that are commonly funded by the NASA New Investigator Program (NIP). Restrictions of eligibility articulated in the NIP do not apply to this call. Proposals need to be aligned with the LCLUC program goals and themes (see http://lcluc.hq.nasa.gov). All the topics addressing LCLUC science are welcome.

Increasing demand for land is leading to significant land-cover and land-use changes around the world. Changes in market forces and demand for agricultural products are leading to changes in traditional agricultural land-use practices. Forest and woodlands continue to be converted to agriculture. Urban expansion has been rapid and significant over the last few decades, as populations in developing countries become increasingly urban. Suburban areas of the developed world continue to expand. Changing land rights and ownership are changing land management. Land use in some regions is adapting to the increased frequency of extreme weather events and a warming climate. Coastal regions are under various pressures, such as sea level rise, land reclamation for development, mangrove destruction and recreational activities. Land use affects ecosystems and biodiversity and itself is affected by changing climate and changes in hydrological regimes.

Documenting LCLUC using satellite observations and understanding the causative factors and impacts on carbon cycle, water cycle, ecosystems and societal processes is gaining importance. High performance computing and increased frequency and availability of moderate resolution and fine resolution systems are enabling enhanced monitoring of land-cover and land-use change. The accurate reporting and analysis of the observed land-use changes provides an opportunity to advance land-change science and inform land-use policy.

The LCLUC program takes a regional approach to studying changes that have regional to global scale impacts. The regions of interest for this solicitation are Latin America, the Mediterranean region, Central Asia and western Asia (west of India). Latin American proposals may include Central American, Caribbean and/or South American countries. Amazon is not the region of interest for this particular solicitation because there had been fewer previous studies in the other areas of Latin America as compared to the Amazon region, for which there has been synthesis work based on the research results obtained during NASA's earlier Land-Biosphere-Atmosphere (LBA) program. The Mediterranean region includes the coastal countries and islands around the Mediterranean Sea. The eastern and southern sectors are of more interest than the north-western and western (European) sectors of the region, where much research on land use continues to be conducted by EU institutions.

To understand the drivers of land-use change and the processes affected by land use, the socio-economic processes need to be considered and, as such, social science needs to be an integral part of each proposal (see 3.1). Studies can vary from the landscape to regional scale, integrating multiple data sources as needed and providing an understanding of LCLUC dynamics at multiple spatial and temporal resolutions. Local case studies that document LCLUC trajectories and their causative factors are welcome, however, an example demonstrating that the method, analysis and outputs are scalable to larger regions will be required.

Proposals should highlight the theoretical and analytical frameworks appropriate for investigating the patterns of physical and socio-economic interactions influencing land-use and land-cover changes in the region. Further, proposals including data acquisition, preprocessing, image interpretation, and accuracy assessment for land-use and land-cover characterization, mapping and change analysis, should apply state-of-the-art methods and techniques.

Proposers should familiarize themselves with the existing literature and make the case for how their proposal offers improved methods, advances land-use science, or could inform land-use policy. Proposers should explore the LCLUC program web site to learn from the projects on a particular subject that have already produced relevant results.

The successful proposals from this round will contribute to the international program Global Observation of Forest Cover and Land Use Dynamics (GOFC-GOLD; https://gofcgold.org/). The GOFC-GOLD Regional Information Networks rely on the science developed by participating scientists, therefore Science Teams selected from this round will feed in to the regional networks' new algorithms and data products developed under the LCLUC Program, as appropriate. Specifically, the emerging Mediterranean network (MedRIN), the established Red Latinoamericana de Teledeteccion e Incendios Forestales (RedLaTIF) network and the revived Central Asian network (CARIN) will be the relevant GOFC-GOLD networks for this solicitation. For regional proposals, the LCLUC program strongly encourages collaborations with regional scientists with experience and insights on the topic of the proposal. It is intended that such collaborations will strengthen the research with local knowledge. Collaborations may be developed following the guidelines and with the appropriate letters of support at Step-2.

3. Principles of the LCLUC program to be reflected in proposals

3.1 Social and Economic Sciences in the NASA LCLUC program

The NASA LCLUC program is aimed at using satellite observations to improve our understanding of land-cover and land-use change as an important component of global and climate change. The LCLUC program includes studies that quantify land-cover and land-use changes; examine their impact on the environment, climate, and society; or model future scenarios of land-cover and land-use change and its various impacts and feedbacks. Humans play an important role in modifying land cover and are instrumental in land-use change. To understand the process of land-use change it is, therefore, important to address its human dimensions.

Social and economic science research plays an important role in the NASA LCLUC program and includes analyses of the impacts of changes in human behavior at various levels on land use, studies of the resultant impacts of land-use change on society, or how the social and economic aspects of land-use systems adapt to climate change.

The LCLUC program evaluates a proposal's responsiveness to the above aspects in terms of a meaningful integration of social and economic science theories, perspectives, methods, and data (quantitative and/or qualitative) with innovative analyses of land system dynamics in the proposed research. In this context, simple treatments of human dimensions, such as mere correlations of socioeconomic variables in lieu of rich empirical analyses linked to theorized social dynamics, or summary descriptions of potential societal or policy benefits of the proposed study without demonstrable linkages to the same, are not considered adequately responsive to the socio-economic aspect of the program. Successful proposals will fully integrate social and economic sciences into the research questions, data used, and analytical approaches in order to couple remote sensing observations of land-cover with research on the human dimensions of land-use change.

3.2 Remote Sensing Component

The NASA LCLUC program will only support proposals with a strong remote sensing component. The use of observations and data products from U.S. and/or non-U.S. Earth-observing satellites is a requirement for each proposal. The use of commercial satellites with fine spatial resolution is also encouraged (see, e.g., http://cad4nasa.gsfc.nasa.gov/).

To get the most out of current remotely sensing capabilities, we encourage data fusion from various sources with different spatial and/or temporal resolution and different parts of the solar and microwave spectra. For example, a variety of multispectral, hyper-spectral, optical, thermal, and radar data may be integrated in the analysis, as needed. Proposals that undertake fusion of data from various sources of Landsat-type data, as well as radar observations, are welcome. Special attention should be given to the dissemination of data and products associated with the proposed research. If appropriate, we also encourage use of NASA's collaboration facility for the NASA Earth science community: NASA Earth Exchange (NEX; https://c3.nasa.gov/nex/) web portal. This portal includes a state-of-the-art supercomputing Earth system modeling system for the use of remote sensing data from NASA and other agencies. Much of the global Landsat data have been transferred to that facility. The NEX web portal represents a scientific social networking platform to deliver a complete work environment in which users can explore and analyze large Earth science data sets, run modeling codes, collaborate on new or existing projects, and share results.

3.3 International Collaboration

NASA's policy welcomes the opportunity to conduct research with non-U.S. organizations on a cooperative, no exchange-of-funds basis. Although Co-Is or Collaborators employed by non-U.S. organizations may be identified as part of a proposal submitted by a U.S. organization, as noted in the *NASA Guidebook for Proposers* "NASA funding may not be used for foreign research efforts at any level, whether as a collaborator or a subcontract. The direct purchase of supplies and/or services, which do not constitute research, from non-U.S. sources by U.S. award recipients is permitted". Note that travel by a non-U.S. participant in the research investigation, whether for the purpose of conducting the research, for collaboration, or for attending a conference, is considered to be a research expense. NASA funding may not be used for research efforts by foreign organizations at any level, including payment of travel expenses. See also Section III (c) of the *Summary of Solicitation* for restrictions involving China.

4. Programmatic Information

4.1 Period of Performance for Selected Proposals

Research awards will be for a three-year period of performance (or less) with annual funding contingent upon satisfactory progress reporting and available funding. Principal Investigators are expected to provide input to the program web site, submit research highlights and participate in the program webinars and outreach activities.

4.2 Funding Available for Support of Selected Proposals

Approximately $2.5M per year is expected to be available for new awards from proposals submitted to this program element. NASA anticipates supporting 15-16 investigations, each with annual budgets not exceeding $150K. NASA will make selections for this announcement in the Fall of 2020 with anticipated starting date in late 2020-early 2021.

To foster the alliance of remote sensing and socio-economic science we encourage remote sensing early career scientists to team up with early career social scientists (with a similar restriction for years since PhD). The number of participating paid Co-investigators is limited to two. A budget for domestic travel to at least one LCLUC Science Team Meeting in the DC area per year and international travel to workshops or project meetings overseas is required in the proposal. Involvement of local scientists from the selected region is strongly encouraged and letters of endorsement from foreign partners, with financial commitments, although not needed at Step-1, will be required at Step-2. The number of regional collaborators is not limited and there is no restriction on the time since PhD for regional collaborators. Note that direct support by NASA for research by investigators at foreign organizations is not allowed, (see Section 3.2 of the *NASA Guidebook for Proposers)*. See more details above in 3.3 on what is and what is not allowed in the budget concerning non-U.S. participation.

4.3 The Two-Step Proposal Procedure

To streamline the proposal process and relieve the work load on the community of interested applicants and those that help NASA in reviewing proposals, the LCLUC program is using a two-step procedure (see also Section IV(b)(vii) of the *ROSES Summary of Solicitation*). Step-1 proposals replace the Notice of Intent (NOI). Step-1 proposals must be submitted electronically by the Step-1 Due Date (see Tables 2 and 3 of *ROSES*). Unlike an NOI, a Step-1 proposal is required and must be submitted electronically by the Authorized Organizational Representative (AOR). Proposers should refer to the "Instructions for Submitting a Step-1 Proposal" under "Other Documents" on the NASA Solicitation and Proposal Integrated Review and Evaluation System (NSPIRES) page for this program.

NSPIRES will be open for the submission of Step-1 proposals starting ~30 days in advance of the Step-1 Due Date. NASA will then review each Step-1 proposal to determine whether or not the anticipated research project is considered of sufficient merit, responsiveness, and relevance to warrant submission of a full Step-2 proposal. A separate Step-1 proposal must be submitted for each intended (and thus corresponding) Step-2 proposal.

No individualized feedback will be provided in response to Step-1 proposals. Instead, proposers will be informed via NSPIRES whether their proposal has been encouraged or discouraged. Whether or not the Step-1 proposal is encouraged or discouraged, proposers who submitted a Step-1 proposal are eligible to submit a Step-2 proposal. Submission of a Step-1 Proposal is, therefore, required in order to submit a Step-2 proposal. Step-2 proposals must contain the same scientific goals proposed in Step-1, but the proposal team identified at Step-1 is not considered binding and (other than the PI) can be adjusted in a Step-2 proposal. However, the submission of a Step-1 proposal is not a commitment to submit a Step-2 proposal.

The NSPIRES system will guide proposers through submission of all required proposal information. Please note that the Proposal Summary, Business Data, Program Specific Data, and Proposal Team are required Cover Page Elements for a Step-1 proposal. A budget should not be included with the Step-1 proposal, but will be needed with a budget explanation at Step-2. Proposers may refer to the PDFs on the NSPIRES page for this program element entitled "How to create and submit a Step-1 proposal" and "How to create and submit a Step-2 proposal" for a walkthrough.

To facilitate the work by reviewers on Step-1 proposals, the following abbreviated template is suggested for use. Step-1 proposals should be provided as a PDF proposal document-upload not to exceed five pages, including any references or citations. The five-page, Step-1 proposal must:

a) Emphasize responsiveness, clearly indicating how the proposed project addresses the call, and which remote sensing assets are to be used. Identify social science aspects in the proposed study.

b) Describe the proposed research, showing knowledge of previous research carried out by the the LCLUC Program and the international scientific community in the subject area. Identify new research aspects being proposed.

c) Outline the expected outcomes of the research. Identify proposed deliverables. Provide a tentative schedule.

Step-2 proposals should provide more detail on the previous studies related to the research topic, the science question to be addressed, the rationale for the study and the proposed research methodology, the anticipated results and deliverables, and schedule. Step-2 proposals must include a budget and the associated explanation. For consistency and to ease the burden of reviewing, it is preferable that Step-2 proposals follow approximately the same structure as outlined for the Step-1 proposals expanded to 15 pages.

Step-2 proposals must be submitted electronically by the due date in full compliance with the requirements specified in this NRA's *Summary of Solicitation* and the *NASA Guidebook for Proposers*. Moreover, for Step-2 propsals (only) proposers are strongly encouraged to use the templates for the table of work effort and current and pending support that have been provided by the Earth Science Division.

The five-page limit for Step-1 proposals must include all information necessary to evaluate the Step-1 proposal. The text of the proposal is limited to four pages. That specifically includes any references or citations included in the Step-1 proposal. One page of the allowed five should be used for a brief CV and research experience.

4.4 Evaluation of Step-2 Proposals

All Step-2 proposals will be submitted to the NASA peer review process in accordance with the guidelines provided in this NRA and the *NASA Guidebook for Proposers*. This program is unique in that the evaluation of Relevance will include an assessment of the extent to which the proposal successfully includes social and economic sciences, as described in Section 3.1. The inclusion of remote sensing is not an evaluation criterion but is a compliance requirement: proposals that don't address remote sensing, as described in Section 3.2 may be rejected without review. Finally, International Collaboration is encouraged but not required, i.e., all else being equal when deciding between proposals of otherwise equal merit, NASA will give preference to those with International Collaboration.

The peer review will be followed by a programmatic review of the proposal, in which NASA will assess program balance across the competitive range of proposals, and evaluate any logistical, implementation, cost, and/or management concerns. The funding recommendations will then be forwarded to the Selecting Official for confirmation. NASA then will announce the official selection of proposals for award via NSPIRES.

5. Summary of Key Information

Expected annual program budget for new awards	~ $2.5M, see Section 4.2
Number of new awards pending adequate proposals of merit	15-16
Maximum duration of awards	3 years
Due date for Step-1 proposals	See Tables 2 and 3 of this ROSES NRA
Due date for Step-2 proposals	See Tables 2 and 3 of this ROSES NRA
Planning date for start of investigation	Early Calendar 2021
Page limit for the central Science-Technical-Management section of proposal	For Step-1 5 pp. For Step-2 15 pp and also see Table 1 of ROSES *Summary of Solicitation* and the *Guidebook for Proposers*.
Relevance	This program is relevant to the Earth science questions and goals in the NASA Science Plan. Proposals that are relevant to this program are, by definition, relevant to NASA.
General information and overview of this solicitation	See the *ROSES Summary of Solicitation*.
Detailed instructions for the preparation and submission of proposals	See the *NASA Guidebook for Proposers* at http://www.hq.nasa.gov/office/procurement/nraguidebook/.
Submission medium	Electronic proposal submission is required; no hard copy is permitted.

Web site for submission of proposals via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Web site for submission of proposals via Grants.gov	http://grants.gov (help desk available at support@grants.gov or (800) 518-4726)
Funding opportunity number for downloading an application package from Grants.gov	NNH19ZDA001N-LCLUC
NASA point of contact concerning this program	Garik Gutman Earth Science Division Science Mission Directorate NASA Headquarters Washington, DC 20546-0001 Telephone: 202-358-0276 Email: ggutman@nasa.gov

A.3 OCEAN BIOLOGY AND BIOGEOCHEMISTRY

NOTICE: NASA will not solicit research proposals under the Ocean Biology and Biogeochemistry program element in ROSES-2019. The next release of an Ocean Biology and Biogeochemistry Program element is ROSES-2020.

1. Scope of Program

NASA's Ocean Biology and Biogeochemistry program focuses on describing, understanding, and predicting the biological, ecological, and biogeochemical regimes of the upper ocean, as determined by observation of aquatic optical properties using remote sensing data, including those from space, aircraft, and other suborbital platforms.
Overarching programmatic goals include:

1. Understanding and quantifying the impacts and feedbacks of Earth System processes, particularly oceanographic mechanisms, on the global and regional spatial and temporal variability of ocean biology, including phytoplankton and organisms from other trophic levels;
2. Understanding and quantifying the impacts and feedbacks of Earth System processes, particularly oceanographic mechanisms, on the global and regional spatial and temporal variability of ocean biogeochemistry, including carbon sources and sinks and the fate of other chemical species or components in the ocean;
3. Exploring the development of new biological and biogeochemical observations (e.g., plankton functional types) beyond traditional ocean color (e.g., phytoplankton chlorophyll a) from space-based assets, as well as furthering the climate research enabled by existing time series of climate observations (Earth System Data Records); and
4. Improving future climate predictions (impacts and feedbacks) by incorporating a dynamic understanding of ocean biology and biogeochemistry into global biogeochemical and ecological models to understand the ocean's role in the Earth System.

Ocean Biology and Biogeochemistry research mainly supports the Carbon Cycle and Ecosystem Focus Area (https://science.nasa.gov/earth-science/focus-areas/carbon-cycle-and-ecosystems). Each of the Earth Science Focus Areas portrays a strategy for a progress based on a suite of systematic observations, novel new Earth Science observations, and specific programmatic elements. NASA's Ocean Biology and Biogeochemistry program utilizes remotely sensed observations from land, ocean, cryosphere, and atmosphere, as well as field studies and campaigns, and interdisciplinary data assimilation and modeling efforts to better understand the ocean's role in the Earth System and to predict future causes of change and feedbacks on ocean biology, ecology, and biogeochemistry within the Earth System. The Ocean Biology and Biogeochemistry program also integrates report recommendations from National Academy of Science, Engineering, and Mathematics, including "Thriving on Our Changing Planet: A Decadal Strategy for Earth Observations from Space" (http://sites.nationalacademies.org/DEPS/ESAS2017/index.htm).

In support of the Carbon Cycle and Ecosystems Roadmap, scientific questions of interest to the Ocean Biology and Biogeochemistry Program include (but are not limited to):

1. How are ocean ecosystems and the biodiversity they support influenced by climate and environmental variability and change, and how will these changes occur over time?
2. How do carbon and other elements transition between ocean pools and pass through the Earth System, and how do biogeochemical fluxes impact the ocean and Earth's climate over time?
3. How (and why) are the diversity and geographical distribution of coastal marine habitats changing, and what are the implications for the well-being of human society?
4. How do hazards and pollutants impact the hydrography and biology of the coastal zone? How do they affect us, and can we mitigate their effects?

Appendix A.1 of ROSES (Earth Science Research Overview) provides an overview of how the Ocean Biology and Biogeochemistry program fits into the Earth Science Division within NASA's Science Mission Directorate. Program goals and objectives for the coming decades can be found in the Ocean Biology and Biogeochemistry program's advance plan (https://oceancolor.gsfc.nasa.gov/docs/technical/obb_report_5.12.2008.pdf), and update of which is underway and will be finalized in 2019.

2. Programmatic Information

Questions or comments may be directed to the Ocean Biology and Biogeochemistry Program Managers at the addresses given below:

Paula Bontempi
Earth Science Division
Science Mission Directorate
NASA Headquarters
Washington, DC 20546-0001
Telephone: (202) 358-1508
Email: paula.bontempi@nasa.gov

Laura Lorenzoni
Earth Science Division
Science Mission Directorate
NASA Headquarters
Washington, DC 20546-0001
Telephone: (202) 358-0917
Email: laura.lorenzoni@nasa.gov

A.4 TERRESTRIAL ECOLOGY

NOTICE: The Terrestrial Ecology program does not plan to solicit proposals in ROSES-2019. This program will be competed again in ROSES-2020.

NASA Terrestrial Ecology research addresses changes in Earth's carbon cycle and ecosystems using space-based observations. The goals of NASA's Terrestrial Ecology research are to improve understanding of the structure and function of global terrestrial ecosystems, their interactions with the atmosphere and hydrosphere, and their role in the cycling of the major biogeochemical elements and water. This program of research addresses variability in terrestrial ecosystems, how terrestrial ecosystems and biogeochemical cycles respond to and affect global environmental change, and future changes in carbon cycle dynamics and terrestrial ecosystems. The research approach combines (i) use of remote sensing to observe terrestrial ecosystems and their responses; (ii) field campaigns and related process studies to elucidate ecosystem function; and (iii) ecosystem and biogeochemical cycle modeling to analyze and predict responses. Research to establish a theoretical and scientific basis for measuring Earth surface properties using reflected, emitted, and scattered electromagnetic radiation and to develop the methodologies and technical approaches to analyze and interpret such measurements is an important component of the Terrestrial Ecology research program.

Priorities for new research within NASA's Terrestrial Ecology program derive from the goals and objectives for Earth Science in NASA's 2018 Strategic Plan (https://www.nasa.gov/sites/default/files/atoms/files/nasa_2018_strategic_plan.pdf), the research agenda of the U.S. Global Change Research Program (USGCRP) (http://www.globalchange.gov/), the science priorities of the U.S. Carbon Cycle Science Program (https://www.carboncyclescience.us), and some of the research gaps described in the State of the Carbon Cycle Report 2 (SOCCR-2) (https://www.globalchange.gov/content/about-soccr-2). A major recent emphasis within the Terrestrial Ecology program has been ecological field studies, airborne science studies, and ecosystem modeling activities for the Arctic-Boreal Vulnerability Experiment (ABoVE) (http://above.nasa.gov). The ABoVE Study Area encompasses much of the boreal and tundra area of Alaska and western Canada. The overarching science question for ABoVE is: How vulnerable or resilient are ecosystems and society to environmental change in the Arctic and boreal region of western North America?

For further information on this program, contact:

Hank Margolis, Program Manager
NASA Terrestrial Ecology Program
Earth Science Division
Science Mission Directorate
NASA Headquarters
Washington, DC 20546-0001
Telephone: (202) 358-4760
Email: Hank.A.Margolis@nasa.gov

A.5 CARBON CYCLE SCIENCE

NOTICE: The carbon cycle science program will not solicit proposals in ROSES-2019. All funds currently available for a dedicated carbon cycle science opportunity are committed to the support of awards selected through the 2016 carbon cycle science solicitation. The agency's timeline for competition of carbon cycle science funds is ROSES-2020.

NASA expects to continue to solicit some carbon cycle research through its core research and analysis programs, in particular, the Terrestrial Ecology, Ocean Biology and Biogeochemistry, Land Cover and Land Use Change, and Atmospheric Composition programs. Interested researchers are encouraged to consult these other program elements for potential funding opportunities.

1. Scope of Program

NASA's carbon cycle science research opportunity is offered every three years and usually in partnership with one or more U.S. government agencies, most recently with the U.S. Department of Agriculture (USDA) National Institute of Food and Agriculture (NIFA), the U.S. Department of Energy (DOE) Terrestrial Ecosystem Sciences Program, and the Ocean Acidification Program within NOAA. Proposals were sought to improve understanding of changes in the distribution and cycling of carbon among the active land, ocean, and atmospheric reservoirs and how that understanding can be used to establish a scientific foundation for societal responses to global environmental change.

The goals of the NASA Earth Science Program for carbon cycle science are to improve understanding of the global carbon cycle and to quantify changes in atmospheric CO_2 and CH_4 concentrations, as well as terrestrial and aquatic carbon storage in response to fossil fuel combustion, land use and land cover change, and other human activities and natural processes. NASA carbon cycle research encompasses multiple temporal and spatial scales and addresses atmospheric, terrestrial, and aquatic carbon reservoirs, their coupling within the global carbon cycle, and interactions with climate and other aspects of the Earth system. A focus on observations from space guides carbon cycle research by NASA and is a foundation for partnerships with other U.S. Government agencies and institutions. NASA carbon cycle research contributes toward the goals of major US Global Change Research Program (USGCRP) activities, including the Carbon Cycle Science Program's U.S. North American Carbon Program (NACP) and the Ocean Carbon and Climate Change Program (OCCC) (http://www.globalchange.gov/, https://www.carboncyclescience.us/, http://www.nacarbon.org/nacp/, and the Ocean Carbon and Biogeochemistry Program (OCB) https://www.us-ocb.org). NASA carbon cycle research also contributes toward the goals of the federal oceans related planning.

For further information on this program, contact:

Paula Bontempi
Earth Science Division
Science Mission Directorate
NASA Headquarters

Washington, DC 20546-0001
Telephone: (202) 358-1508
Email: Paula.Bontempi@nasa.gov

A.6 Carbon Monitoring System: Continuing Prototype Product Development, Research, and Scoping

NOTICE: September 23, 2019. NASA will not solicit proposals for the Carbon Monitoring System (CMS) in ROSES-2019 because all currently available funding has been committed. We expect to solicit in ROSES-2020.

Because of the delayed release of ROSES-2019 caused by the extended partial government shutdown, CMS was also solicited as program element A.49 in ROSES-2018 with early CY19 due dates. Interested proposers should check that program element for details.

1. Scope of Program

The NASA Carbon Monitoring System (CMS) is designed to make significant contributions in characterizing, quantifying, understanding, and predicting the evolution of global carbon sources and sinks through improved monitoring of carbon stocks and fluxes.

NASA's approach toward its contribution to a carbon monitoring system emphasizes exploitation of current and future satellite remote sensing resources, computational capabilities, integrated ecosystem and atmospheric modeling, scientific knowledge, airborne science capabilities, and end-to-end system expertise that are major strengths of the NASA Earth Science program. The emphasis has been on regional, national, and global satellite-based carbon monitoring products relevant to national needs for completely transparent carbon and biomass inventory processes that provide a robust statistical framework for reporting precision and accuracy in a geospatially explicit manner. Significant effort is being devoted to rigorous evaluation of the carbon monitoring products being produced, as well as to the characterization and quantification of errors and uncertainties in those products.

NASA's approach takes into account data and expertise that are the domain of other U.S. Government agencies and anticipates continuing close communications and/or partnerships with those agencies and their scientific and technical experts as U.S. national efforts toward integrated carbon monitoring mature, especially as coordinated through the Carbon Cycle Interagency Working Group of the U.S. Global Change Research Program (https://www.carboncyclescience.us/). NASA also recognizes a need for complementary local-scale (airborne and *in situ*) information to demonstrate quantitative remote sensing methods; to aid in scaling up from project, county, and/or state levels; and for essential evaluation of regional-, national-, and global-scale products.

The current CMS activities take advantage of currently available space-based remote sensing observations like from the MODerate-resolution Imaging Spectroradiometer (MODIS) on Terra and Aqua, Landsat, and Orbiting Carbon Observatory-2 (OCO-2). Additionally, the current approach lays the groundwork for CMS-related applications of future NASA satellite sensors now in development i.e., Global Ecosystem Dynamics Investigation (GEDI), Orbiting Carbon Observatory-3 (OCO-3), Ice, Cloud, and Land

Elevation Satellite-2 (ICESat-2), and the NISAR (NASA-Indian Space Research Organization L- and S-band synthetic aperture radars).

A list of the multiple, past solicitations for CMS can be found at:

ROSES-2011 CMS call at https://nspires.nasaprs.com/external/solicitations/summary.do?method=init&solId={DDC97177-454E-5B99-5CA9-EC6290FA6D52}&path=closedPast

ROSES-2013 CMS call at https://nspires.nasaprs.com/external/solicitations/summary.do?method=init&solId={3026BD1C-F069-382C-6FCE-A3A3BB156454}&path=closedPast

ROSES-2014 CMS call at https://nspires.nasaprs.com/external/solicitations/summary.do?method=init&solId={41E74515-E19D-72E5-3111-41FE7A816E29}&path=closedPast

ROSES-2015 CMS call at https://nspires.nasaprs.com/external/solicitations/summary.do?method=init&solId={596D5BFF-421D-5E5B-2B9C-C191EDCB0AFC}&path=closedPast

ROSES-2016 CMS call at https://nspires.nasaprs.com/external/solicitations/summary.do?method=init&solId={A629F55E-9479-F323-F985-E2F9A58D9B5A}&path=closedPast

A NASA Carbon Monitoring System Science Team (CMS ST) has been established to include members from all NASA CMS investigations. The CMS ST is responsible for providing broad research community involvement in the development and evaluation of NASA CMS products; coordinating their NASA-funded CMS activities to ensure maximum returns for science, management, and policy and providing scientific, technical, and policy-relevant inputs to help set priorities and directions for future NASA CMS activities.

Additional information on these initial activities, progress reports, the CMS ST, and links to available data and data products are provided at http://carbon.nasa.gov. The work conducted in this prototyping effort to date has leveraged the much larger investment currently made by NASA in remote sensing observations of carbon-related properties of the Earth system that are pertinent to understanding carbon stocks and fluxes, as well as to carbon cycle science and carbon management research.

For further information on this program, contact any of the following:

Kenneth W. Jucks Telephone: (202) 358-0476 Email: kenneth.w.jucks@nasa.gov	Kathleen Hibbard Telephone: (202) 358-0245 Email: Kathleen.A.Hibbard@nasa.gov
Hank Margolis Telephone: (202) 358-4760 Email: Hank.A.Margolis@nasa.gov	

A.7 BIODIVERSITY

NOTICE: The Biodiversity program element will not be competed in ROSES-2019. NASA anticipates that this program will be solicited again in ROSES-2020.

1. Scope of Program

Biodiversity is the variety of life on Earth at all levels of organization, from ecosystems to species to genes. It incorporates the compositional, structural, and functional aspects of life at these different levels. Biodiversity both enables and represents life's responses to the changing environments of our dynamic planet, while also serving as a driver of environmental change. Biodiversity encapsulates life's evolutionary history. In doing so, it provides humanity, indeed all life, with a tremendous resource of opportunities to survive and thrive in an uncertain future.

Recent efforts to track the status of biodiversity globally have consistently reported significant declines throughout its levels of organization. A growing scientific consensus posits that we are losing biodiversity at rates comparable to those seen in the major extinction events documented in the geologic record. Humanity's role in this decline and our concerns over the subsequent loss of the many benefits, goods, and services we derive from biodiversity demand efforts to understand the condition of biodiversity and its changes in space and time. In addition, there is a need to understand biodiversity because it drives changes in the wider Earth system. Thus, NASA seeks tools to understand the condition of biodiversity and how it is changing over time.

Biodiversity is often studied and addressed locally, especially with regard to the spatial scales at which we seek to understand the causes and consequences of change. To address biodiversity loss as a global issue requires integrating research efforts across multiple spatial and temporal scales and observing biodiversity at all of its levels of organization. Accomplishing this integration of dynamic biodiversity patterns and processes across multiple scales is easier said than done and continues to be one of the major challenges for all of the biological sciences.

The NASA Earth Science Division approaches biodiversity science from the standpoint of two of its key aspects: pattern and process. Using observations from satellites, airborne and seaborne platforms, and *in situ* efforts, NASA explores patterns of biodiversity extant upon the land and within the water. Our tools are ideally suited for detecting many of biodiversity's patterns, especially at the ecosystem level, but also at finer levels such as species. Biodiversity pattern often follows process. Thus, we also seek to understand the geophysical and ecological processes that result in the patterns of biodiversity our observations detect. Understanding these processes requires observations, with some of these observations at finer spatial scales than available from NASA satellites. It also requires models, essentially simplified representations of our knowledge of how certain systems work that in turn allow us to test the validity of this knowledge. Process-oriented research offers the additional benefit of connecting the Biodiversity program to the activities of other NASA Earth Science programs.

2. Programmatic Information

Questions or comments may be directed to the Biodiversity Program Manager using the information below:

Woody Turner
Earth Science Division
Science Mission Directorate
National Aeronautics and Space Administration
Washington, DC 20546-0001
Telephone: (202) 358-1662
Email: woody.turner@nasa.gov

A.8 GEDI SCIENCE TEAM

NOTICE: Amended October 11, 2019. Due to delays in the release of initial GEDI data to the public, the GEDI Science Team program element has been moved to next year. The due dates will be announced with the release of ROSES-2020, on February 14, 2020.

~~NASA plans to offer this program element in ROSES-2019, but for now the due dates are listed as TBD. The final text and the proposal due date for this program element will be released via a ROSES amendment no fewer than 90 days in advance of the proposal due date~~.

1. Scope of Program

NASA launched the Global Ecosystem Dynamics Investigation (GEDI) instrument to the International Space Station (ISS) in late 2018. This program element will solicit proposals for studies that use GEDI data to address key scientific questions in terrestrial ecology, carbon cycle science, and biodiversity. Selected principal investigators will become members of the GEDI Science Team.

NASA selected the GEDI instrument in July 2014 through the Earth Venture Instrument-2 solicitation. The GEDI instrument is mounted on the International Space Station's (ISS) Japanese Experiment Module – Exposed Facility (JEM-EF) and is a full-waveform lidar instrument that makes detailed measurements of the 3-dimensional (3-D) structure of the Earth's forests and land surface. The GEDI instrument collects data for footprints averaging 25 m in diameter, separated by 60 m along-track and 600 m across track, with a horizontal accuracy within +/- 9 m. The ISS has an orbital inclination of 51.5 degrees, which prevents observations over high-latitude regions. Thus, GEDI measurements will be made over the Earth's surface between 51.6° N and 51.6° S. GEDI can be rotated on the JEM-EF by up to 6°, allowing the lasers to be pointed up to 40 km on either side of the ISS ground track. This capability will allow greater sampling of the Earth's land surface. During GEDI's nominal two-year mission life, approximately 10 billion cloud-free observations of the Earth's surface will be acquired.

Data collected by the GEDI mission are intended to address three core science questions:

1. What is the above-ground carbon balance of the land surface?
2. What role will the land surface play in mitigating atmospheric CO_2 in the coming decades?
3. How does ecosystem structure affect habitat quality and biodiversity?

GEDI data can also be used to address other scientific questions but these will be a lower priority.

The GEDI project will produce GEDI waveforms, canopy height metrics, canopy profile metrics, and empirical estimates of footprint-level and gridded aboveground biomass. GEDI enables a wide range of other possible data products related to changes in carbon stocks, habitat and biodiversity metrics, and other land surface characteristics. Overall, GEDI's science data products will include footprint and gridded data sets that describe different 3D features of the Earth. The GEDI website at https://gedi.umd.edu has additional information on GEDI instrument, mission specifications, calibration/validation strategies, and Algorithm Theoretical Basis Documents (ATBDs) for the planned data products.

2. Participation on the GEDI Science Team

Principal Investigators on selected proposals will become members of the GEDI Science Team (ST). The team will:

- Report to NASA Headquarters on scientific progress;
- Facilitate collaborative work with GEDI data;
- Provide guidance to calibration and validation plans for the mission; and
- Identify potential postlaunch studies to better meet the science objectives, and evaluate such studies when completed.

All proposals should include in their budget support for attendance at two in-person GEDI Science Team Meetings each year in varying locations in the U.S.

For further information on this program, contact:

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Earth Science Division
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A.9 PHYSICAL OCEANOGRAPHY

1. Scope of Program

NASA's Physical Oceanography program supports basic research and analysis activities that enable development of NASA's current and future physical oceanography satellite missions and the scientific interpretation of data from them. The primary centers of support for the Physical Oceanography program are the NASA Jet Propulsion Laboratory Earth Science Directorate and the external (non-NASA) scientific community. This announcement serves as the vehicle for participation in the Physical Oceanography program for all institutions.

The primary scientific thrust for physical oceanography at NASA is toward understanding the ocean's role in climate variability and its prediction. Since the general ocean circulation plays a critical role in the global heat balance and materially changes atmospheric properties through air-sea exchange, understanding and modeling the state of the coupled ocean-atmosphere system are fundamental to climate studies. NASA utilizes the unique vantage point of space to enable rapid collection of global ocean data sets and contributes significantly to the World Climate Research Program's Climate Variability and Predictability (CLIVAR) Program (http://www.usclivar.org).

The Physical Oceanography Program encompasses science teams supporting satellite altimetry (Ocean Surface Topography Science Team), ocean surface salinity via radiometry (Ocean Surface Salinity Team), sea surface temperature (Sea Surface Temperature Science Team), and ocean vector winds (Ocean Vector Winds Science Team). Proposals focused on one of these variables are better submitted to those competitions and may be considered non-responsive to this program element. In this program element, NASA is looking for work that cuts across multiple variables and focuses on the ocean's role in climate.

While NASA's focus remains global in nature, it is recognized that many of the practical problems with respect to human interaction with the ocean lie within the coastal seas. Compelling proposals that address the physical oceanographic characteristics of coastal seas in a global context are, therefore, welcome. Three research themes are identified in the Physical Oceanography program and represent priority areas for proposals solicited through this announcement:

1. Analysis and interpretation of the ocean circulation using satellite and *in situ* data, data-derived products and NASA ocean state estimates (e.g. ECCO - Estimating the Circulation and Climate of the Oceans). Tailoring such proposals to support the objectives and priorities the U.S. CLIVAR Program is encouraged. NASA recommends that proposals focused on a single variable (e.g., sea level, ocean vector winds, salinity) that is already supported by a dedicated science team be submitted to those science team elements in ROSES.
2. Development of novel remote sensing techniques for physical oceanography. NASA has successfully developed remote sensing techniques for ocean surface winds, sea level, sea surface temperature, and sea surface salinity. Each of these variables has a science team and dedicated research activity. NASA will support modest proposals that explore new concepts for remote sensing of interest to

physical oceanography. This opportunity is NOT for technology or instrument development, but for concept articulation and exploration.

3. The intensity and location of mixing in the ocean remains an area of active research. The third priority area for this year's announcement is seeking proposals that expand our spatial and temporal estimates of ocean mixing through the use of remote sensing and likely the joint analysis of satellite data sets with *in situ* ocean mixing (microstructure) data.

2. Programmatic Information

Total funds available for work selected under this solicitation are approximately $1.5M per year for three years.

Proposers are encouraged to include travel funding for one domestic trip per year to support participation in a relevant NASA Physical Oceanography Program workshop or scientific meeting (e.g. a U.S. CLIVAR workshop, a workshop on technology developments, or a workshop of investigators working on ocean mixing).

Programmatic priority will be given to those proposals making the strongest links to analysis of satellite data and addressing oceanographic problems at basin or global scale. Modeling of the Earth system, including physical oceanography aspects, is ably covered but not annually by NASA's Modeling, Analysis and Prediction Program (the most recent active solicitation is the program element A.16 of ROSES-2019) and thus proposers should articulate special circumstances or situations where modeling-dominated proposals should be considered for Physical Oceanography Program funding.

Based on the quality of proposals received, awards will be distributed across the three research themes identified in Section 1. Proposals outside these research themes may be considered but must be highly meritorious.

3. Summary of Key Information

Expected program budget for first year of new awards	~ $1.5M
Number of new awards pending adequate proposals of merit	~ 6-10
Maximum duration of awards	3 years
Due date for Notice of Intent to propose (NOI)	See Tables 2 and 3 of this ROSES NRA
Due date for proposals	See Tables 2 and 3 of this ROSES NRA
Planning date for start of investigation	January 1, 2020
Page limit for the central Science/Technical/Management section of proposal	15 pp; see also Table 1 of ROSES *Summary of Solicitation* and the *Guidebook for Proposers*.

Relevance to NASA	This program is relevant to the Earth science questions and goals in the NASA Science Plan. Proposals that are relevant to this program are, by definition, relevant to NASA.
General information and overview of this solicitation	See the *ROSES Summary of Solicitation*.
Detailed instructions for the preparation and submission of proposals	Please see *ROSES Summary of Solicitation* Section I(g) Order of Precedence and the *NASA Guidebook for Proposers*.
Submission medium	Electronic proposal submission is required; no hard copy is required or permitted.
Web site for submission of proposal via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Web site for submission of proposal via Grants.gov	http://grants.gov/ (help desk available at support@grants.gov or (800) 518-4726)
Funding opportunity number for downloading an application package from Grants.gov	NNH19ZDA001N-PO
NASA points of contact concerning this program, both of whom share the following postal address: Earth Science Division Science Mission Directorate NASA Headquarters Washington, DC 20546-0001	Eric Lindstrom Telephone: (202) 358-4540 Email: eric.j.lindstrom@nasa.gov Nadya Vinogradova-Shiffer Telephone: (202) 358-0976 Email: nadya.vinogradova-shiffer@nasa.gov

A.10 OCEAN SALINITY SCIENCE TEAM

1. Scope of Program

The NASA Ocean Salinity Science Team (OSST) supports basic research and analysis activities associated with production, improvement, and understanding of sea surface salinity data. The objective of this program element is to renew or select additional members for the OSST to support the salinity science within NASA's Physical Oceanography Program.

The overall goals of the OSST are to provide the scientific underpinning for production of the best possible satellite-derived ocean salinity data sets and to demonstrate the Earth science and applications arising from analyses of the ocean surface salinity data. The team assures that data made available are of the highest quality and validated for scientific exploitation. It also conducts ocean science investigations that are possible only through exploitation of remotely sensed sea surface salinity.

NASA's Aquarius satellite (http://aquarius.nasa.gov) completed a nearly four-year mission (June 2011-June 2015), providing global measurements of sea surface salinity (SSS). SSS are also being retrieved from NASA's Soil Moisture Active-Passive (SMAP) satellite (http://smap.jpl.nasa.gov/; launched in January 2015) to provide continuity of NASA's SSS measurements. Version 3 of the SMAP SSS product was released in November 2018. These data products are complemented by SSS measurements from the European Space Agency's Soil Moisture and Ocean Salinity (SMOS) mission and by *in situ* salinity measurements (e.g., from the Argo array of profiling floats). NASA has also supported two major SSS process studies under the name of Salinity Processes in Upper Ocean Regional Studies (SPURS; http://spurs.jpl.nasa.gov/). SPURS investigators and science are also part of the Ocean Salinity Science Team.

Previous announcements for the OSST (in 2009, 2012, 2013, 2015, and 2017) have emphasized the calibration/validation and production of SSS products from Aquarius, as well as applications of Aquarius SSS products for ocean science investigations. The current announcement solicits proposals that address the following topics.

1. Exploitation of NASA satellite SSS measurements to investigate SSS variability, its influence on ocean circulation, and the linkage with climate and water cycle. Synergistic use of NASA SSS measurements with other satellite and *in situ* observations is encouraged.
2. Evaluation and improvement of Aquarius and SMAP SSS products. The Aquarius Project, at its conclusion, produced Version 5.0 of mission data at the end of 2017. There is still much to be learned and improved in the Aquarius retrievals. Likewise, salinity retrievals from SMAP have advanced to Version 3.0 (November 2018) and much work remains to evaluate and improve this product. Also, work to assure the continuity and consistency of the SSS products across the two missions is a high priority. Products and software developed under this solicitation is to be distributed to the public as opean source software, following NASA's Earth Science Data System (ESDS) Open Source Sofware Policy (https://earthdata.nasa.gov/earth-science-data-systems-program/policies/esds-open-source-policy).
3. Improve estimates of total error budget for SMAP and Aquarius SSS for more

meaningful integration of satellite SSS into global observing system and climate models. Revised error budgets are sought to include both observational and sampling errors associated with sub-footprint variability, temporal aliasing, and near-surface stratification. Understanding the underlying physical mechanisms of the expected differences between *in situ* and satellite salinity (e.g., precipitation, small-scale noise, high-frequency fluctuations, etc.) continue to need attention.

2. Programmatic Information

Total funds available for work selected under this solicitation are approximately $2M per year for three years.

Programmatic priority will be given to those proposals making the strongest links to analysis of satellite data and addressing oceanographic problems at basin or global scale. It is expected that all proposals will use satellite SSS in a fundamental way (so that it is not perceived to be peripheral to the proposed work). Selected PIs and/or Co-Is are expected to attend annual OSST meetings in varying US locations, and should include travel support in their budget.

Based on the quality of proposals received, awards will be distributed across the three research themes identified in Section 1. Proposals outside these research themes may be considered but must be highly meritorious.

3. Summary of Key Information

Expected program budget for first year of new awards	~ $2.0M
Number of new awards pending adequate proposals of merit	~ 10-15
Maximum duration of awards	3 years
Due date for Notice of Intent to propose (NOI)	See Tables 2 and 3 of this ROSES NRA
Due date for proposals	See Tables 2 and 3 of this ROSES NRA
Planning date for start of investigation	March 1, 2020
Page limit for the central Science/Technical/Management section of proposal	15 pp; see also Table 1 Table 1 of ROSES *Summary of Solicitation* and the *Guidebook for Proposers*.
Relevance to NASA	This program is relevant to the Earth science questions and goals in the NASA Science Plan. Proposals that are relevant to this program are, by definition, relevant to NASA.
General information and overview of this solicitation	See the *ROSES Summary of Solicitation*.
Detailed instructions for the preparation and submission of proposals	See the *NASA Guidebook for Proposers* at http://www.hq.nasa.gov/office/procurement/nraguidebook/.

Submission medium	Electronic proposal submission is required; no hard copy is required or permitted.
Web site for submission of proposal via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Web site for submission of proposal via Grants.gov	http://grants.gov/ (help desk available at support@grants.gov or (800) 518-4726)
Funding opportunity number for downloading an application package from Grants.gov	NNH19ZDA001N-OSST
NASA points of contact concerning this program, both of whom share the following postal address: Earth Science Division Science Mission Directorate NASA Headquarters Washington, DC 20546-0001	Eric Lindstrom Telephone: (202) 358-4540 Email: eric.j.lindstrom@nasa.gov Nadya Vinogradova-Shiffer Telephone: (202) 358-0976 Email: nadya.vinogradova-shiffer@nasa.gov

A.11 SEA LEVEL CHANGE SCIENCE TEAM

NOTICE: Amended May 30, 2019. This amendment releases the final text for this program element. Notices of intent to propose are requested by September 26, 2019, and the due date for proposals is October 31, 2019.

1. Introduction

Rising seas are one of the most disruptive consequences of climate change, impacting highly-populated coastal communities through an increased occurrence and intensity of flooding events, storm surges, coastal erosion, salt-water intrusion, losses of biodiversity and freshwater resources.[1] Understanding the physical processes behind these changes is key to predicting the potential impact of rising seas and extreme events on coastal communities, the national and global economy, and is recognized as one of the Grand Challenges of our time by the World Climate Research Programme (WCRP).

To address this challenge, NASA has assembled a multi-disciplinary Sea Level Change Science Team (N-SLCT) consisting of leading experts in the fields of oceanography, geodesy, cryosphere, hydrology, modeling, statistics, and science communication.[2] Multiple NASA science programs have contributed to various aspects of this research including programs in Physical Oceanography, Cryospheric Sciences, Interdisciplinary Sciences, Earth Surface and Interior, and Earth Science Data and Information System (ESDIS). Since 2014, the N-SLCT has been conducting interdisciplinary sea level science by collecting and analyzing observational evidence of sea level change, quantifying the underlying causes and driving mechanisms, producing projections of future changes in sea level, as well as communicating NASA's latest discoveries to the public through NASA's Sea Level Portal at https://sealevel.nasa.gov. As a result, progress has been made on a number of important problems in sea level science, resulting in a better understanding of ice sheet dynamics, the development of tools and assessments of the impacts of mass loss from ice sheets and glaciers on coastal cities, and improved representation of vertical land motion related to coastal subsidence, tectonics, and Earth's post-glacial rebound.

Building on the progress of the previous N-SLCT, NASA is soliciting proposals to continue the work of the Team in order to address remaining open questions as outlined below.

2. Scope of Program

The program is intended to integrate research results, data sets, and model outputs to improve the accuracy of sea level estimates and its components, to integrate results into better forecasts of sea level rise, and to communicate the results of NASA's sea level research in a simplified manner to the science community and the public.

[1] USGCRP (2018), Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II, *U.S. Global Change Research Program*, Washington, DC, 1515, doi:10.7930/NCA4.2018.

[2] See previous NASA solicitations ROSES-2013 (A.15) and ROSES-2016 (A.10) for details, including abstracts of selected proposals.

To achieve these goals, the specific objectives that appear in the following subsections have been identified for proposers.

2.1 Provide observational evidence of sea level change with improved accuracy

Satellite radar altimetry from TOPEX/Poseidon, Jason-1, 2, and 3 and *in situ* tide-gauge records offer important observations that allow measurement of sea level change directly and characterization of its spatial and temporal variability. Gravitational measurements have been used to measure mass change in the ice sheets and oceans, and mass movement within the solid Earth. Laser altimetry, Interferometric-Synthetic Aperture Radar (InSAR), the Global Navigation Satellite System (GNSS), including Global Positioning System (GPS) have been used to characterize dynamic aspects of ice loss and monitor vertical land motion due to natural and anthropogenic processes. New observations from recently launched NASA missions such as the Ice, Cloud, and land Elevation Satellite-2 (ICESat-2) and Gravity Recovery and Climate Experiment Follow-On (GRACE-FO), and from future missions such as the Sentinel-6 (Jason-CS), the NASA-ISRO SAR (NISAR) mission and the Surface Water and Ocean Topography (SWOT) mission will add to the existing methods for detecting sea level change and the physical processes driving the change.

Continued efforts to provide updated datasets of best estimates of sea level and its components are critical to assess sea level change from a variety of independent measurements and missions. Furthermore, advances in monitoring and predicting sea level rise rely upon our ability to resolve small, sub-mm signals in the data, such as secular trends and acceleration. These measurements depend on a precise terrestrial reference frame, to which NASA's space geodesy network data and analyses contribute. This program element seeks to provide updated estimates of relative (with respect to the land) sea level change on regional and global scales with improved accuracy and resolution. Synergistic use of NASA observations, data products, and/or NASA's ocean-ice state estimates (e.g., ECCO – Estimating the Circulation and Climate of the Oceans) is encouraged.

2.2 Quantify contribution of underlying physical mechanisms of sea level variability

Although the main drivers of sea level change are generally known, the specific details of interaction between the components are still poorly constrained. Improving our understanding of regional sea level fluctuations requires consideration of changes in the ocean, cryosphere, solid Earth, and terrestrial storage of water, as well as characterizing the forcing, response, and feedback mechanisms within the ocean-land-atmosphere system. Examples of areas where new N-SLCT investigations can build on or improve previous advances are given below.

Earth System Feedbacks: A fair amount of progress has been made by previous N-SLCT efforts to improve our knowledge of the mass of glaciers and ice sheets of Greenland and Antarctica (see at https://sealevel.nasa.gov for the latest N-SLCT discoveries). The results indicate that ice surface mass balance, ice-ocean, and ice-solid Earth interactions are important factors controlling sea level rise, and thus warrant further attention by the Team. To continue to advance our understanding in this area, NASA welcomes investigations of the impact of land ice melt on sea level patterns that goes beyond gravitational effects (fingerprints), which are relatively well-understood by the Team's previous efforts. For example, this program element seeks proposals that consider dynamical ocean-ice coupling and quantify the ocean's response and feedbacks across the range of scales – from rapid, barotropic adjustments over a few days to longer baroclinic responses occurring over decades driven by various wave dynamics, changes in ocean density and circulation. Similarly, while regional feedbacks associated with glacial isostatic adjustment (GIA) on timescales of millennia are sufficiently understood, proposals addressing new feedbacks between ice melt and solid-Earth processes, such as those that include shorter spatial and temporal scales of kilometers and centuries, respectively, are welcomed.

Hydrological Cycle and Terrestrial Water Storage: The ongoing changes in the hydrological cycle, including changes in river runoff, changes in the amount of water stored in the ground or its surface, and general amplification of atmospheric moisture transport, further contribute to sea level changes at regional and global scales. With this program element, NASA aims to expand N-SLCT investigations of the impacts of hydrological cycle and terrestrial water storage on sea level change. Anticipating the launch of the SWOT mission in 2021, exploration of hydrological observations for sea level research is of interest to NASA. In particular, NASA encourages regional case studies (e.g., along the US East coast and other urban coastlines) that couple regional hydrologic, oceanographic, cryospheric, and geodynamic processes that affect sea level dynamics and associated coastal inundation processes.

Solid Earth Dynamics: NASA continues to support studies that improve representation of vertical land motion related to solid-Earth dynamics, including isostacy, tectonics, local land subsidence; and other processes affecting the height of the existing solid surface that cause submergence (or emergence) of land, alteration of the coastlines, and additional variations in relative sea level. Self-consistent models that include the full range of solid-Earth processes contributing to sea level variation, from GIA, to rotational dynamics, to other processes driving vertical land motion, are critical to the objectives of this Team. This program element seeks proposals that improve the description of the vertical motion of land surfaces due to various local-to-global processes, and quantify the impact of solid-Earth dynamics in shaping patterns of regional and local relative sea level.

2.3 Develop projections of global and regional relative sea level change on various time horizons

Projections of future sea level rise suggest dramatic implications for coastal communities, with even a relatively small rise potentially displacing millions of people and threatening America's trillion-dollar coastal property market and public infrastructure.[1] Observations from satellite altimetry and tide gauges show that the current projections are approaching the upper end of the model projections of sea level for the highest representative carbon dioxide concentration pathways in the IPCC Fifth Assessment Report, increasing the need for updated estimates of future sea level rise.

NASA is charging the N-SLCT to develop improved sea level projections on global and regional levels. Driven by societal and economic demand, there is a strong need to develop projections on multiple time horizons, associated with various modes of climate variability ranging from seasonal and interannual to sustained sea level changes over decades to centuries. Given NASA's overall mission and strategic goals, this program element encourages investigators to produce observation-based and physics-based projections with uncertainties informed by our best knowledge of the system and the outcomes from new research conducted in response to Objectives 2.1 and 2.2. Production of a common set of projections as well as individual estimates from different groups is expected. The Team is encouraged to analyze differences among various Team-generated projections to provide insight into the uncertainties and sensitivities of various approaches.

Unified, science-based estimates of future sea level rise (with uncertainty estimates) produced by the Team are meant to serve as a contribution to various assessment frameworks, such as the U.S. Global Change Research Program (USGCRP) National Climate Assessment (NCA) studies, as well as international IPCC assessment and special reports related to sea level science. Projections produced with regional resolution can also serve as guides for the development of public policy and investments in regional adaptation. These projections must provide probabilistic estimates of accuracy so as to properly present this information to the public and decision-makers.

2.4 Synthesis of disciplinary results enabling a team product

An overarching goal of the Team is to break the barriers between sea level scientists from different disciplines in order to address this multi-faced problem. Therefore, an important element of this program element is the production of a common product by the Team informed by the most recent knowledge from various disciplines. An example of a common product could be the development of regional sea level projection on range of timescales – a unifying target that was identified by the previous N-SLCT members. As a multi-disciplinary team of experts, the Team is also positioned and expected to make a significant contribution to international (e.g., WCRP) and national (e.g., US CLVIAR) sea level activities by providing an integrated view of the current observing system, data, and tools that will inform the decadal surveys of the future.

NASA's Sea Level Portal at https://sealevel.nasa.gov will serve as the Team's face to the public as well as a vehicle for the cross-team collaboration and integration of the results. Therefore, the role of the Portal is to provide an infrastructure that:

- promotes coordination among the Team members by creating tools to work on a common science product (e.g., sea level budget tools, regional assessments and projections, etc.);
- allows the Team to share knowledge and recent results;
- helps untangle complex physics of sea level science for the public by translating the Team's discoveries into accessible, actionable results and aligning them with specific decision-making contexts;
- reuses the existing portal system at the current web location

The web Portal team selected through this announcement is expected to work closely with the Earth Science Data and Information Systems (ESDIS) Project, which operates and maintains the sea level Portal, and will provide support in integrating new portal capabilities into the existing system following NASA's integration policies[3].

3. Team Structure and Evaluation

3.1 Team Structure

As with the previous N-SLCT, the Team is intended to consist of four to six interdisciplinary research teams and a web portal science coordination team. The announcement also serves to continue the work of the Team initiated in 2014 and continued in 2017 onward. It is envisioned that the N-SLCT will build on the achievements and groundwork laid by the previous Team members, under the guidance of a Team Leader who is expected to ensure continuity of the ongoing activities, foster integration of results, and oversee the production of a common science product. NASA will appoint a Team Leader among the investigators outside of this solicitation process, and thus is not soliciting Team Leaders here.

3.2 Evaluation

The three primary evaluation criteria (Merit, Relevance, and Cost) are presented and defined in Appendix D of the *NASA Guidebook for Proposers* and some information on how they are evaluated are presented in Section VI.(a) of the *ROSES-2019 Summary of Solicitation*. In addition, to be considered responsive:

a) Proposals must include investigators from two or more of the core scientific disciplines of oceanography, geodesy, cryosphere, Earth surface and interior, and hydrology.
b) Proposals must address Objective 2.4 and include appropriate work effort, resources, and deliverables that support regular cross-team activities and synthesis of the results across the Team. As with previous N-SLCT, willingness to be a team player is essential. All members are expected to work collectively for the common success of the Team by sharing results, interacting with the broader team, and contributing to a production of a common product.
c) Work must be based on NASA's satellite observations and, if appropriate, based on NASA's sub-orbital sensors, models, and ocean state estimates.
d) Proposals must provide clear management plans that include milestones and schedule of deliverables to the web Portal that aid production of a common science product and communication of new results to the public (see data and software requirements below).

Most favorable consideration will be given to those proposals that can integrate work on the objectives and interact constructively with the web portal and across the members of the Team.

[3] https://earthdata.nasa.gov/earth-science-data-systems-program/competitive-programs/access/community-data-system-capabilities-overview

4. Data and Software Policy

Data, model results, and other information created under this announcement are subject to NASA's Earth Science Data policy.[4] Proposals to develop products and software must provide a data management plan[5] and open source software development plan,[6] identifying an open source software license and stating an open source software release milestones. Appropriate deliverables will be archived by ESDS at a NASA Distributed Active Archive Center (DAAC) in formats that can be readily used for a range of research needs. All data products must meet applicable U.S. Government-mandated standards adhering to requirements by NASA Earth Science Data Products[7]. All software along with source code for the web portal development element must be released by the grantee to the NASA Github per the NASA Open Source Software (OSS) policy and is subject to the NASA Earth Science Alternate Data Rights language to be included into award agreements. This includes all software developed with ESDS Program funding used in the production of data products, as well as software developed to discover, access, analyze, visualize, and transform NASA data. OSS is defined as software that can be accessed, used, modified, and shared by anyone. OSS is often distributed under licenses that comply with the definition of "Open Source" provided by the Open Source Initiative[8] or meet the definition of "Free Software" provided by the Free Software Foundation.[9]

5. Summary of Key Information

Expected program budget	~$2.5M/year
Number of new awards pending adequate proposals of merit	~4-6
Maximum duration of awards	4 years
Due date for Notice of Intent to propose (NOI)	See Tables 2 and 3 of this ROSES NRA
Due date for proposals	See Tables 2 and 3 of this ROSES NRA
Planning date for start of investigation	May 2020
Page limit for the central technical section of the proposal	15 pp; See also Chapter 3 of the *NASA Guidebook for Proposers*
Relevance to NASA	Proposals that are relevant to this program are, by definition, relevant to NASA
General information and overview of this solicitation	See the *ROSES Summary of Solicitation*
Detailed instructions for the preparation and submission of proposals	See the *ROSES Summary of Solicitation* and the NASA Guidebook for Proposers
Submission medium	Electronic proposal submission is required; no hard copy is required or permitted.

4 http://science.nasa.gov/earth-science/earth-science-data/data-information-policy/
5 https://science.nasa.gov/researchers/sara/faqs/dmp-faq-roses
6 https://earthdata.nasa.gov/collaborate/open-data-services-and-software/esds-open-source-policy
7 https://earthdata.nasa.gov/about/esdis-project/eso/standards-and-references
8 https://opensource.org/osd
9 https://www.gnu.org/philosophy/free-sw.html

Web site for submission of proposal via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Web site for submission of proposal via Grants.gov	http://grants.gov (help desk available at support@grants.gov or (800) 518-4726)
Funding opportunity number for downloading an application package from Grants.gov	NNH19ZDA001N-SLCST
Main point of contact concerning this program	Nadya Vinogradova Shiffer Phone: (202) 358-0976 Email: nadya@nasa.gov

General questions about the Sea Level Change Program should be directed to the main point of contact above. Additional questions related to specific disciplines may be addressed to those listed below all of whom share the following postal address:

Earth Science Division
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A.12 SURFACE WATER AND OCEAN TOPOGRAPHY (SWOT) SCIENCE TEAM

Amended August 22, 2019. This amendment releases the final text for this program element. Notices of intent to propose are requested by October 17, 2019, and the due date for proposals is November 21, 2019. The Data Management Plan (DMP) is not requested on the NSPIRES cover page. Instead, the DMP is to be included in the proposal PDF after the page limited S/T/M section, see Section 3.1 of this program element. A mandatory template is provided for the Summary Table of Work Effort and Current And Pending Support, see Section 3.2.

1. Introduction

Surface Water and Ocean Topography (SWOT) is a satellite mission being jointly developed by NASA and CNES (Centre National d'Etudes Spatiales), the French space agency, with contributions from the Canadian Space Agency (CSA) and the United Kingdom Space Agency (UKSA) and is currently scheduled for launch in 2021. Information on the SWOT mission and its capability to fulfill the objectives laid out for it can be found at the SWOT web site https://swot.jpl.nasa.gov/.

SWOT mission will be NASA's first global survey of Earth's surface water to observe ocean surface topography, major lakes, rivers, and wetlands with unprecendented resolution. Technical and scientific challenges include reducing measurement noise by two orders of magnitude below that of conventional altimetry missions like Ocean TOPography EXperiment (TOPEX)/Poseidon and Jason series. The systematic measurement errors (e.g., baseline roll and metrology, water-vapor induced range errors, etc.) must also be reduced at oceanic mesoscales to more than one order of magnitude below the signal levels. Mesoscale tidal errors caused by coastal and internal tides must be corrected for. The effects of vegetation, target layover, and water mask accuracy over land are challenges to be met by the mission’s measurement system.

The SWOT mission will use Ka-band radar interferometry to produce a swath of elevation measurements collected over land surface waters and over the ocean water surface. These elevation measurements are necessary for studying changes in the amount of water stored and flowing through the world’s rivers, lakes, wetlands, reservoirs, etc. The measurements are fundamental for studying ocean surface topography and mesoscale and submesoscale processes in the ocean. On land, the SWOT mission will make the first high-resolution mapping of the height and area variations of water bodies such as lakes, reservoirs, and wetlands. SWOT will also provide measurements necessary for estimating river discharge. All of these elements are of key importance to monitoring and understanding the shifting freshwater resources. Over the ocean, the SWOT mission will extend the capability of existing nadir profiling altimeters to two-dimensional mapping at higher resolution enabling the study of energetic ocean currents, eddies, and fronts that contain most of the kinetic energy of the ocean.

The objective of this announcement is to select a Science Team to assist with prelaunch planning and immediate post-launch scientific exploitation of the SWOT mission. The selection will be conducted in coordination with CNES, CSA, and UKSA. The Science Team will function for the period 2020 through 2024. Its role, along with relevant scientific research, will be to provide expert guidance to the SWOT project in the areas of measurement requirements, product definition, geophysical error sources, algorithm development, calibration, validation, and liaison with the broader science and applications communities.

2. Primary Research Priorities for the Science Team

2.1 Oceanography

The oceanography science goals of SWOT are to observe the sea surface height (SSH) in two dimensions at scales not resolved by conventional altimetry for studying the role of ocean circulation in exchange of heat and ocean properties between the upper and deep ocean. The SSH measurement is to be made by the technique of radar interferometry that is fundamentally different from conventional altimetry. The observations are also expected to advance the understanding of the processes of the coastal oceans and interactions with the estuaries.

The mission's science requirements were developed with the participation of the mission's Science Definition Team during 2013 – 2016. As the thrust of SWOT is to make SSH observations at previously unresolved scales, the observational requirements were specified in terms of wavenumber spectrum. Based on the prediction of signal strength and measurement errors, the spatial along-track resolution of SWOT is estimated to be 15 km for 2 m significant wave height. However, both signal strength and measurement errors are dependent on seasonal conditions, the actual resolved wavelengths vary from 15 km in the tropics to 30-50 km at high latitudes with the largest values in the Southern Ocean.

The mission's Science Team (2016 – 2019) has continued preparing the algorithms for open ocean and coastal processing, and contributed to the scientific understanding of the SWOT ocean signal, errors and applications. The mission has two phases with a 1-day repeat Validation orbit, and a 21-day repeat Science orbit. To aid in the preparation of ocean science studies, a SWOT ocean simulator has been developed to simulate the realistic SWOT swath, ground track and errors. The simulator can be applied to most high-resolution model formats, and is freely available at SWOT simulator GitHub.

The specific objectives for proposers addressing mission's Oceanographic priorities have been identified in the following subsections.

2.1.1 *Mesoscale ocean dynamics*

The oceanic mesoscale eddy field, which has not been adequately resolved by the conventional altimeters, is a central focus of SWOT oceanography. After mapping to two-dimensional gridded fields, the resolution of conventional altimeters is about 150 km in wavelength with on-going improvement owing to the increased number of altimeters on orbit. SWOT will also carry a nadir-looking conventional altimeter. With the constellation of conventional altimeters providing the global mesoscale field down to

150 km, the new high-resolution observations of SWOT will provide opportunities to study the interaction of the mesoscale variability within its wide range of scales from hundreds to tens of kilometers. The fine-scale swath observations will allow a better characterization of the anisotropic structure of the mesoscale field, its strain and vorticity, and local 2D energy fluxes. Studies are encouraged that will further our understanding of these smaller mesoscale processes, and their observability with SWOT. In addition, synergistic applications with other observations capable of revealing mesoscale variability such as in situ or airborne data, or satellite sea surface temperature and salinity, ocean color and SAR images, are also encouraged.

2.1.2 *Tides and high-frequency motions*

SWOT's orbits have been specifically designed to resolve the major tidal constituents during its lifetime. SWOT is expected to provide unprecedented observations of the barotropic tides, especially in the coastal and high-latitude regions where current tidal models have the largest errors. The development of high-resolution barotropic tide models will be a high priority for SWOT, and these should be progressively improved during the mission lifetime. Science studies addressing the barotropic tide, its modification due to the baroclinic tide, and improved tidal models will be encouraged.

Internal tides and low-mode internal gravity waves have SSH signals comparable to mesoscale geostrophic motions. How to separate them is a challenge of the SWOT mission. Investigations addressing the development of predictive models for the internal tides are encouraged, including those incorporating the SWOT data. The swath observations of SWOT will provide new opportunities to validate and improve the internal tide models. Understanding and improving the non-phase-locked, incoherent part of the internal tide is a big challenge for SWOT, but also an important scientific opportunity to learn more on this pathway to ocean mixing and dissipation.

Internal gravity waves are not deterministic processes amenable to prediction. Their potential presence in the SWOT observations presents an unprecedented challenge and an opportunity for studying the interaction of these waves with the mesoscale geostrophic motions.

2.1.3 *Ocean fronts and air-sea interactions*

Horizontal gradients in SWOT's 2D SSH data can reveal the larger ocean fronts, with scales of tens of kilometers. SWOT will also provide collocated Synthetic Aperature Radar (SAR) images at 250 m resolution including power and variance, as well as SAR Doppler Centroid products providing higher resolution observations of the surface roughness changes across fronts. Studies are encouraged that use the collocated SSH and SAR images and other data and models to investigate frontal dynamics and upper-ocean wind-wave interactions across ocean fronts.

2.1.4 *Geophysical Corrections and Algorithms*

There are anticipated contributions from the Science Team to better understanding of the measurement physics and the mission's algorithm development. Particular challenges include the correction for the electromagnetic bias at the Ka-band frequency and its spatial variability across the measurement swath; the estimation of wind speed and significant wave height across the swath; the use of radar imagery to estimate surface current features; the detection of land, ice, and rain contamination; and, finally, the removal of errors due to the presence of ocean waves.

2.1.5 *Ocean state estimation*

The challenge of the separation of tides/waves from geostrophic motions is exacerbated by the deficiency of temporal sampling by SWOT. Owing to the limitation of near-nadir look angles to minimize the measurement errors, the swath of the observation is only 120 km wide with a 20-km nadir gap. It will take 21 days to complete the coverage of the world's oceans, with the revisit time varying from 10 days at the equator to two days at the poles. Apart from high latitudes, the repeat observations are most likely incoherent, presenting a challenge for estimating the continuously evolving state of the ocean. It is anticipated this challenge will motivate the development of creative approaches, including but not limited to the application of high-resolution assimilative models.

2.1.6 *High-level data products*

The number of observations at a given location in a repeat cycle ranges from two near the equator to more than ten at the highest latitudes. To reconstruct regular two dimensional SSH fields from the irregularly sampled observations, with complex error characteristics, will pose a significant challenge for advancing the study of ocean circulation from this new type of observation. Development of a methodology for producing optimally estimated products on regular space and time grids on both global and regional basis will be an important activity of the Science Team. The capacity to calculate derivatives of the SWOT gridded data (reconstruction of vorticity, strain, vertical velocities, and detection of fronts and filaments) must also be addressed.

2.1.7 *Calibration and Validation (Cal/Val)*

The interferometry measurement of SSH is fundamentally different from conventional altimetry. The approach to CalVal requires innovation and planning. First, the SWOT project needs to validate the measurement in terms of wavenumber spectrum, as opposed to previous point-wise validation. Second, the project must validate the utility of the SSH observations to the study of ocean circulation to meet the science goals. Cal/Val for SWOT will be orchestrated and conducted by the SWOT project at JPL. NASA is not seeking Cal/Val proposals with this program element. However, all members of the Science Team may involve themselves in analysis of the Cal/Val data.

2.2 Hydrology

The primary objective of SWOT hydrology, described in the Science Requirements Document, is to "characterize the spatial and temporal variations in surface waters, globally." In particular, SWOT aims to measure variations in lake and wetland water storage and river height, slope and discharge at sub-monthly, seasonal, and annual timescales. SWOT will provide these measurements for rivers wider than 100 m, globally, and for lakes larger than 250 m^2. These measurements will constitute the first globally consistent database of surface water storage and fluxes from space. They are expected to substantially advance hydrologic science in several areas, as specified in the Science Description Document. The following specific objectives for proposers address the mission's Hydrologic priorities have been identified:

2.2.1 *River, lake, and wetland science*

The storage of water in lakes and reservoirs, fluxes through rivers, and interactions with inland and coastal floodplains and wetlands are critical to understanding a broad range of science questions focused on hydrology, hydraulics, biogeochemistry, water resources engineering, etc. For example, the SWOT Science Definition Team identified the following core SWOT hydrology science questions:

- What is the spatial distribution of freshwater storages and runoff through rivers, lakes, and reservoirs? Does inclusion of the knowledge "close" water budgets of regional/global hydrology and climate models?
- What are the impacts of water impoundments in reservoirs and natural lakes, human water withdrawals, and trans-boundary rivers on the global water cycle, societal water supply, and global sea level rise?
- What are the regional-to-global-scale responses of lake volumes and river flows to climatic phenomena, e.g. droughts, floods, and a warming Arctic?
- What are the three-dimensional forms of waves propagating through natural river channels, and how may these be used to improve hydrodynamic models of flood hazard and risk?
- What are the spatial and temporal dynamics of water storage in millions of unmapped lakes and river floodplains, and how do they impact biogeochemical fluxes of carbon, nutrients, and greenhouse gases, waterborne diseases/public health, sediment transport, and ecosystem functioning?

There are also many other fruitful science questions related to SWOT hydrology, including in the areas of remote sensing science (e.g., radar phenomenology), the terrestrial cryosphere (e.g., snow processes), and the science of deltas and estuaries.

The SWOT Science Team projects focused in this category will finalize development of ways to address science questions before launch and then use the first SWOT data post-launch to begin addressing them. Science investigations may focus exclusively on SWOT data or may use a combination of SWOT measurements, other satellite or in situ data, and/or numerical models. All projects should make clear their plans for both pre-launch and post-launch activities.

2.2.2 *SWOT algorithms and hydrologic data products*

In order to effectively address science questions using SWOT, robust algorithms and high-quality data products are essential. The SWOT Science Team is integrally involved in development of such algorithms and data products. Key areas that are solicited here include:

- Development and implementation of algorithms to produce river discharge estimates from SWOT data globally. These may be based on so-called mass-conserved flow law inversion algorithms or other novel or established algorithms. Emphasis should be on global-scale implementation of algorithms rather than in only a few rivers. Proposals on discharge may also seek to integrate multiple existing or novel discharge algorithms into multi-model ensembles.

- Development and implementation of algorithms and data products based on assimilation of SWOT river, lake, and/or wetland data into hydrologic or hydrodynamic models
- Development of data products, led by the Science Team, that combine SWOT data with other remote sensing or in situ datasets to aid in addressing key SWOT science questions. Examples of other current and future satellite instruments providing data that could be used in combination with SWOT data include nadir altimeters such as the JASON series, GRACE-FO, various Sentinel satellites, BIOMASS, ICE-Sat 2, MODIS/VIIRS, the Landsat suite, and NISAR.

All proposals in this category should demonstrate that it is possible to fully develop and distribute any proposed data products using proposed resources.

As for Oceanography, Cal/Val in hydrology is being conducted by the SWOT Project so proposals for Cal/Val sites and Cal/Val-related field activities are not sought.

2.3. Synergistic Sciences

2.3.1 *Coastal and estuarine processes*

The limitation of land contamination of conventional altimeter observations near coasts will be alleviated by the radar interferometry measurement. This improvement, plus the availability of high-resolution data (~ 50 m) in the region where river meets the ocean, or the estuarine regions, will provide unprecedented opportunities to advance understanding of the complex water flow and its effects on this important environment.

Understanding coastal and estuarine processes, as well as removing tidal signals, will be aided by using the improved knowledge of coastal bathymetry, which will be derived from SWOT measurements of deviations from the vertical, for the development of better coastal tides and circulation models.

2.3.2 *Cryosphere*

SWOT is required to identify water covered by floating ice. Additionally, it is possible that SWOT will provide useful measurements of snow surface elevation, especially during snowmelt when liquid water is present within the snowpack. Similarly, SWOT may provide some information on variations in elevation of glaciers and ice sheets, especially in low-slope regions. These measurements may provide useful information on variations in the cryosphere of importance to understanding of the terrestrial water cycle.

SWOT measurement will be useful to determine the freeboard of sea ice to allow an estimate of the sea ice volume. The high-resolution observation, at 1-km everywhere with limited data at resolution ~100 m, will allow better determination of ocean surface topography in the polar ocean in the midst of sea ice. SWOT will also be useful to determine the height of ice sheets and thus provide all-weather information for studying the evolution of polar ice sheet topography. Water cycles involving melting of glaciers and ice sheets are a potentially fruitful subject of investigation.

2.3.3 *Marine geophysics*

The SSH slope accuracy achieved by conventional altimetry is about 2 microradians, equivalent to 2 miliigals in gravity anomaly. Every SWOT measurement promises to achieve 1 microradian slope accuracy at 15 km wavelength over two dimensions as opposed to one-dimensional measurement by conventional altimetry. Over the lifetime of the mission, the precision of the measurement, as well as contamination due to mesoscale eddy slopes, will improve by an order of magnitude due to temporal averaging. Such global measurement is anticipated to result in an order of magnitude improvement in the accuracy of estimating seafloor depth at small scales. This would reveal the currently hidden abyssal hill fabric of the slow-spreading rate seafloor, as well as perhaps 10-20 thousand uncharted seamounts taller than 1000 m.

3. Programmatic Information

3.1 Data and Software Policy

Data, model results, and other information created under this announcement are subject to NASA's Earth Science Data policy. Proposals to develop products and software must provide a Data Management Plan (see below) and open source software development plan, identifying an open source software license and stating an open source software release milestones. Appropriate deliverables will be archived by ESDS at NASA Physical Oceanography Distributed Active Archive Center (PO.DAAC) in formats that can be readily used for a range of research needs. All data products must meet applicable U.S. Government-mandated standards adhering to requirements by NASA Earth Science Data Products. All software along with source code for the web portal development element must be released by the grantee to the NASA GitHub per the NASA Open Source Software policy and is subject to the NASA Earth Science Alternate Data Rights language to be included into award agreements. This includes all software developed with ESDS Program funding used in the production of data products, as well as software developed to discover, access, analyze, visualize, and transform NASA data. Open Source Software is defined as software that can be accessed, used, modified, and shared by anyone, and is often distributed under licenses that comply with the definition of "Open Source" provided by the Open Source Initiative or meet the definition of "Free Software" provided by the Free Software Foundation.

Proposed Data Management Plan (DMP) must provide information on how data will be managed and shared throughout its lifecycle in compliance with NASA's Earth Science data policy. Example information to consider for inclusion in a DMP are provided below. Additional information about data management best practices is available at PO.DAAC website that lists file formats and metadata models, with recommended metadata attributes. Specifically, each DMP must include the following information:

1) Data and formats produced by proposer, including information on
    a) data sources, e.g., satellites, in situ, airborne, model output, etc.
    b) data packaging, e.g., discrete points such as trajectory or fixed location, irregular grids of orbital or airborne swaths, regular grids of Level 3 or Level 4 products, time series, etc.;

   c) file format, such as NetCDF, HDF, GeoTIFF, ASCII, shapefile, etc. NetCDF or HDF are the preferred PO.DAAC file format as they are both self-describing and platform/software interoperable;
   d) metadata model conventions, such as Climate Forecast and Attribute Convention for Data Discovery, which are the preferred PO.DAAC metadata conventions for NetCDF and HDF file formats;
   e) expected data latency, i.e., the time lag between the last observation in the data file and when data is fully processed and packaged for that data file.
   f) total expected data volume for the life of the project; and
   g) data reprocessing or new versions expected as part of the proposed project.
2) The timeline for the full cycle of data product delivery; starting from measurement, through production, review, and distribution. The timeline for re-processed versions of datasets.
3) Strategy for regularly documenting data product characteristics, including spatial, temporal, measurements characteristics, and data structure.
4) A plan to document data validation and uncertainty.

Consistent with a DMP, costs for all data management activities, including quality assessment, documentation, data and product sharing, data/metadata formatting, and preparation for long-term archive, must be included in the budget presented in the proposal. The DMP section must be inserted immediately after the 15-page S/T/M section. The DMP section does not have a page limit.

3.2 Budgetary and Programmatic Guidance

Total funds available for work selected under this program element are approximately $3.0M per year for four years.

Proposers must budget for mandatory project representation at annual Science Team meetings (odd years in Europe and even years in North America). Moreover, proposers are encouraged to include travel funding for one domestic or foreign trip per year to support participation in a relevant SWOT mission activity, workshop or scientific meeting.

ROSES requires that all proposals include a Summary Table of Work Effort and a list of Current And Pending Support. This program element mandates the use of the templates from the SARA web page.

Programmatic priority will be given to those proposals making the strongest scientific links to SWOT and address technical contributions to the overall SWOT mission and data products. Based on the quality of proposals received, awards will be distributed across the three research themes identified in Section 2 (~40% Oceanography, ~40% Hydrology, and ~20% Synergistic Science). Proposals outside these research themes may be considered but must be highly meritorious.

4. Summary of Key Information

Expected program budget	~$3M/year
Number of new awards pending adequate proposals of merit	~14-18

Maximum duration of awards	4 years
Due date for Notice of Intent to propose (NOI)	See Tables 2 and 3 of this ROSES NRA
Due date for proposals	See Tables 2 and 3 of this ROSES NRA
Planning date for start of investigation	June 2020
Page limit for the central technical section of the proposal	15 pp; See also Chapter 3 of the NASA Guidebook for Proposers
Relevance to NASA	Proposals that are relevant to this program are, by definition, relevant to NASA
General requirements for content of proposals	See Section 3 of the *NASA Guidebook for Proposers* and Section IV and Table 1 of *the ROSES Summary of Solicitation*.
Detailed instructions for the submission of proposals	See https://nspires.nasaprs.com/tutorials/ Sections 3.22-4.4 of the *NASA Guidebook for Proposers* and Section IV(b) of *the ROSES Summary of Solicitation*.
Documenting Work Effort and Current and Pending Support	Work Effort and Funding Support for PIs and Co-Is must be documented using the templates available on the SARA webpage
Submission medium	Electronic proposal submission is required; no hard copy is required or permitted.
Web site for submission of proposal via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Web site for submission of proposal via Grants.gov	http://grants.gov (help desk available at support@grants.gov or (800) 518-4726)
Funding opportunity number for downloading an application package from Grants.gov	NNH19ZDA001N-SWOTST
Points of contact concerning this program, both of whom share the following postal address: Earth Science Division Science Mission Directorate NASA Headquarters Washington, DC 20546-0001	Eric Lindstrom Phone: (202) 358-4540 Email: eric.j.lindstrom@nasa.gov Nadya Vinogradova Shiffer Phone: (202) 358-0976 Email: nadya@nasa.gov

A.13 SURFACE WATER AND OCEAN TOPOGRAPHY MISSION - CALIBRATION AND VALIDATION FIELD CAMPAIGNS

NOTICE: Amended August 12, 2019. This program element will not be solicited. Field campaigns for SWOT Calibration and Validation will be conducted by the SWOT project, which is based at the NASA Jet Propulsion Laboratory with science support from the SWOT Science Team, to be selected via program element A.12.

~~NASA expects developments within the present SWOT Mission activities to inform the call for proposals articulated below. It is expected that the final text of this element will be published as an amendment to ROSES by the end of July 2019, with the expectation of a proposal due date in late October 2019. In any case, the final proposal due date for this program element will be no fewer than 90 days after the release of final text.~~

1. Scope of Program

Surface Water and Ocean Topography (SWOT) is a satellite mission being jointly developed by NASA and CNES (Centre National d'Etudes Spatiales), the French space agency, with contributions from the Canadian Space Agency (CSA) and the United Kingdom Space Agency (UKSA) and is currently scheduled for launch in 2021. Information on the SWOT mission and its capability to fulfill the objectives laid out for it can be found at the SWOT web site (http://swot.jpl.nasa.gov/).

The SWOT project had always planned to deploy the needed scientists and equipment for the mission calibration and validation (Cal/Val). Early plans identified a requirement for a separate small science team to analyze the Cal/Val data. As plans have matured, the SWOT project has entrained many community scientists in the planning and execution of Cal/Val campaigns. In addition, all members of new science team, to be selected in response to proposals submitted to program element A.12 of ROSES 2019, may involve themselves in analysis of the Cal/Val data. Therefore, there is no longer need for separate Cal/Val call in ROSES, so program element A.13 will not be solicited.

~~NASA expects to have robust well-planned calibration and validation field campaigns performed soon after the launch of the SWOT mission (LRD 9/2021). Specific plans for both Ocean and Hydrology Field Campaigns are still in formulation and will be available to inform an announcement for proposals by mid-2019.~~

2. Points of contact

Points of contact concerning this program, both of whom share the following postal address: Earth Science Division Science Mission Directorate NASA Headquarters Washington, DC 20546-0001	Eric Lindstrom Telephone: (202) 358-4540 Email: eric.j.lindstrom@nasa.gov Nadya Vinogradova-Shiffer Telephone: (202) 358-0976 Email: nadya@nasa.gov

A.14 OCEAN SURFACE TOPOGRAPHY SCIENCE TEAM

NOTICE: NASA does not intend to offer this program element in ROSES this year. The next expected solicitation for this element will be in ROSES-2020.

The joint NASA/National Oceanograpic and Atmospheric Administration (NOAA)/Centre National D'Etudes Spatiales (CNES) Ocean Surface Topography Science Team (OSTST) supports basic research and analysis activities associated with joint satellite altimetry missions (TOPEX/Poseidon (TP), Jason-1, Ocean Surface Topography Mission/Jason-2, and Jason-3) and other ocean altimetry data sets. The team is recompeted every four years.

The goals of the OSTST are to provide the scientific underpinning for production of the best possible satellite-derived altimetry data sets and to demonstrate the Earth science and applications arising from analyses of ocean surface topography data. The team is also involved in the calibration and validation of the cooperative altimetry mission between NASA, CNES, NOAA, and the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) and the European Space Agency.

NASA points of contact concerning this program, both of whom share the following postal address: Earth Science Division Science Mission Directorate NASA Headquarters Washington, DC 20546-0001	Eric Lindstrom Telephone: (202) 358-4540 Email: eric.j.lindstrom@nasa.gov Nadya Vinogradova-Shiffer Telephone: (202) 358-0976 Email: nadya.vinogradova-shiffer@nasa.gov
NOAA point of contact concerning this program	Laury Miller NESDIS/STAR Laboratory for Satellite Altimetry NOAA Center for Weather & Climate Prediction E/RA3 5830 University Research Court College Park, Maryland 20740 Telephone: (301)683-3331 Email: laury.miller@noaa.gov

A.15 OCEAN VECTOR WINDS SCIENCE TEAM

NOTICE: NASA does not intend to offer this program element in ROSES this year. The next active solicitation for this element is expected to be in ROSES-2021.

1. Scope of Program

The Ocean Vector Winds Science Team (OVWST) supports the analysis and interpretation of ocean vector winds and other applications derived from Earth-observing missions carrying scatterometers and polarimetric radiometers. Every four years, this program element solicits scientific investigations that require the accurate and extensive vector wind and backscatter measurements provided by a range of NASA and international missions that provide such data. Notable NASA data sets for research analysis include:

- NASA launched the QuikSCAT satellite instrumented with the SeaWinds scatterometer on June 19, 1999. This instrument is a copy of the dual conically-scanning pencil beam Ku-band SeaWinds scatterometer that flew on JAXA's Midori-2 mission. QuikSCAT is no longer fully functional, but still collects Ku-band backscatter measurements to assist in calibration of other Ku-band scatterometers.
- NASA RapidScat mission (http://winds.jpl.nasa.gov/missions/RapidScat/), was installed on the International Space Station (ISS) in September 2014 and suffered a mission ending power anomaly in August 2016. RapidScat's unique non-Sun-synchronous sampling from the ISS can be used to characterize diurnal and subdiurnal wind variability.
- The Compact Ocean Wind Vector Radiometer (COWVR) is a new U.S. Air Force mission built by the NASA Jet Propulsion Laboratory (JPL) to provide ocean vector winds from a small satellite microwave radiometer system. COWVR is a fully polarimetric conically imaging radiometer operating at 18.7, 23.8 and 33.9 GHz with a full fore/aft viewing geometry providing observations at two azimuth angles for each point on the ground. It is designed to provide wind vector data over a 900km swath, at 30km spatial resolution, with an uncertainty at least equivalent to data produced by the Naval Research Laboratory WindSat sensor. COWVR is now planned for deployment on the International Space Station no earlier than January 2021. Investigators wishing to use the data will be able to acquire it from the Jet Propulsion Laboratory.

Extensive background on NASA's ocean vector winds science team and missions are available at http://winds.jpl.nasa.gov/.

2. NASA points of contact

NASA points of contact concerning this program, both of whom share the following postal address: Earth Science Division Science Mission Directorate NASA Headquarters Washington, DC 20546-0001	Eric Lindstrom Telephone: (202) 358-4540 Email: eric.j.lindstrom@nasa.gov Nadya Vinogradova-Shiffer Telephone: (202) 358-0976 Email: nadya.vinogradova-shiffer@nasa.gov

A.16 MODELING, ANALYSIS, AND PREDICTION

1. Overview

NASA's Science Mission Directorate (SMD) supports a broad portfolio of research in the Earth Science Research Program. Key questions that drive the core research efforts of the Earth Science Division within SMD include:

- How is the Earth system changing?
- What are the sources of change in the Earth system and their magnitudes and trends?
- How will the Earth system change in the future?
- How can Earth system science improve mitigation of and adaptation to global change?

Within Earth Science Research, the Modeling, Analysis, and Prediction (MAP) program seeks to develop an understanding of the Earth as a complete, dynamic system. To accomplish this objective, the program funds the development of comprehensive, physically-based models of the Earth system, observation/model syntheses, and supporting research.

The modeling and data assimilation supported by the MAP program is observation-driven. That is, the direction of the modeling/assimilation work is guided by available and anticipated observations and its goal is to extract from the observations as much value as possible. This involves rigorous examination and utilization of observations in a comprehensive Earth system context. The modeling integrates across all the research activities in NASA's Earth science research program, and spans and connects the spatial and temporal scales that characterize satellite observations and observations from ground and air-based campaigns. This approach facilitates the validation of the satellite observations and observationally-based improvements of Earth system model components, leading to models that accurately represent the Earth system with diagnostic and predictive skill. The data assimilation is focused on developing and utilizing model/data synthesis techniques to optimally characterize the state of the Earth system through time, allowing expanded scientific analysis and improved initialization of predictive models.

MAP strives to generate modeling and analysis systems that are well documented, thoroughly evaluated, interoperable, robust, and consistent with current coding standards and practices. An overview of the current program may be found at http://map.nasa.gov/.

2. Background

MAP funds primary projects and/or functional organizations that comprise the core activities of the program. These efforts include:

NASA Goddard Institute for Space Studies (GISS: http://www.giss.nasa.gov). GISS engages in research on global Earth system change occurring on the decadal to centennial timescales. GISS makes use of analyses of comprehensive global datasets and develops and utilizes integrated global models of the Earth system. The research includes the study of paleoclimate and the study of other planets as an aid to prediction of future evolution of Earth on a planetary scale. GISS has a long-term involvement in the Coupled Model Intercomparison Project (CMIP) that forms the basis of International Panel on Climate Change (IPCC) assessments of climate change. The primary GISS modeling tool supported by the MAP program is the GISS Model E (http://www.giss.nasa.gov/tools/modelE/), a coupled atmosphere-ocean Earth system model (ESM).

NASA Goddard Global Modeling and Assimilation Office (GMAO: http://gmao.gsfc.nasa.gov). GMAO addresses the optimal use of satellite and *in situ* observations to generate research quality data sets for analyses and reanalyses (such as the NASA Modern Era Reanalysis for Research and Applications - version 2, or MERRA-2), and also for weather, climate, and air quality forecasts. The modeling and assimilation research includes coupling to and assimilation of atmospheric aerosols and chemistry and ocean biology and carbon. GMAO focuses on developing and maintaining world-class data assimilation systems in order to maximize satellite data utility and serve as a centralized resource for testing and validating as wide a range of modeling and observational efforts as possible. The goal is to undertake modeling and assimilation as components of an end-to-end process, from defining an instrument, characterizing its in-flight performance, through to the development of algorithms and forward models for data assimilation, integrating the data into assimilation products, and finally assessing the impact of the data on the products of the assimilation system. GMAO is supported by MAP to develop and utilize the Goddard Earth Observing System (GEOS). GEOS includes both a coupled atmosphere-ocean GCM and a data assimilation system (DAS). More information is available at: https://gmao.gsfc.nasa.gov/GEOS_systems/.

MAP also funds several smaller projects that further core program interests. One such project is the Estimating the Circulation and Climate of the Ocean (ECCO) project. The ECCO project produces optimal estimates of the time-evolving global ocean state by constraining model results with observations. Unlike the data assimilation methodology typically employed in meteorologically-based assimilation systems, the ECCO state estimates are generated so that they do not possess the anomalous sources and sinks that occur in meteorological data assimilation systems from the incorporation of observations. More information about ECCO can be found at: https://ecco.jpl.nasa.gov.

3 Modeling, Analysis, and Prediction Research Themes

The specific research themes included in this Modeling, Analysis, and Prediction (MAP) solicitation are listed here, to be addressed using available and anticipated observations as discussed in section 4 below.

3.1 Representation and prediction of regional sea level rise in GCMs

Rapid sea level rise is one of the most important threats to human populations that could result from global climate change over the next century, due to the large number of people residing in low-lying coastal regions and associated infrastructure supporting those populations. Numerous processes govern regional sea levels, including thermal expansion of ocean water, changes in salinity, melting of land ice (glaciers and ice sheets), regional effects on sea level due to ocean and wind currents, changes in river input, isostatic adjustment of the lithosphere, and effects due to changes in gravitation, such as caused by ice sheet melting.

In this solicitation, MAP seeks proposals to improve and evaluate the representation of those processes in ESMs that would lead to improved prediction of sea level rise, at regional to global length scales and at up to multidecadal time scales, including the ability to quantify the contributions of the various components. Of particular interest are the representation of isostatic adjustment, effects due to gravitation changes, and processes that might result in unexpectedly rapid sea level change, such as from ice sheet melting.

3.2 Representation of the Cryosphere in GCMs

The Cryosphere consists of the polar ice sheets, glaciers, ice shelves, and sea ice. Properly representing these processes within ESMs presents a significant challenge for a variety of reasons, including for instance the differing grid structure of the ice sheet models and the high resolution required to adequately represent ice sheet outlet glacier structure and function. In this solicitation, the MAP program seeks proposals to improve the representation of the Cryosphere in ESMs, including:

- Improvements of the representation of ice sheets in ESMs and their interaction with ice shelves, sea ice, oceans, and the lithosphere.
- Improved understanding of ocean/sea ice/ice sheet/ice shelf interactions that could lead to improvements in ESMs.
- Improved representation of ice sheet surface mass balance in ESMs.

3.3 Ocean Modeling and Data Assimilation including the Cryosphere

A long-term goal of the MAP program is the development of an Integrated Earth System Analysis (IESA) capability. IESA is the process of consistently combining all available observations of the Earth System (atmosphere, ocean, land surface, sea-ice, and biogeochemistry) at some time with a model of the Earth System in such a way to produce a best estimate of the state of the Earth System at that time. This capability is not currently available; fundamental advances in data assimilation techniques, important development of fully-coupled models of the Earth system, and technological advances in computation are necessary for such a task.

At the present time, MAP is funding efforts to produce atmospheric analyses and reanalyses, and funds a related effort aimed at developing a best estimate of the evolution of the ocean state at high resolution, including sea ice, ice shelves, and ice sheet processes over the time period when significant ocean observations are available.

In this solicitation, MAP seeks proposals aimed at furthering NASA's capabilities in the area of ocean modeling and data assimilation, with a particular focus on development toward an integrated Earth System analysis. Issues MAP is interested in addressing in the area of ocean modeling and data assimilation include:

- Improved understanding and representation in global models of atmosphere/ocean/ocean biosphere interactions, including exchanges of heat, momentum, and carbon dioxide.

- Improved understanding and representation of oceans and their interactions in the Earth system, consistent with the goal of developing an up-to-decadal Earth system prediction capability.
- Ocean state estimation including interactions between the ocean and the cryosphere, incorporating all relevant observations and including evaluation of the state estimates.
- Combined ocean/atmosphere data assimilation systems.

3.4 Earth System Modeling Framework for MAP-supported modeling efforts

The National Research Council (NRC) Committee on a National Strategy for Advancing Climate Modeling released a report which recommended that climate models evolve toward utilization of a common software infrastructure capable of supporting a diverse set of models. The rationale for this recommendation is that the common infrastructure would serve to promote a number of desired outcomes, such as increased reliability, easier migration of models to new computing platforms, increased computational efficiency, increased interoperability and code portability, and consistency of output formats. This recommendation is consistent with a long-standing MAP program requirement that the code developed with MAP support be written using standardized software tools that increase code interoperability and utility, and reduce sources of error. The Earth System Modeling Framework (ESMF) is a software package designed to facilitate the development of Earth Science codes with increased interoperability, reuse, ease of use, and portability which has been extensively used in the design of GEOS5 and is increasingly used in GISS Model E. (See https://www.earthsystemcog.org/projects/esmf/) for a full description of the software.

The standard ESMF distribution has been augmented over the past few years with the development of two "usability" layers, which facilitate the implementation of ESMF in Earth system models. These are the Modeling Analysis and Prediction Layer (MAPL), developed at the NASA Goddard Space Flight Center and extensively used in the GEOS-5 and GISS models, and the National Unified Operational Prediction Capability (NUOPC) Layer, which was developed jointly by Navy and NOAA personnel. These two usability layers have much in common, and recent work has resulted in greater similarity between the two, but differences exist. MAPL is more fine-grained, allowing standardized component coupling from the parameterization level to large model components (e.g., ocean, atmosphere), while the NUOPC layer is more focused on the coupling of the larger model components. Independent development of two separate usability layers would threaten code interoperability, so there is a continuing need to rectify the two layers.

The NASA MAP program is interested in continuing the process of utilizing ESMF in MAP-supported codes, and in supporting continued development of the ESMF in ways that address MAP-supported software needs. The MAP program is therefore soliciting proposals that contribute to utilization of ESMF software within MAP-supported code, and propose work to further develop ESMF software in directions which are demonstratively of benefit to NASA's modeling interests. Specific efforts of interest to NASA include:

- Efforts to continue incorporation of MAPL within the base ESMF implementation, including documentation of MAPL software, development of tests to confirm correct operation on all computational platforms on which ESMF runs, and unification of the NUOPC and MAPL usability layers.
- The addition of concurrency to MAPL, facilitating parallel execution resulting in increased execution speeds.
- Development of the base ESMF implementation to expand its utility in ways that are demonstrably advantageous to MAP-supported ESMs. Of particular interest are efforts to improve ESMF capabilities on multi-core computing systems.
- Efforts to enhance the ESMF compliance of MAP-supported ESMs.

3.5 Code Refactoring for MAP-supported modeling efforts

As mentioned above, MAP strives to generate models and model components that are well documented, thoroughly evaluated, interoperable, robust, and consistent with current coding standards and practices. Current MAP-supported codes may not comply with these goals. This solicitation requests efforts to refactor MAP-supported code to bring codes into compliance. A critical consideration for this theme is the problem of refactoring working code – that is, code that is actively being developed by other modelers for other reasons. If a piece of code is refactored, and during the process the changes to the code that are being continuously made by other efforts are not included in the refactored code, then the result will be a piece of code that has improved software engineering but is essentially obsolete. Therefore, proposals responsive to this theme must explain the process by which the refactoring can be accomplished while incorporating code changes made for other reasons by other developers.

4. Programmatic Priorities

Characterizing the limits of validity of models and model components and identifying the sources of uncertainties is important to realizing the goal of enabling whole Earth system models. Therefore, preference will be given to proposals that: 1) characterize and/or help reduce uncertainties in the models and products; 2) extend the range of model or product validity by using new components; 3) exploit these products to address NASA Earth Science Division research questions; 4) are in alignment with the goals and objectives of the core MAP elements described in section 2 above; and 5) enable independent community validation and characterization of the core MAP elements leading to improvement of the models or products. Proposals must explicitly discuss the observations that will either be used in the proposed investigation (including the manner of their use), or whose use will be facilitated by the proposed investigation. Preference will be given to proposals utilizing or enabling analysis of NASA satellite and suborbital observations. A discussion of how the proposed investigation will interact with or inform the core modeling efforts discussed in Section 2 is also required.

Note also that programmatic balance (e.g., across research themes) is an important consideration. To achieve this balance, a proposal with higher merit rating may not be selected, especially in areas for which we received a disproportionate number of proposals. This program element also does not guarantee the selection of at least one proposal for every theme (in the case that there are no proposals of sufficient merit or programmatic value for that theme).

New model components that are proposed shall be Earth System Modeling Framework (ESMF) compliant and make use of ESMF utilities where appropriate. A discussion of the software engineering aspects of the proposed work should be included in the proposal. Components shall be "seamless" in the sense that they are capable of spanning the weather to climate continuum of time scales. Proposals to develop and implement new parameterizations in MAP-supported models should demonstrate awareness of the parameterization to be replaced (if there is one), the code that implements it, and how it interacts with other parts of the model. They should discuss why the new parameterization is expected to improve model simulations relative to the existing parameterization, include an implementation plan, and propose observationally-based metrics, preferably based on NASA data that will diagnose the improvement. They should discuss the nature and extent of the interaction with the core model team. Proposals for new model component capabilities must include an evaluation activity that characterizes its limits of validity by comparing to observational data. In all cases, the proposer must explain how the validation methodology will help identify the source of uncertainty within the model or analysis product. Proposals for new or improved model components for NASA MAP supported models and proposals that utilize NASA MAP-supported models or model output will be preferred over those that do not. Proposed evaluations of the MAP-supported models mentioned in Section 2 should consider the use of appropriate existing simulations, including those contained in the CMIP (Coupled Model Intercomparison Project) archives or simulations that have already been conducted by the NASA modeling teams. If new simulations are required, resources to support those simulations should be included in the proposal, as well as the agreement of the modeling team to provide the needed simulations (if the proposing team is unwilling or unable to conduct the simulations themselves).

5. MAP Infrastructure

As mentioned above, a MAP program goal is a set of models and model components that are well documented, thoroughly evaluated, interoperable, robust, and consistent with current coding standards and practices. Therefore, code development proposals should adhere to the multiagency Earth System Modeling Framework (https://www.earthsystemcog.org/projects/esmf/), which provides a robust software infrastructure for coupling model elements. Proposals should identify resources to provide software engineering and interface support necessary to assure that the final product meets ESMF standards and investigator verification that the ESMF-compatible product yields desired results.

High-end computing (HEC) support is available from the NASA Center for Computational Sciences (NCCS, https://www.nccs.nasa.gov/user_info/new_user) and the NASA Advanced Supercomputing facility (NAS, http://www.nas.nasa.gov/) (see Section I(d) of the ROSES *Summary of Solicitation*). Proposers who require computing time at NCCS or NAS must provide an accurate estimate (including the basis of the estimate) of the number of node-hours required each year of the proposal by providing the HEC appendix and answering the HEC questions on the NSPIRES cover pages.

Note that the availability of computing resources will be considered in the evaluation process.

6. Summary of Key Information

Expected program budget for first year of new awards	~ $3M
Number of new awards pending adequate proposals of merit	~9 -12 (Note the smaller number assumes ~3 larger and 6 smaller awards, and the larger number assumes awards of approximately equal size).
Maximum duration of awards	4 years
Due date for Notice of Intent	See Tables 2 and 3 of this ROSES NRA
Due date for Proposals	See Tables 2 and 3 of this ROSES NRA
Planning date for start of investigation	January 1, 2020
Page limit for the central Science/Technical/Management section of proposal	15 pp; see also Table 1 of ROSES and Section 3.7 of the guidebook for proposers.
Relevance to NASA	This program is relevant to the Earth science strategic goals and subgoals in NASA's *Strategic Plan*. Proposals that are relevant to this program are, by definition, relevant to NASA.
General information and overview of this solicitation	See the *ROSES Summary of Solicitation*.
Detailed instructions for the preparation and submission of proposals	See the *NASA Guidebook for Proposers* at http://www.hq.nasa.gov/office/procurement/nraguidebook/.
Submission medium	Electronic proposal submission is required; no hard copy is permitted.
Web site for submission of proposal via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Web site for submission of proposal via Grants.gov	http://grants.gov/ (help desk available at support@grants.gov or (800) 518-4726)
Funding opportunity number for downloading an application package from Grants.gov	NNH19ZDA001N-MAP

NASA point of contact concerning this program	David B. Considine Earth Science Division Science Mission Directorate NASA Headquarters Washington, DC 20546-0001 Telephone: 202-358-2277 Email: david.b.considine@nasa.gov

A.17 CRYOSPHERIC SCIENCE

NOTICE: The Cryospheric Science program will not solicit proposals in ROSES-2019. This program may be competed again in ROSES-2020.

Text from the previous version of this program element is appended below to provide general information about the program.

1. Background

NASA's Cryospheric Sciences Program supports remote sensing research on the Earth's polar ice sheets to understand their connections to the global system. Increases in ice loss from the glaciers of Antarctica, Greenland, and the Arctic are contributing to sea level rise, while similarly dramatic changes are occurring in sea ice of the Arctic and Southern Oceans. Characterizing these changes to understand the processes controlling them is required to improve our understanding of the Earth system and forecast the impacts of continued change.

The Earth's polar ice sheets cover continent-sized areas in the most inaccessible and inhospitable regions of the globe. NASA's capabilities in satellite and aircraft remote-sensing are critical tools for understanding the changes occurring there.

2 Scope of Program

This program element supports investigations that use remote sensing to study the land-based ice sheets of Antarctica, Greenland, and the Arctic, and the sea ice of the Arctic and Southern oceans. Supported studies are based on satellite and aircraft remote sensing observations to understand the factors controlling changes in the ice and its interaction with the ocean, atmosphere, solid Earth, and solar radiation.

The polar ice sheets represent one of the best time-integrated records of change in the Earth system that can be quantitatively characterized. This program element seeks proposals that exploit the polar ice sheets as unique records of the global system that can improve understanding of poorly constrained aspects of the polar oceans and atmosphere. The program is open to proposals in any area, but proposers are reminded that their work must be founded upon remote sensing observations of the ice.

In addition, the program seeks to continue its longer-term goals to:

- Determine the mechanisms controlling sea-ice cover, such as quantification of the connections between sea ice and the ocean and atmosphere;
- Characterize sea ice properties—such as ice and snow thickness, roughness, melt ponds, and albedo—and physical processes—such as deformation and rifting—such that they can be incorporated into sea ice models;
- Use remote sensing products to validate and improve models of changes in sea-ice cover to elucidate connections to the global system;
- Determine the mechanisms controlling mass balance and dynamics of the Greenland and Antarctic ice sheets, including studies aimed at improving fundamental understanding of the connections to the ocean, sea-ice cover, and atmosphere;

- Characterize land ice properties—such as thickness, surface mass balance, englacial and surface water, layering, bed and grounding line properties, and albedo—and physical processes—such as flow, crevassing, ice shelf behavior, melt water fate, and calving—such that they can be incorporated into models;
- Use remote sensing data to validate and improve models of land-based ice and their contributions to sea-level change; and
- Study of polar and nonpolar mountain glaciers and small ice caps to understand systemic impacts of global change and contributions to sea-level rise.

NASA expects synergy among observations, modeling, and field campaigns, and encourages all projects to consider recommendations identified by the various polar research organizations in their white papers and reports. Some recent examples are as follows:

- *Understanding the Dynamic Response of Greenland's Marine Terminating Glaciers to Oceanic and Atmospheric Forcing* (2014) from U.S. CLIVAR, available at http://www.usclivar.org/sites/default/files/documents/2014/2013GRISOWorkshopReport_v2_0.pdf
- *Seasonal-to-Decadal Predictions of Arctic Sea Ice: Challenges and Strategies* (2012) from the National Research Council, available at http://www.nap.edu/catalog.php?record_id=13515
- *Future Science Opportunities in Antarctica and the Southern Ocean* (2011) from the National Research Council, available at http://dels.nas.edu/Report/Future-Science-Opportunities-Antarctica/13169
- *SEARCH 5-year Science Goals* from The Study of Environmental Arctic Change (SEARCH), available at http://www.arcus.org/search/goals
- *Climate and Cryosphere (CLiC)* of the World Climate Change Research Program, available at http://www.climate-cryosphere.org/
- *IARPC Research Plan* from the Interagency Arctic Policy Committee (IARPC), available at http://www.nsf.gov/od/opp/arctic/iarpc/start.jsp

Proposers are reminded that use of satellite and or airborne remote sensing is required. Data from any NASA or non-NASA satellite or aircraft mission is appropriate. Proposers are encouraged to consider the extensive data holdings of NASA's Distributed Active Archive Centers (DAAC), including the:

- National Snow and Ice Data Center (NSIDC, https://nsidc.org/), which hosts a wide range of data and products from satellite and aircraft missions, including those from NASA's ICESat (https://nsidc.org/data/icesat) and Operation IceBridge (OIB) (http://www.nasa.gov/mission_pages/icebridge/index.html). The OIB mission collects altimetry, radar, gravity, bathymetry and other data over ice in the Arctic and Antarctic.
- Alaska Satellite Facility (https://www.asf.alaska.edu/), which hosts satellite radar data.
- Oceans Melting Greenland (OMG) mission portal (https://omg.jpl.nasa.gov/portal/). OMG is a new NASA *Earth Ventures Suborbital*

mission collecting radar altimetry, gravity, bathymetry and other oceanographic data in and around Greenland.

- MEaSUREs Program (https://earthdata.nasa.gov/community/community-data-system-programs/measures-projects). MEaSUREs (Making Earth System Data Records for Use in Research Environments) supports the development of satellite radar records of land ice flow velocities and sea ice motion.

2.1 Arctic Studies

For Arctic sea ice, the program's focus is to characterize and understand sea ice processes and the observed changes—in extent, concentration, thickness, character, and dynamics—in the context of their couplings to the Earth system. Extensive remote sensing records of Arctic sea ice extent extend back to the 1970s. Understanding the feedback mechanisms associated with sea ice—and the atmosphere, ocean, land, and incident sunlight—is intended to improve models of the Arctic, and potentially support other projects linking high- and low-latitude climates. NASA's OIB mission has performed extensive studies of Arctic sea ice (https://nsidc.org/data/icebridge).

For Arctic land ice, characterizing the Greenland ice sheet and other northern hemisphere glaciers is essential to understanding and modeling their mass balance, dynamics, and contributions to sea level. The program's focus is to advance understanding of land-ice processes, especially connections among the warming ocean and increases in glacial flow rates; determining how the ice sheet interior is tapped by outlet glaciers; and determining the connections between glacial dynamics, bed characteristics, and melt water. The program also focuses on determining surface mass balance and the fate of surface melt to support overall ice sheet and Arctic glacier mass balance estimates. Some unique data resources available to support this work include the altimetry, radar, and other data collected by NASA's Operation IceBridge mission, as well as data available from ICESat, GRACE, and various international radar satellites.

Projects requiring Arctic fieldwork in Greenland, utilizing the National Science Foundation's (NSF's) Arctic Program resources, must obtain a cost estimate as discussed in NSF's *Arctic Research Opportunities* solicitation located at https://www.nsf.gov.

2.2 Antarctic Studies

For the Southern Ocean and the Antarctic ice sheet, the program focuses on the dynamics and mass balance of the overall ice sheet, the potential instability of the West Antarctic ice sheet, the interaction of the warming ocean with ice shelves, characteristics and changes of the glacial grounding lines, subice-sheet hydrology, and changes in the extent of sea ice. There is also a need to assess the likelihood of rapid ice-sheet response to large changes in elevation and mass loss observed in some outlet glaciers and ice shelves – by ICESat, GRACE, Operation IceBridge, and radar satellites – and how changes in these outlet glaciers may affect the stability of the interior ice sheet.

Projects requiring Antarctic fieldwork are required to review the information at http://www.usap.gov/proposalInformation/ and provide enough information to allow for adequate review of the plan, its utility, and expected costs. For projects that receive assistance from the U.S. Antarctic Program, acknowledgements should include: "Logistical support for this project in Antarctica was provided by the U.S. National Science Foundation through the U.S. Antarctic Program."

3. NASA point of contact concerning this program

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A.18 Atmospheric Composition: Upper Atmosphere Research Program

NOTICE: The Upper Atmosphere Research Program (UARP) will not solicit proposals in ROSES-2019. All funds currently available for UARP are committed to the support of awards selected through the 2016 and 2017 UARP related solicitations. These next UARP related solicitations will be competed again in ROSES-2020.

Atmospheric composition determines air quality and affects weather, climate, and critical constituents such as ozone. Exchanges with the atmosphere link terrestrial and oceanic pools within the carbon cycle and other biogeochemical cycles. Solar radiation affects atmospheric chemistry and is, thus, a critical factor in atmospheric composition. Atmospheric chemistry and associated composition are a central aspect of Earth system dynamics, since the ability of the atmosphere to integrate surface emissions globally on time scales from weeks to years couples several environmental issues. NASA's research for furthering our understanding of atmospheric composition is geared to providing an improved prognostic capability for such issues (e.g., the recovery of stratospheric ozone and its impacts on surface ultraviolet radiation, the evolution of greenhouse gases and their impacts on climate, and the evolution of tropospheric ozone and aerosols and their impacts on climate and air quality). Toward this end, research within the Atmospheric Composition Focus Area addresses the following science questions:

- How is atmospheric composition changing?
- What trends in atmospheric constituents and solar radiation are driving global climate?
- How do atmospheric trace constituents respond to and affect global environmental change?
- What are the effects of global atmospheric chemical and climate changes on regional air quality?
- How will future changes in atmospheric composition affect ozone, climate, and global air quality?

NASA expects to provide the necessary monitoring and evaluation tools to assess the effects of climate change on ozone recovery and future atmospheric composition, improved climate forecasts based on our understanding of the forcings of global environmental change, and air quality forecasts that take into account the feedbacks between regional air quality and global climate change. Achievements in these areas via advances in observations, data assimilation, and modeling enable improved predictive capabilities for describing how future changes in atmospheric composition affect ozone, climate, and air quality. Drawing on global observations from space, augmented by suborbital and ground-based measurements, NASA is uniquely poised to address these issues. This integrated observational strategy is furthered via studies of atmospheric processes using unique suborbital platform-sensor combinations to investigate, for example: (1) the processes responsible for the emission, uptake, transport, and chemical transformation of ozone and precursor molecules associated with its production in the troposphere and its destruction in the stratosphere and (2) the formation, properties, and transport of aerosols in the Earth's troposphere and stratosphere. NASA's research strategy for atmospheric composition encompasses an end-to-end approach for instrument design, data collection, analysis, interpretation, and prognostic studies.

UARP solicitations concentrate on field observations which were selected for 4 year in ROSES-2016 (https://nspires.nasaprs.com/external/solicitations/summary.do?method=init&solId={B554F971-2BDF-A8A0-A909-8CF7C07DB175}&path=closedPast) and laboratory research selected for 3 years in ROSES-2017 (https://nspires.nasaprs.com/external/solicitations/summary.do?method=init&solId={F0BC4C45-C828-FA58-E900-414F71C81DB1}&path=closedPast). The next solicitation for each of these is expected in ROSES-2020.

For further information on this program, contact:

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A.19 ATMOSPHERIC COMPOSITION: RADIATION SCIENCES PROGRAM

NOTICE: The Radiation Sciences program will not solicit proposals in ROSES-2019. Funds currently available in Fiscal Year 2019 for the Radiation Sciences Program are committed to the support of awards selected from previous solicitations. The Radiation Sciences Program expects to solicit proposals for an airborne campaign data analysis in ROSES-2020 or ROSES-2021. Interested researchers are encouraged to consult other program elements for potential funding opportunities.

1. Scope of Program

The Radiation Sciences Program (RSP) strives to develop a quantitative and predictive understanding of how aerosols, clouds, and radiatively active gases scatter and absorb radiation (including both solar and terrestrially originated radiation) in the Earth's atmosphere, especially as it relates to climate variability and change. The program supports studies to improve the theoretical understanding of radiative transfer, as well as field measurements of aerosol and cloud particle concentration, composition, microphysics, and optical properties. These measurements include both airborne and surface-based remote and *in situ* measurements. The program also supports the analysis of satellite remote sensing and field data, as well as the development of process models, which contribute to an Earth system modeling capability.

For further information on this program, contact:

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A.20 ATMOSPHERIC COMPOSITION: MODELING AND ANALYSIS

NOTICE: The Atmospheric Composition Modeling and Analysis program will not be competed in 2019. The Atmospheric Composition Modeling and Analysis program is tentatively scheduled to next solicit proposals in ROSES-2020.

The Atmospheric Composition Modeling and Analysis program (ACMAP) addresses the issues of tropospheric air quality and oxidation efficiency, pollution sourced aerosol and its impact on cloud properties, stratospheric chemistry and ozone depletion, and chemistry/climate interactions. Studies of long-term trends in atmospheric composition (potentially using both current and past mission data sets) are also of interest to the program, where the connection between cause and effect is elucidated using models. The program is interested in studies that integrate observations from multiple instruments with models to address attribution and predictions. The use of satellite and suborbital data sets and ground based measurements are encouraged for modeling constraints and verification where applicable. Proposals were last received in August 2018, and it is anticipated that proposals will be solicited again in ROSES-2020.

For information on this program, contact:

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A.21 ATMOSPHERIC COMPOSITION: TROPOSPHERIC COMPOSITION PROGRAM

NOTICE: The Tropospheric Composition Program (TCP) will not be competed in ROSES-2019. The TCP program is tentatively scheduled to next solicit proposals in ROSES-2020. Proposers with interests that match the TCP programmatic objectives are encouraged to submit to the A.22 Atmospheric Composition: AURA Science Team.

The Tropospheric Composition Program (TCP) seeks to improve the utility of satellite measurements in understanding of global tropospheric ozone and aerosols, including their precursors and transformation processes in the atmosphere. Ozone and aerosols are fundamental to both air quality and climate. The program emphasizes suborbital and ground-based measurements acquired during focused field deployments. Along with the other Atmospheric Composition programs, TCP also sponsors interpretation of these comprehensive, but infrequent, measurements to improve the continuous monitoring of tropospheric ozone, aerosols, and their precursors from space and the improvement of atmospheric composition prognostic models. TCP also supports limited laboratory studies that are directly relevant to improved understanding of tropospheric chemistry.

For further information about the Tropospheric Composition Program, contact:

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A.22 ATMOSPHERIC COMPOSITION: AURA SCIENCE TEAM

NOTICE: Amended April 4, 2019. The proposal due date for this program element has been deferred to September 19, 2019 to deconflict it from a rescheduled science team meeting, which was delayed due to the government shutdown.

1. Scope of Program

Atmospheric composition changes affect air quality, weather, climate, and critical constituents such as ozone. Atmosphere-biosphere exchange links terrestrial and oceanic pools within the carbon cycle and other biogeochemical cycles. Solar radiation affects atmospheric chemistry and is thus a critical factor in atmospheric composition. Atmospheric composition is central to Earth system dynamics, since the atmosphere integrates surface emissions globally on time scales from weeks to years and couples several environmental issues. NASA's research for furthering our understanding of atmospheric composition is geared to providing an improved prognostic capability for such issues (e.g., the recovery of stratospheric ozone and its impacts on surface ultraviolet radiation, the evolution of greenhouse gases and their impacts on climate, and the evolution of tropospheric ozone and aerosols and their impacts on climate and air quality). Toward this end, research within the Atmospheric Composition Focus Area addresses the following science questions:

- How is atmospheric composition changing?
- What trends in atmospheric composition and solar radiation are driving global climate?
- How does atmospheric composition respond to and affect global environmental change?
- What are the effects of global atmospheric composition and climate changes on regional air quality?
- How will future changes in atmospheric composition affect ozone, climate, and global air quality?

NASA expects to provide the necessary monitoring and evaluation tools to assess the effects of climate change on ozone recovery and future atmospheric composition, improved climate forecasts based on our understanding of the forcings of global environmental change and air quality forecasts that take into account the feedbacks between regional air quality and global climate change. Achievements in these areas via advances in observations, data assimilation, and modeling enable improved predictive capabilities for describing how future changes in atmospheric composition affect ozone, climate, and air quality. Drawing on global observations from space, augmented by suborbital and ground-based measurements, NASA is uniquely poised to address these issues. This integrated observational strategy is furthered via studies of atmospheric processes using unique suborbital platform-sensor combinations to investigate, for example: (1) the processes responsible for the emission, uptake, transport, and chemical transformation of ozone and precursor molecules associated with its production in the troposphere and its destruction in the stratosphere and (2) the formation, properties, and transport of aerosols in the Earth's troposphere and stratosphere, as well as aerosol interaction with clouds. NASA's research strategy for atmospheric composition encompasses an end-to-end approach for instrument design, data collection, analysis, interpretation, and prognostic studies.

2. Aura Science Team Activities

This program element seeks proposals for the analysis of satellite remote-sensing data of the Earth's atmosphere, particularly those using data generated by the Earth Observing System (EOS) Aura satellite. Observations from Aura include those from the Microwave Limb Sounder (MLS), Ozone Monitoring Instrument (OMI), Tropospheric Emission Spectrometer (TES) that ceased operation in 2018, and High Resolution Dynamics Limb Sounder (HIRDLS) that ceased operation in 2008. We are also encouraging proposals that combine data from Aura with data from other sensors within the "A-Train", S-NPP orbit, or AM constellations (particularly Aqua, Terra, CALIPSO, and CloudSAT, S-NPP) or satellites or instruments from other space agencies (for example; OMPS, SciSat/ACE, MetOp, Sentinel 5 Precursor), ground based networks (e.g., but not limited to ozonesondes, NDACC, AGAGE, AERONET, and MPLNET), and NASA suborbital campaigns (e.g., but not limited to DISCOVER-AQ, ATTREX, POSIDON, FIREX-AQ and SEAC4RS). These proposals should enable NASA research in the area of stratospheric and tropospheric chemistry, as well as improve the measurements of aerosols and trace gases, and determining the impacts of trace gasses and aerosols on climate and air quality. Proposals should specifically address the use of the satellite data.

The goals of this program element include:

- Developing new or significantly improved Level-2 data that are not supported by the Aura project core data analysis budget or as a part of NASA Center work packages (http://disc.sci.gsfc.nasa.gov/Aura/);
- Using Aura data to track changes in stratospheric and tropospheric composition, determine the exchange of trace gases within the troposphere, between the stratosphere and troposphere, and estimate the transport properties of the stratosphere and upper troposphere;
- Using Aura data along with other satellite trace gas data sets to quantify and map emissions and quantify the impact of long-range transport and export of trace gases important to air quality;
- Using the above-described data sets to study tropospheric air quality and oxidizing capacity of the troposphere, including the effects of climate change on tropospheric air quality and air quality on climate, and studies of the attribution of changes in air quality and oxidizing capacity over the past 20 years;
- Using the above-described data sets to study aerosol characteristics with respect to their impacts on tropospheric chemical processes, including studies that deal with the effects of clouds on atmospheric chemical processes, either by changing the radiative properties of the atmosphere or by providing a place for aqueous chemical reactions to occur.

A-Train (Aura, CALIPSO, Aqua) instrument algorithm maintenance, incremental algorithm improvement, data product and the production of standard data products are excluded from this program element.

3. Summary Table of Key Information

Expected program budget for first year of new awards	~ $3.0M/year
Number of new awards pending adequate proposals of merit	~ 12-18
Maximum duration of awards	3 years
Due date for Notice of Intent to propose (NOI)	Not requested.
Due date for proposals	See Tables 2 and 3 of this ROSES NRA
Planning date for start of investigation	6 months after proposal due date.
Page limit for the central Science-Technical-Management section of proposal	15 pp; see also Table 1 of *ROSES Summary of Solicitation* and the *Guidebook for Proposers.*
Relevance to NASA	This program is relevant to the Earth Science questions and goals in the NASA Science Plan. Proposals that are relevant to this program are, by definition, relevant to NASA
General information and overview of this solicitation	See the *ROSES Summary of Solicitation*.
Detailed instructions for the preparation and submission of proposals	See the *NASA Guidebook for Proposers* at http://www.hq.nasa.gov/office/procurement/nraguidebook/
Submission medium	Electronic proposal submission is required; no hard copy is permitted.
Web site for submission of proposal via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Web site for submission of proposal via Grants.gov	http://grants.gov (help desk available at support@grants.gov or (800) 518-4726)
Funding opportunity number for downloading an application package from Grants.gov	NNH19ZDA001N-AURAST

Points of contact concerning this program	Kenneth W. Jucks Earth Science Division Science Mission Directorate National Aeronautics and Space Administration Washington, DC 20546-0001 Telephone: (202) 358-0476 Email: kenneth.w.jucks@nasa.gov Richard S. Eckman Earth Science Division Science Mission Directorate National Aeronautics and Space Administration Washington, DC 20546-0001 Telephone: (202) 358-2567 Email: richard.s.eckman@nasa.gov

A.23 TERRESTRIAL HYDROLOGY

1. Scope of Program

The NASA Terrestrial Hydrology program (THP) has the scientific objective to use remote sensing to develop a predictive understanding of the role of water in land-atmosphere interactions and to further the scientific basis of water resources management. The NASA THP is a component of the Global Water and Energy Cycle Focus Area (see Section 2.4 of program element A.1).

THP uses NASA's unique view from space to study hydrologic processes associated with runoff production, hydrologic fluxes at the land-air interface, and terrestrial water stores. THP works in concert with other Earth Science Division (ESD) programs, also studying the global water cycle (e.g., precipitation, physical oceanography), to describe and understand the connections between the cycle's different parts. THP fosters the development of hydrologic remote sensing theory, the scientific basis for new hydrologic satellite missions, hydrologic remote sensing field experiments, and the interface of hydrology with other disciplines, such as those addressed by the Terrestrial Ecology program and Interdisciplinary Science (see ROSES-2019 elements A.4 and A.32, respectively). Particular emphasis is placed on the application of satellite-based remotely sensed data for characterizing, understanding, and predicting the terrestrially linked components of the hydrologic cycle and the dynamics of large-scale river basins. THP furthers study of the relationship between satellite interferometric measurements of surface deformation and changes in underground water stores. THP is currently focused on research relating to multiple missions, either currently operating, such as Global Precipitation Measurement (GPM), Soil Moisture Active Passive (SMAP) and the Gravity Recovery and Climate Experiment Follow-On (GRACE-FO); or in planning and development, such as Surface Water Ocean Topography (SWOT). THP projects are also extensively using data collected at previous or current field campaigns and projects, such as SMAPVEX (http://smap.jpl.nasa.gov), AirMOSS (http://airmoss.jpl.nasa.gov), SnowEx (https://snow.nasa.gov/campaigns/snowex), or numerous others, both national and international.

THP continues to encourage use of NASA investments to improve the use of remote sensing information in weather and climate models, primarily through data assimilation approaches involving land surface models. The Land Information System (LIS; http://lis.gsfc.nasa.gov) provides a modeling test bed for potential investigations of this domain, along with an entrée into activities of other U.S. agencies.

THP is one of the nation's programs supporting the Global Energy and Water Cycle Exchanges Project (GEWEX) and the U.S. Global Research Program (USGCRP), especially its interagency water cycle working group.

More information on current THP projects and plans, as well as links to related field campaigns, can be found at mission and project specific websites, e.g., http://smap.jpl.nasa.gov/, http://snow.nasa.gov, http://swot.jpl.nasa.gov/.

2. Description of Solicited Research

The importance of water requires no preamble. As a nation and a global community, our ability to measure and predict water in all its forms and locations must improve to better assess and understand our changing environment and demands of human society and ecosystems. Research is sought to make such improvements on our understanding of the land-oriented portion of the water cycle, either by improving and/or exploiting current satellite data, describing requirements of future satellite systems, or improving and/or creating new remote sensing algorithms with an eye towards future satellites.

Proposed research must fall into one of the following three categories described in subsections 2.1-2.3.

2.1 Multi-Sensor Data Fusion

For some components of the land water-cycle there are now multiple satellite data sets, which use different methods to observe physical characteristics of a water body. For example, one can use both visible and microwave remote sensing to determine if water is on the surface of the earth. In addition, for both, different products exist for active and passive approaches. Each remote sensing combination offers a different blend of spatial scales, error characteristics, and repeat (of observation) frequency.

This element solicits research to combine multiple, inherently different remote sensing approaches to better describe the past and current quantity and characteristics of water stores or fluxes, at the land surface, including "surface water" or "inundation", groundwater, evaporation, and river discharge.

Proposers should keep in mind the variety of needs of the science and applications research community when constructing their approach and planned output. For example, water on the land surface is detectable by many remote sensing approaches and numerous data sets exist. Some users may require the best data to support a static or time-varying land/water mask, while others need the latest information on changes in water coverage to determine inundation on a variety of time scales (e.g. daily to seasonal).

Proposed projects do not need to include large scale data production. Only produce the relevant science and algorithms that might be needed to create a long-term data set of such a product. Projects however, should produce sufficient data that they themselves can produce credible self-evaluations as well as allow for others to gain familiarity with their methods and results in different climatic zones.

Proposed approaches should primarily rely on only the satellite observations of the target variable. Thus, proposers should not include modeling (and data assimilation) as a method of data fusion. As a result, approaches should not require high frequency meteorological observations. Use of observations of variables that are slowly varying, such as of topography or vegetation type, are allowed.

Projects are free to use advanced computational techniques (e.g. neural networks) however, these should only be used to expose missing scientific understanding. Generated fusion approaches should track information content from different sources and resulting hybrids should have traceable origination.

2.2 Land Model Improvement

Land surface models (LSM) have long been used to provide surface fluxes to General Circulation, Climate, and Weather Models. Today, LSMs are used for so much more yet they are still primarily water quantity tracking tools. NASA solicits for research to update a land model, currently used by the LIS system, to include some component(s) of water quality. In order to be responsive, the aspects of water quality and the method of inclusion in the LSM must be aligned with current or planned remote sensing approaches of water quality variables as well as set up the model for data assimilation of a satellite data product (or products). Proposers should be mindful of current expansion of LSMs to better track groundwater recharge or be conducive to assimilation of data from the Surface Water and Ocean Topography Mission (SWOT).

2.3 Hydrological Test Bed Scoping Studies

NASA has a rich history of successfully mounting field campaigns to explore the use of a variety of remote sensing approaches, evaluate existing satellite data products, and exploit synergistic observations (e.g. *in situ*, airborne, and satellite data acquisition) to address pressing scientific questions and problems. However, a majority of these campaigns done for the Terrestrial Hydrology program have been short lived, emphasizing only a few consecutive weeks of data collection. As well, most THP campaigns have focused on a single water cycle variable.

To expand on the utility of THP investments in field work, NASA solicits for two scoping studies on how to construct new or augment existing long-term data observatories that would allow for

- Multi-year observations of the land portion of the water cycle
- Sufficient ancillary data collection to allow for rigorous use of Land Surface Models
- Support (future) spatial re-scaling studies
- Occasional combination with airborne data collection to evaluate new remote sensing approaches and use existing ones to address a broad range of hydrological science challenges.

Scoping studies should consider the Earth Science Division's program of record and consult the first six chapters of The National Academies' *Thriving on Our Changing Planet: A Decadal Strategy for Earth Observation from Space* when considering the current and future needs of the Terrestrial Hydrology Program.

Proposers are free to develop their own work plan but it is anticipated that a typical scoping study might support the activities of a small planning/writing group and one or more community workshops. Proposals should also detail how they will consult with and consider longer term leveraging of other known high quality hydrological observatories (e.g., DOE-ARM, NSF-Critical Zone Observatories, NOAA Climatological and Meteorological networks, USDA SCAN, etc.)

Scoping studies must produce a written report that provides the initial design of a hydrological test bed as well as the scientific rationale for its specifications. Scoping study reports do not have to address potential methods of implementing the test bed.

3. Programmatic Information

Funds available for work selected under this program element are apportioned as follows:

For section 2.1: $1M per annum for three years, to support approximately five selections.
For section 2.2: $0.5M per annum for three years to support approximately three selections.
For section 2.3: $0.25M total to support two selections for a period of ~18 months.

For all sections, it is anticipated that project start dates will be no earlier than January 1, 2020.

4. Table of Key Information

Expected total program budget for lifecyle of new awards	~ $4.75 M. See Section 3.
Number of investigator awards pending adequate proposals of merit	~10
Maximum duration of awards	3 years for sections 2.1 and 2.2; 18 months for responses to section 2.3
Due date for Notice of Intent to propose (NOI)	See Tables 2 and 3 of ROSES
Due date for proposals	See Tables 2 and 3 of ROSES
Planning date for start of investigation	January 2020
Page limit for the central Science/Technical/Management section of proposal	15 pp; see also Table 1 of the *ROSES Summary of Solicitation* and the *Guidebook for Proposers*.
Relevance to NASA	This program is relevant to the Earth Science questions and goals in the NASA Science Plan. Proposals that are relevant to this program are, by definition, relevant to NASA.
General information and overview of this solicitation	See the *ROSES Summary of Solicitation*.
Detailed instructions for the preparation and submission of proposals	Please see *ROSES Summary of Solicitation* Section I(g) Order of Precedence and the *NASA Guidebook for Proposers*.
Submission medium	Electronic proposal submission is required; no hard copy is permitted.
Web site for submission of proposal via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376)

Web site for submission of proposal via Grants.gov	http://grants.gov/ (help desk available at support@grants.gov or (800) 518-4726)
Funding opportunity number for downloading an application package from Grants.gov	NNH19ZDA001N-THP
NASA point of contact concerning this program	Jared Entin Earth Science Division Science Mission Directorate NASA Headquarters Washington, DC 20546-0001 Telephone: 202-358-0275 Email: jared.k.entin@nasa.gov

A.24 NASA Energy and Water Cycle Study

NOTICE: The NASA Energy and Water cycle Study (NEWS) does not currently plan to solicit proposals in ROSES-2019. This program will be competed again in ROSES-2021.

1. Scope of Program

The current state and evolution of the environment are critically intertwined with the water and energy cycles of the climate system. Progress towards comprehensive understanding of both cycles is enabling a better description of the current state of the climate, as well as the subtle shifts that may be going on. While global warming is often summarized as an index of mean temperatures, it is alterations of the water cycle that may be most relevant to life on Earth, especially human society. Water is fundamentally within the center of what all life needs to survive and thrive on the planet and it is no different for human society whose agriculture, energy production, recreation, etc., all require water.

Accomplishing any goals related to better understanding these two cycles requires, in part, an accurate accounting of the key reservoirs and associated fluxes, including their spatial and temporal variability. To accomplish this, integration of existing observations and research tools is a requirement. To achieve this, the NASA Energy and Water Cycle Study (NEWS) grand challenge can be summarized as documenting and enabling improved, observationally based, predictions of water and energy cycle consequences of Earth system variability and change*.* This challenge requires documenting and predicting trends in the rate of the Earth's water and energy cycling that corresponds to climate change and changes in the frequency and intensity of naturally occurring related meteorological and hydrologic events, which may vary as climate may vary in the future. The cycling of water and energy has obvious and significant implications for the health and prosperity of our society. The importance of documenting and predicting water and energy cycle variations and extremes is necessary to accomplish this benefit to society.

A coordinated team effort is required that will integrate NASA's global water and energy cycle resources to directly address the NEWS challenge*.* More information on NEWS is available at http://wec.gsfc.nasa.gov Interested collaborators with NEWS are specifically recommended to review progress and plans of current NEWS activities that are available at this web location.

Through national and international relationships, NEWS will ultimately facilitate NASA providing added value to the Earth observations resulting from NASA research and development, assist in bringing in added satellite calibration/evaluation data sources, and deliver independent observationally-based data sets for evaluating 4-dimensional data assimilation (4DDA) and prediction capabilities on a regional and global basis.

The overarching goal of NEWS investigations is to integrate Earth Science Research Program components to make decisive progress toward the NEWS challenge. To achieve this objective, the NEWS investigations will integrate and interpret past, current, and future space based and *in situ* observations into assimilation and prediction products and models that are global in scope. These activities will serve efforts to improve understanding, modeling, and information for global prediction systems. To achieve these goals, the NEWS investigations must recognize that accurate prediction of not only trends in the mean, but also extremes and abrupt changes, is a key step toward useful applications. The critical feedbacks within the overall NEWS strategy are the lessons that scientific analysis, modeling, prediction, and consequences can guide and identify the technological and observational requirements of future NASA missions.

2. Table of Key Information

NASA point of contact concerning this program	Jared Entin Earth Science Division Science Mission Directorate NASA Headquarters Washington, DC 20546-0001 Telephone: 202-358-0275 Email: jared.k.entin@nasa.gov

A.25 SOIL MOISTURE ACTIVE-PASSIVE MISSION SCIENCE TEAM

1. Scope of Program

Proposals are solicited for science investigations that utilize data from the Soil Moisture Active-Passive (SMAP) mission (https://smap.jpl.nasa.gov/). The Soil Moisture Active-Passive mission primarily uses passive (radiometer) L-band microwave remote sensing to determine the land surface soil moisture and freeze/thaw state. These measurements will advance the study of the water, carbon, and energy cycles, both individually and at their points of interconnection.

SMAP was launched as a result of the recommendation from the National Research Council report *Earth Science and Applications from Space: National Imperatives for the Next Decade and Beyond* (http://www.nap.edu/catalog.php?record_id=11820).

The objective of this solicitation is to select research projects that will respond to the Decadal Survey outlined science priorities for the SMAP mission, as well as enable pursuit of new methods of exploiting SMAP's observations for Earth System Science. These priorities and possibilities include, but are not limited to:

1) Enabling advances in the study of the water, carbon, and energy cycles, especially on those topics that deal with the intersections of these cycles.
2) Exploring the impact of soil moisture variability and its role as the 'memory' for the land surface, on weather and climate.
3) The role of soil moisture in floods, droughts, agricultural productivity, and public health related concerns (e.g., vector borne diseases).

2. Types of Proposals Solicited

2.1 Utilization of SMAP Products for Process Studies

The state and amount of water in the soil is a critical determinant in many complex Earth System processes. For example, it can limit or enable photosynthesis. It can determine the ratio of precipitation and snowmelt that percolates into the ground or runs off. The amount of water in the soil will affect if incoming radiation is used to heat the lowest layer of the atmosphere or to evaporate water, which might later be used to form clouds and/or precipitation. Studies are encouraged that use the SMAP observations to improve our understanding of these and other processes, be they aspects of the water, carbon, or energy cycles.

2.2 Utilization of SMAP for Model Evaluation and Improvement

SMAP's products, with inherent radio frequency interference mitigation, offer an unprecedented look at global soil moisture variability. This should be instrumental in global evaluation of land surface model performance and highlight areas that can be improved. Through this work, evaluation and improvement of other types of models (i.e., those used for weather forecast, climate prediction, or vegetation activity) should be possible.

2.3 Algorithms

2.3.1 *Maintenance*

Environmental observations from SMAP may benefit from continued scrutiny of the existing calibration of its radiometric data. Also, it is known that radiofrequency interference (RFI) may undesirably influence SMAP observations. NASA encourages efforts that evaluate the existing SMAP calibration and RFI mitigation operations and seek improvements that benefit the soil moisture and state data products.

2.3.2 *Novel topics*

The L-band observations of SMAP can be used to observe aspects of the Earth System other than land surface moisture. NASA will accept proposals that seek to develop new or advance existing uses for SMAP data that are not duplicative to other supported efforts. New uses of the SMAP data will be viable only if they address high priority gaps in our global observing system.

2.3.3 *Similar Data products*

The level one data products (e.g., brightness temperatures) can be used in other fashions than those planned by the SMAP project to produce soil moisture (both surface and root-zone), freeze-thaw state, and carbon-cycle metrics (e.g., net ecosystem exchange). NASA will accept efforts that propose new algorithms and/or approaches that would offer data products that would be significantly different than those produced by the SMAP project, provided that they present substantial added value. This may be accomplished by combining SMAP data with other satellite data products (e.g., surface temperature or precipitation). Proposed new algorithms should not require ongoing ingesting of limited area land-based or airborne-based observations. NASA continues to be interested in alternative methods to downscale the radiometer soil moisture to finer spatial scales and/or determine root-zone soil moisture. NASA is also interested in investigations that seek to leverage current and future active L-band systems such as CYGNSS and NISAR to achieve higher spatial and/or temporal resolutions.

2.4 Evaluation research and data sets

A strong motivation for a soil moisture satellite was presented by Koster et al. (2002, 2004, 2006) that started with a single model configuration simulation that was standardized so that other modeling research could duplicate the initial effort. Coherence of model results led to greater confidence in research findings. Valuable community efforts involving evaluation of soil moisture data have been produced via the Global Soil Wetness Project (GSWP) and the Project for Intercomparison of Land Surface Parameterizations Schemes (PILPS). This solicitation encourages research that might provide standardize data sets and procedures to evaluate soil moisture data sets, including those that are satellite, downscaled, and/or model-generated.

3. Requirements

All proposals submitted in response to this solicitation must exhibit comprehensive knowledge of the relevant SMAP data products to be employed. Details on these products are available in the SMAP handbook (http://smap.jpl.nasa.gov/mission/description/) and Algorithm Theoretical Basis

Documents (ATBDs). Proposers should also be knowledgeable of past and ongoing SMAP calibration and validation efforts and should not look to duplicate those. Any proposed activities that might replicate calibration and/or validation activities should explicitly defend those with a description of their well-documented additional value.

All proposed studies must plan to use SMAP data in a critical way. Proposed studies should not be accomplishable without SMAP data.

New algorithms (Section 2.3) should be globally implementable, with an expectation of adequate performance over a majority of the relevant Earth surface. Proposals to develop new algorithms should include a description of:

a.) Preparing and writing an ATBD
b.) Product calibration and validation
c.) Error characterization

Proposals from currently funded NASA investigators should make clear in their proposals how the proposed work is different from their currently funded projects.

4. Programmatic Information

Total funds available for work selected under this solicitation are approximately $4.5M per year for three years. The program anticipates making a total of approximately 30 selections. There is no a priori planned distribution of projects across the solicited areas of Section 2. Proposals that are outside of the research areas described in Section 2 and/or those that do not meet the requirements of Section 3 will not be considered. It is anticipated that project start dates would be on or soon after November 1, 2019.

5 Science Team Membership

Principal Investigators (PIs) of the selected investigations, solicited here, would comprise the SMAP science team going forward and be expected to help advise the project. PIs should expect to be invited to future annual SMAP team meetings and plan accordingly.

6. References

Koster, R. D., P. A. Dirmeyer, A. N. Hahmann, R. Ijpelaar, L. Tyahla, P. Cox, and M. J. Suarez, 2002: comparing the degree of land-atmosphere interaction in four atmospheric general circulation models. *J. Hydrometeor*., 3, 363-375, doi:10.1175/1525-7541(2002)003<0363:CTDOLA>2.0.CO;2.

Koster, R. D., and Coauthors, 2004: Regions of strong coupling between soil moisture and precipitation. *Science*, 305, 1138-1140, doi:10.1126/science.1100217

Koster, R. D. and Coauthors, 2006: GLACE: The Global Land-Atmosphere Coupling Experiment. Part I: Overview. *J. Hydrometeor*., 7, 590-610, doi:10.1175/JHM510.1.

7. Summary of Key Information

Expected annual program budget for new awards	~ $4.5M

Number of investigator awards pending adequate proposals of merit	~30
Maximum duration of awards	3 years
Due date for Notice of Intent to propose (NOI)	See Tables 2 and 3 of ROSES
Due date for proposals	See Tables 2 and 3 of ROSES
Planning date for start of investigation	November 1, 2019
Page limit for the central Science-Technical-Management section of proposal	15 pp; see also Table 1 of ROSES *Summary of Solicitation* the *Guidebook for Proposers*.
Relevance	Every proposal must address one or more Decadal Survey outlined science priorities for the SMAP mission and/or the priorities and possibilities in Section 1 of this Program Element.
General information and overview of this solicitation	See the *ROSES Summary of Solicitation*.
Detailed instructions for the preparation and submission of proposals	See the *NASA Guidebook for Proposers* at http://www.hq.nasa.gov/office/procurement/nraguidebook/.
Submission medium	Electronic proposal submission is required; no hard copy is permitted.
Web site for submission of proposal via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Web site for submission of proposal via Grants.gov	http://grants.gov/ (help desk available at support@grants.gov or (800) 518-4726)
Funding opportunity number for downloading an application package from Grants.gov	NNH19ZDA001N-SMAP
NASA point of contact concerning this program	Jared Entin Earth Science Division Science Mission Directorate NASA Headquarters Washington, DC 20546-0001 Telephone: 202-358-0275 Email: jared.k.entin@nasa.gov

A.26 Weather and Atmospheric Dynamics

NOTICE: Clarified July 31, 2019. Section 2 has been modified to include additional information about aircraft, instrumentation, and three more example research questions. The due dates have not changed. New text is in bold and deleted text is struck through.

1. Scope of Program

1.1 Background

The study and analysis of the dynamics of the atmosphere and its interaction with the oceans and land is an important component of the Weather Focus Area. Improvement of our knowledge of weather processes and related phenomena is crucial in gaining an understanding of the Earth system. This component of the Weather Focus Area is primarily designed to apply NASA Scientific remote sensing expertise to the problem of obtaining accurate and globally distributed measurements of the atmosphere to enhance our understanding of atmospheric dynamical processes and assimilate these measurements into NASA's research, cloud and climate models, and quasi-operational weather models in order to improve and extend U.S. and global weather prediction. NASA-sponsored research continues to gain new insight into weather and extreme weather events by the utilization of data obtained from a variety of satellite platforms [e.g., Tropical Rainfall Measuring Mission (TRMM), Global Precipitation Measurement (GPM), Aqua, Terra, Suomi National Polar-orbiting Partnership (Suomi-NPP), CloudSat, Cloud Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO), Soil Moisture Active Passive (SMAP), Cyclone Global Navigation Satellite System (CYGNSS), RainCube, TEMPEST-D, IceCube, and the Lightning Imaging Sensor (LIS) on ISS] and related NASA field experiments [e.g., CPEX, OLYMPEX, NAMMA, GRIP, TCSP, polar winds, HS3, etc.].

1.2 Scope of Proposed Projects

This solicitation is aimed at enabling improved predictive capability for certain weather and extreme weather events in three specific sub-element areas. The first relates to difficult-to-retrieve weather conditions such as in complex environments, or with orographic influences, light precipitation cases, rain/snow transitions, etc. The second focuses on the use of past NASA field campaign data from a long series of field experiments, and in conjunction with satellite data and numerical models, to better understand relationships between remotely sensed data and the physical properties of the underlying atmospheric and surface conditions for improving process knowledge, algorithm assumptions, and advancing models. The third offers an opportunity to participate in a field experiment in 2020. In all three sub-element areas, strong preference will be given to proposals that identify at least one testable hypothesis and describe the process and NASA data to be used to test the hypothesis. Other non-NASA data sources can also be included in these proposed analyses.

2. Types of Proposals Solicited

The three research sub-element areas are described in more detail below. A number of potential research items are suggested in each case. These suggestions do not form a complete list and not all items covered in these lists are likely to be selected for funding. Also, these suggestions are optional. All worthy research ideas related the three sub-elements will be considered. As mentioned in Section 3, the maximum duration of awards is three years. Approximate per year funding available for the areas are $0.6M for topic 2.1, $0.6M for topic 2.2, and $1.9M in the first year and $1.3M in years 2-3 for topic 2.3.

2.1 Difficult-to-Retrieve Weather

In this sub-element, research pertaining to difficult-to-retrieve weather events, the focus will be on topics such as novel and robust techniques for combining datasets for improving the understanding of the processes in these events, advancement of models, and also approaches to substantially improve satellite retrieval algorithms. Difficult-to-retrieve weather conditions of interest include, but are not limited to, complex environment/orographic precipitation, light precipitation cases, rain/snow transitions, fast evolving/under-sampled events, pyrocumulus resulting from fires, etc. Note that this sub-element will not support proposals to improve operational weather forecasts, however retrospective research that can demonstrate improvements in forecasting capability that utilize NASA information could be of interest.

Often difficult-to-retrieve weather lacks detail on the processes occurring within the events. Thus, this sub-element aims to improve the basic knowledge about processes and to explore techniques to combine datasets in order to elucidate and classify these processes.

Models often play an essential role in difficult-to-retrieve weather events. Here, research proposals that apply, improve, or implement models within the framework of advancing our knowledge about difficult-to-retrieve weather conditions, processes, regimes, and/or events are encouraged. Such modeling proposals must include the use of NASA satellite remote sensing data.

Some potential science questions that might be addressed by proposals in this sub-element could include:

- For orographic precipitation, can terrain height, along with the temperature lapse rate, be used to separate the boundaries between near-surface liquid and frozen precipitation? Are there satellite-only observations that can be used reliably and globally for separating liquid rain from falling snow? Can a relationship be established that can be applied (nearly) globally? What internal processes might cause any relationships to break down?
- How might data assimilation or machine learning be used to combine datasets to advance knowledge of atmospheric dynamic processes or the understanding of weather phenomena?
- What are the fundamental mechanisms governing the evolution of embryonic cloud droplets and ice crystals to precipitation sized particles? How do updrafts support these growth mechanisms?

- How can existing NASA observations be used to investigate fast evolving atmospheric and weather processes?
- Based on existing satellite data, what are the limitations of satellite sensors for light rain/snow and/or shallow/warm precipitation events? Are there scientific options for mitigating these sensor limitations?
- How can blowing snow be discriminated from precipitating snow in upper cloud layers?
- How can light snow and Arctic/Antarctic precipitation be better estimated as they account for a substantial fraction of total snow precipitation during polar winters and also play key roles in the internal atmospheric water and radiative budget.

If the proposed research is on the advancement of satellite retrieval algorithms, the proposal must identify which satellite product(s) are being addressed and include at least a collaborator from the satellite algorithm team developing the product to prove that the improvement could be implemented if successful. This solicitation does not call for the development of new products, rather to improve existing satellite products. This sub-element also does not support improvement of ground or aircraft-based products. This sub-element will entertain proposals regarding weather-related research from small/CubesSat datasets such as TEMPEST-D, RainCube, and/or IceCube.

2.2 Field Campaign Data Analysis **[This section was modified July 31, 2019]**

NASA spends considerable time, energy, and resources conducting field campaigns. ~~However, sometimes funding is only available for the field campaign operations, data calibration, and data archiving.~~ In this sub-element, proposals are encouraged for 3-year innovative research activities using prior NASA field campaign datasets [e.g., CPEX, OLYMPEX, NAMAA, GRIP, TCSP, polar winds, CPEX, HS3, etc.] some of which can be found at https://ghrc.nsstc.nasa.gov/home/field-campaigns or https://eosweb.larc.nasa.gov/. Novel/unique studies using multiple field campaigns tied together in space, or time, or process observed, or regime dependence are encouraged. In addition, research efforts that incorporate NASA satellite data in conjunction with the field campaign datasets are of greater interest for this solicitation.

Research topics should be affiliated with weather and/or atmospheric dynamics topics, such as, but not limited to:

- Improve the understanding of 4-D atmospheric dynamic and/or precipitation processes;
- Reduce particle size distribution (PSD)-related uncertainties by exploiting process knowledge within aerosol, cloud, and precipitation interactions (e.g., 4-D scale, lifecycle, regional characteristics), and quantify impact on retrieved precipitation parameters;
- Quantify supercooled water in mixed-phase clouds, especially the vertical distribution of the supercooled liquid water;
- Develop robust procedures for mitigating non-uniform beam filling;
- Develop and advance end-to-end (e.g., precipitation to runoff) observations, models and data analysis;
- Improve the understanding of underlying dynamical and microphysical properties of weather systems throughout their life cycles.

This funding opportunity will be a one-time 3-year effort; thus, proposers should clearly state in their proposals how they plan to accomplish the research to be done and produce deliverables, such as publications, within the 3-year period. Proposers should also provide a background section on what research has been accomplished with the dataset(s), how the proposed analysis is different than prior work, and why it is still important to investigate. This solicitation will not consider data visualization portals, data combining (e.g., for providing coincident datasets from disparate observations) and these proposals will be marked non-responsive to the call as this funding is for scientific research and advancement.

2.3 Field Campaign Opportunity **[This section was modified July 31, 2019]**

Currently NASA and the European Space Agency (ESA) are in discussion on future joint post-launch Calibration and Validation activities supporting the recently launched ESA Aeolus wind lidar satellite system (https://www.esa.int/Our_Activities/Observing_the_Earth/Aeolus/Facts_and_figures). As part of engaging the broader scientific atmospheric dynamics community and to assist in validating Aeolus observations, in summer 2020 a joint-NASA-ESA campaign focusing on the Tropics is being planned from the Cape Verde Islands. **Also participating in the field campaign are the French SAFIRE Falcon aircraft (http://www.safire.fr/en/content_page/16-safire-utilisateurs/49-the-falcon-20.html with cloud and dust imaging instruments) and the German Aerospace Center (DLR) Falcon aircraft (https://www.dlr.de/dlr/en/desktopdefault.aspx/tabid-10203/339_read-275/#/gallery/129 with instruments: Lux et al., 2018 and Witschas et al., 2017). The NASA part of the field campaign will begin intensive operations in early July 2020 and end 4 weeks later. If additional funding is available the intensive operations will continue until mid-August.** Nominally, this is a follow-on to the Convective Processes Experiment (CPEX) field campaign which took place in the summer of 2017 (https://cpex.jpl.nasa.gov/). This 2020 field campaign (not yet named) will provide opportunities to study the dynamics and microphysics related to the Saharan Air Layer, African Easterly Waves and Jets, Tropical Easterly Jet, and deep convection in the ITCZ. This campaign is an opportunity to join the U.S. and European airborne wind Lidar system teams addressing the Aeolus validation. The planned field campaign will also provide to the science community unique data to address the science questions while providing further insight into Wind Lidar technologies to support the development of future space borne Wind Lidar systems in Europe and the U.S. This solicitation is geared toward enhancing the field campaign with additional instrumentation and analysis objectives.

For this field campaign NASA has committed to provide the DC-8 aircraft, a coherent Doppler Wind Lidar (https://airbornescience.nasa.gov/instrument/DAWN) for wind retrievals ~~in the planetary boundary layer below 4 km~~, **the High Altitude Lidar Observatory (HALO) to profile atmospheric aerosols and water vapor** and dropsondes to provide a broader picture of the tropospheric environment. **There is a high probability that the Airborne Second Generation Precipitation Radar Instrument, APR-3, will also be on the DC-8 aircraft.** Other instruments may be deemed essential and added to the field campaign program. Approximately 100 flight hours are planned.

Through this sub-element NASA is seeking two types of proposals:

Type-1, a one-year proposal to provide an instrument that has flown on the NASA DC-8 before and that includes funding for field deployment, data processing, and data archival; and

Type-2, proposals of up to three-years duration for using this field campaign data and participating in related research.

Some potential research questions include:

- With regard to Atlantic Easterly Waves: Are all Atlantic tropical cyclones originating in Africa? What is the link to other weather phenomena in West Atlantic and East Pacific?
- What is the role of aerosols and their interactions with African weather (monsoon) and air quality?
- How can these planned observations improve our understanding of tropical dynamics such as Kelvin and gravity waves, intensive storm development (e.g. hurricanes), heat exchange with the ocean, its impact on tropical weather and intense storm development?
- How can these observations be used to remove the double ITCZ effect in GCM models (Type-2 proposals)? What instruments/observations are necessary to make progress in this ITCZ model deficiency (Type-1 proposals)?
- How can this planned field campaign data help obtain realistic parameterizations of convection? What instruments/observations are necessary to make progress in parameterizations (Type-1 proposals)?
- **How do convective systems interact with lower tropospheric and surface winds in the ITCZ?**
- **What are the vertical structures and variability of the boundary layer and how do they affect the convection initiation and lifecycle in the ITCZ?**
- **How do the African easterly waves and Sahara Air Layer (dry air and dust) control the convectively suppressed and active periods of the ITCZ?**

Proposals addressing other research topics are also of interest.

Type-2 proposals have a 15-page limit for the Science/Technical/Management Section. Type-1 proposals are expected to be fairly straightforward and concise. Apart from the detailed budget, these Type-1 proposals should provide a list of prior field campaigns in which these instruments have participated, a justification for participation in this 2020 field campaign, and a metric (publications, number of users, etc.) by which it is possible to determine just how useful the proposed instrument has been in the past. There is a five-page limit for the Science/Technical/Management Section of Type-1 proposals. Potential instrument providers may submit a combined Type-1 and Type-2 proposal (18-page limit), however, costs must be clearly separated for the Type-1 and Type-2 activities to permit funding of only one part of the activities if so selected. In this case, the NSPIRES-based (or Grants.gov) budget must combine all costs and the budget justification and total budget files must then be used to describe the breakdown in costs for each proposal type, to permit NASA to understand the cost of selecting only one of the proposed types.

Costs for travel for instrument integration and field campaign support must be included within the Type-1 proposals. Type-2 proposals should include travel to a 3-day science team meeting in the Washington, D.C. area, as well as to the field campaign, if participation in the field campaign is required as part of their proposed research.

3. Notice of Intent to Propose

A Notice of Intent (NOI) to propose is strongly encouraged for the submission of proposals to this program element. The information contained in the NOI is used to help expedite proposal review activities and, therefore, is of considerable value to both NASA and the proposer. NOIs should be submitted electronically via the NASA Solicitation and Proposal Integrated Review and Evaluation System (NSPIRES; http://nspires.nasaprs.com/) by the due date given in Tables 2 and 3 of ROSES. Since NOIs submitted after the deadline may still be useful to NASA, late NOIs, as well as an indication of intent not to propose on an earlier NOI submission, should be submitted by email directly to the point of contact for this program element (see Section 4, below).

4. Summary of Key Information

Expected program budget for new awards	~$3.1M in the first year and ~$2.5M in years 2 and 3 (see Section 2)
Number of investigator awards pending adequate proposals of merit	~18 total: 4-6 for Section 2.1; 4-6 for Section 2.2; 2-4 for Section 2.3 (Type-1); and 6-8 for Section 2.3 (Type-2)
Maximum duration of awards	3 years for Sections 2.1 and 2.2; 12 months for responses to Section 2.3
Due date for Notice of Intent to propose (NOI)	See Tables 2 and 3 of ROSES
Due date for proposals	See Tables 2 and 3 of ROSES
Planning date for start of investigation	Six months after due date for proposals, possibly earlier for Section 2.3
Page limit for the central Science/Technical/Management section of proposal	5 pp for Type-1 proposals in Section 2.3, 15 pp otherwise; see also Table 1 of ROSES *Summary of Solicitation* and the *Guidebook for Proposers*.
Relevance to NASA	This program is relevant to the Earth Science questions and goals in the NASA Science Plan. Proposals that are relevant to this program are, by definition, relevant to NASA.
General information and overview of this solicitation	See the *ROSES Summary of Solicitation*.

Detailed instructions for the preparation and submission of proposals	Please see *ROSES Summary of Solicitation* Section I(g) Order of Precedence and the *NASA Guidebook for Proposers*.
Submission medium	Electronic proposal submission is required; no hard copy is permitted.
Web site for submission of proposal via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Web site for submission of proposal via Grants.gov	http://grants.gov/ (help desk available at support@grants.gov or (800) 518-4726)
Funding opportunity number for downloading an application package from Grants.gov	NNH19ZDA001N-ATDM
Point of contact concerning this program	Gail Skofronick-Jackson Earth Science Division Science Mission Directorate NASA Headquarters Washington, DC 20546-0001 Telephone: 202-358-2045 Email: gail.s.jackson@nasa.gov

A.27 Earth Surface and Interior

1. Scope of Program

NASA's Earth Surface and Interior (ESI) focus area (http://science.nasa.gov/earth-science/focus-areas/surface-and-interior) supports research and analysis of solid-Earth processes and properties from crust to core. The overarching goal of ESI is to use NASA's unique capabilities and observational resources to better understand the structure and dynamics of the core, mantle, and lithosphere, and interactions between these processes and Earth's fluid envelopes.

ESI studies provide the basic understanding and data products needed to inform the assessment, mitigation, and forecasting of natural hazards, including earthquakes, tsunamis, landslides, and volcanic eruptions. These investigations also exploit the time-variable signals associated with other natural and anthropogenic perturbations to the Earth system, including those connected to the production and management of natural resources.

ESI's Space Geodesy Program (SGP) produces observations that refine our knowledge of Earth's shape, rotation, orientation, and gravity, advancing our understanding of the motion and rotation of tectonic plates, elastic properties of the crust and mantle, mantle-core interactions, solid-Earth tides, and the effects of surface loading resulting from surface water, ground water, glaciers, and ice sheets. SGP infrastructure enables the establishment and maintenance of a precise terrestrial reference frame that is foundational to many Earth missions and location-based observations.

2. Description of Solicited Research

ESI requests the following types of research investigations in 2019. Pending sufficient availability of funds, it is NASA's intent to update these foci and compete this element on an annual basis to best address scientific and programmatic priorities:

1. Innovative Solid-Earth Science: Innovative hypothesis-driven scientific research addressing the seven scientific challenges from NASA's *Challenges and Opportunities for Research in ESI (CORE) Report* (2016) (http://go.nasa.gov/2hmZLQO).
2. Solid-Earth Observational Strategies: Proposals exploring observational strategies (e.g., network optimization and design, tradeoffs among collection strategies) that transcend individual investigator-led studies and inform approaches to achieving broader ESI science objectives. Proposals that address ESI science objectives and associated remote sensing observations as identified in the National Academy of Sciences (NAS) Decadal Survey, *Thriving on Our Changing Planet: A Decadal Strategy for Earth Observation from Space* (2018) (https://www.nap.edu/catalog/24938), and the *CORE Report* will receive higher priority. Proposals that include instrument or technology development will be considered nonresponsive and returned without review.

Further details on this year's solicited topics are described in Sections 2.1 and 2.2 below. Additional context for research under these topics continues to derive from the objectives for solid-Earth science presented in several strategic documents. In particular, the *Decadal Survey* and the *CORE Report* provide the latest comprehensive input to ESI's vision.

The *CORE Report* identifies seven scientific challenges: 1) what is the nature of deformation associated with plate boundaries and what are the implications for earthquakes, tsunamis, and other related natural hazards, 2) how do tectonic processes and climate variability interact to shape Earth's surface and create natural hazards, 3) how does the solid Earth respond to climate-driven exchange of water among Earth systems and what are the implications for sea-level change, 4) how do magmatic systems evolve, under what conditions do volcanoes erupt, and how do eruptions and volcano hazards develop, 5) what are the dynamics of Earth's deep interior and how does Earth's surface respond, 6) what are the dynamics of Earth's magnetic field and its interactions with the rest of Earth system, and 7) how do human activities impact and interact with Earth's surface and interior?

These and other ESI interests underpinning this year's solicited topics 2.1 and 2.2 are described in greater detail in the strategic documents listed below:

- The NAS Decadal Survey, *Thriving on Our Changing Planet: A Decadal Strategy for Earth Observation from Space* (2018) (https://www.nap.edu/catalog/24938)
- The NAS report *Volcanic Eruptions and Their Repose, Unrest, Precursors, and Timing* (2017) (https://doi.org/10.17226/24650)
- The NASA *CORE Report* (2016) (http://go.nasa.gov/2hmZLQO)
- The NASA 2014 Science Plan (https://science.nasa.gov/about-us/science-strategy)
- The report *A Foundation for Innovation: Grand Challenges in Geodesy* (2012) (http://www.unavco.org/pubs_reports/geodesy_science_plan/GrandChallengesInGeodesy-Final-Singles-LR.pdf)
- The NASA report highlighting future pathways for GRACE, *Responding to the Challenge of Climate and Environmental Change: NASA's Plan for a Climate-Centric Architecture for Earth Observations and Applications from Space* (2010) (https://science.nasa.gov/about-us/science-strategy)
- The NAS report *Precise Geodetic Infrastructure: National Requirements for a Shared Resource* (2010) (http://www.nap.edu/catalog.php?record_id=12954)

2.1 Innovative Solid-Earth Science

This subsection seeks innovative hypothesis-driven scientific research addressing the *CORE Report's* seven scientific challenges. Overarching themes of interest include leveraging advances in technology and associated data to address new solid-Earth science questions, or revisit existing paradigms. These themes also include advancing our understanding of how the solid Earth is linked to and interacts with the broader Earth system, including understanding the impact of human activities and their interaction with solid-Earth systems, which can both benefit society and provide avenues for innovative research. Within this theme, proposals that develop new and innovative geodetic analysis techniques that utilize satellite data from missions prioritized for other disciplines, or result in data streams or products that may also benefit other disciplines, are also welcomed. All studies must still demonstrate a focus for the proposed work on advancing the understanding of the solid Earth. Proposals that employ new approaches to addressing questions focused on a particular component of the solid-Earth system described in the *CORE Report* are also welcomed.

Submissions to this subsection may include high-risk, high-return research. High-risk research tests novel and significant hypotheses for which there is limited precedent or preliminary data, or that are counter to the existing scientific consensus. High-return research has outcomes, if confirmed, that would have a substantial and measurable effect on current thinking, methods, or practice. Proposals are required to identify potential risks and mitigation strategies.

Successor proposals submitted under this subsection must describe relevant achievements made during the course of the previous awards, new approaches to interpreting remote sensing data or improving knowledge of the solid Earth not employed during those prior studies, demonstrable scientific advances anticipated from the follow-on work, and continued relevance and priority of the research to ESI.

2.2 Solid-Earth Observational Strategies

Space-based and airborne platforms, in combination with geodetic ground networks, are the foundation of the ESI research program. Developing an effective data collection strategy requires careful consideration of the spatial and temporal nature of the anticipated signals of interest, availability of historical and/or ongoing observations, and practical limitations on acquisition strategies, geographic distribution, and resources. This subsection welcomes theoretical, modeling, and analysis efforts that explore the tradeoffs between different data collection strategies, and the viability of those schemes for capturing specific solid-Earth processes of interest. Proposals to conduct Observing System Simulation Experiments (OSSE) that consider real and simulated observations and errors associated with solid-Earth science questions, and inform remote-sensing observational strategies for solid-Earth research, are also encouraged. Such studies may address the development of future remote-sensing and geodetic observational systems, or the optimization of existing systems. Partnerships with experts from disciplines outside the traditional ESI community that help bring OSSE or related modeling approaches to bear on solid-Earth research are welcomed.

One- to two-year efforts are encouraged under this subsection. All proposals should justify the duration needed to meet proposed objectives, and include clearly defined sub-annual to annual milestones. Proposals that address ESI science objectives and associated remote sensing observations as identified in the *Decadal Survey* and *CORE Report* will receive higher priority under this subsection. Submissions to this subsection that complement NASA's ongoing architecture studies for observing systems associated with *Decadal Survey*-recommended Designated Observables are welcomed (https://science.nasa.gov/earth-science/decadal-survey-community-forum). Proposals addressing topics related to these or other funded NASA observing system studies should seek to clearly articulate how the proposed effort will complement these studies and further benefit solid-Earth objectives, and investigators already involved in those studies must clearly demonstrate that the proposed effort is not duplicative of existing funded work.

It is expected that proposals to this subsection will address observational strategies that serve community scientific interests that are broader than an individual investigator-led study. Proposals to address focused scientific questions using specific, pre-defined observational approaches will be assessed under the guidelines provided for topic 2.1 Innovative Solid-Earth Science. Proposals that include instrument or technology development will be considered nonresponsive and returned without review.

3. Programmatic Guidelines

3.1 Solid-Earth Research Focus

A clear focus on advancing scientific understanding of solid-Earth processes and/or properties is required in all proposals.

3.2 Remote Sensing Focus

Substantive connection to remote sensing data is required in all proposals. Proposers are encouraged to utilize existing or planned ground, airborne, and space-based observational capabilities and their associated data sets. These resources include the existing high-resolution SRTM dataset, ongoing satellite and airborne Lidar, and spectral imaging such as ASTER and MODIS that provide structural and compositional models to inform tectonic and climatic influences on evolving terrains. Geodetic observations utilizing GNSS, SAR, and InSAR, including the airborne UAVSAR facility (L-band, P-band AirMOSS, and Ka-band GLISTIN-A), provide insights into dynamic processes. Ongoing and future missions such as ALOS-2, Sentinel-1, TerraSAR-X, COSMO-SkyMed, SAOCOM, and NISAR provide additional and upcoming opportunities in this realm. Magnetic and gravity missions, such as the historical SAC-C, Ørsted, CHAMP, and GOCE, and ongoing SWARM and GRACE-FO, offer long-term records that inform models of the geodynamo and the structure, composition, and dynamics of the Earth's mantle, lithosphere, and fluid envelopes. Missions prioritized for other disciplines; such as the Jason satellites, ICESat-2, and GEDI designed for ocean, cryosphere, and ecosystem topography, respectively; may also provide data useful to solid-Earth science. These and other NASA datasets are cataloged in the Earth Observing System Data and Information System (EOSIDS) (https://earthdata.nasa.gov) and provided by the DAACs.

3.3 Proposals Requesting Acquisition of New Airborne Data

Proposals requiring data from airborne sensors must detail in their cost plan all costs for acquiring the new data sets, including costs for aircraft hours, deployment costs, mission peculiar costs, data processing costs, and other costs associated with deploying the sensors and aircraft (this includes NASA and non-NASA sensors and platforms). In addition, for any proposed activities requiring NASA aircraft or NASA facility sensors, proposers should submit a Placeholder Flight Request to the Airborne Science Flight Request system (https://airbornescience.nasa.gov). Funding associated with the use of NASA aircraft and facility sensors will be sent directly to the responsible NASA center, and not to the awardee. If the instrument or aircraft are not NASA facilities, proposers must take responsibility for making all arrangements to secure the availability of the needed sensors and aircraft and explain these plans in the proposal.

3.4 Proposals Requesting NASA High-End Computing Resources

Interested proposers should consult ROSES-2019 Appendix A.1 Earth Science Research Overview, Section 5.4 High-End Computing, Networking, and Storage; and the *Summary of Solicitation*, Section I(d), for a summary of HEC offerings and guidance on requesting computing time.

3.5 Participation in the NASA Solid-Earth Team Meeting

All proposals should include funds for participation in an annual two-day NASA solid-Earth team meeting to be held in the Washington, D.C. area. This meeting will bring together current and prospective ESI investigators, technologists, and related members of the scientific community to report on research results and engage in strategic workshops to advance opportunities for the solid-Earth and geodesy research communities. Awardees are required to attend.

3.6 Documenting Work Effort and Current and Pending Support

Work Effort and Current and Pending Support for PIs and Co-Is must be documented using the templates available on the SARA webpage (https://science.nasa.gov/researchers/templates-for-earth-science-division-appendix-a-roses-proposals).

4. Summary of Key Information

Expected annual program budget for new awards	~$3M
Number of new awards pending adequate proposals of merit	~15-20
Maximum duration of awards	3 years
Due date for Notice of Intent to propose (NOI)	See Tables 2 and 3 of ROSES
Due date for proposals	See Tables 2 and 3 of ROSES
Planning date for start of investigation	January 1, 2020
Page limit for the central Science-Technical-Management section of proposal	15 pp; see also Table 1 of the ROSES *Summary of Solicitation* and the *Guidebook for Proposers*.
Relevance	This program is relevant to the Earth science questions and goals in the NASA Science Plan. Proposals that are relevant to this program are, by definition, relevant to NASA.
General information and overview of this solicitation	See the *ROSES Summary of Solicitation*.
Detailed instructions for the preparation and submission of proposals	See the *NASA Guidebook for Proposers* at http://www.hq.nasa.gov/office/procurement/nraguidebook/.
Submission medium	Electronic proposal submission is required; no hard copy is permitted.

Web site for submission of proposal via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Web site for submission of proposal via Grants.gov	http://grants.gov (help desk available at support@grants.gov or (800) 518-4726)
Funding opportunity number for downloading an application package from Grants.gov	NNH19ZDA001N-ESI
NASA point of contact concerning this program	Benjamin R. Phillips Earth Science Division Science Mission Directorate National Aeronautics and Space Administration Washington, DC 20546-0001 Telephone: (202) 358-5693 Email: ben.phillips@nasa.gov

A.28 GRACE-FO SCIENCE TEAM

1. Scope of the Program

The Gravity Recovery and Climate Experiment Follow-On (GRACE-FO) twin satellites launched on a SpaceX Falcon 9 rocket from Vandenberg Air Force Base, sharing their ride into space with five Iridium NEXT communications satellites. The mission is a partnership between NASA and the German Research Centre for Geosciences (GFZ). GRACE-FO is a successor to the original GRACE mission, which operated from 2002 to 2017.

Like its predecessor, the two identical GRACE-FO satellites function as a single instrument. By tracking changes in their separation distance, the satellites are able to map regional gravity changes. A GPS system tracks each spacecraft's position relative to Earth's surface, and onboard accelerometers record forces on the spacecraft other than gravity, such as atmospheric drag and solar radiation. These data are combined to produce global monthly maps of the Earth's gravity and corresponding surface mass variations, which primarily reflect changes in the distribution of water mass in Earth's atmosphere, oceans, land and ice sheets. In addition, the experimental Laser Ranging Interferometer (LRI), designed to improve the precision of measuring the distance between the two spacecraft, is the first demonstration of laser interferometry between satellites. For more information about GRACE-FO, see: https://www.nasa.gov/gracefo and https://gracefo.jpl.nasa.gov/.

The GRACE mission launched March 17, 2002. Since 2010, GRACE operation teams have overcome numerous technical challenges and developed innovative methods to work around the limitations imposed by aging batteries and limited fuel availability for flight control. The mission ended on October 12, 2017, due to a battery cell failure on the GRACE-2 spacecraft, which reduced the satellite system power to an insufficient level and useful dual satellite science data were no longer viable. Over 4,300 peer-reviewed publications based on GRACE data have appeared during the mission's 15-year lifetime.

GRACE-FO will extend the GRACE data record for another five years and expand its legacy of scientific achievements. GRACE chronicled the ongoing loss of mass in the Greenland and Antarctic ice sheets and mountain glaciers. That wealth of data shed light on the key processes, short-term variability and long-term trends that impact sea level rise, improving sea level projections. The estimates of total water storage on land derived from GRACE data, from groundwater changes in deep aquifers to changes in soil moisture and surface water, have provided tools to measure the impact of droughts and monitor and forecast floods.

GRACE data have been used to infer changes in deep ocean currents, a driving force in climate. GRACE data have also been used to measure changes within the solid Earth itself, such as the response of Earth's crust to the retreat of glaciers after the last Ice Age, and the impact of large earthquakes.

The GRACE and GRACE-FO missions are responsive to NASA's Solid Earth Science Working Group Report *Living on a Restless Planet* (http://solidearth.jpl.nasa.gov/) that identifies the study of the dynamics of the Earth's gravity field as one of six significant challenges for the next twenty-five years, as well as NASA's *Challenges and Opportunities for Research in ESI (CORE) Report* (2016) (http://go.nasa.gov/2hmZLQO). The scientific goals of the GRACE and GRACE-FO missions complement a number of international programs, including the World Ocean Circulation Experiment (WOCE), the Climate Variability Program (CLIVAR), and the Global Ocean Observing System (GOOS).

On January 5, 2018 the Committee on the Decadal Survey for Earth Science and Applications from Space (ESAS) of the National Academies of Sciences, Engineering and Medicine (NASEM) Space Studies Board, Division on Engineering and Physical Sciences released the 2017 Decadal Survey, "Thriving on Our Changing Planet: A Decadal Strategy for Earth Observations from Space." The 700-page document, among a broad set of recommendations, identifies five observation types to be continued by NASA, named Designated Observables (DO). Based on the GRACE science accomplishments, Mass Change is one of the five DOs. This perspective of the 2017 DS makes the bridging of GRACE and GRACE-FO mission data of the utmost priority.

The main focus of this program element is to engage the science community in developing methodologies that will enable the development of a continuous mass change measurement record among the GRACE and GRACE-FO observations. Of interest are proposals which also discuss the validation and verification of the proposed methodologies and merged data. Another high priority focus is data assimilation of GRACE and GRACE-FO data in a broad range of Earth System models and modeling systems. Proposals for data assimilation work should clearly identify the expected advances and qualify the benefits of the improved models.

This program element seeks proposals that will advance the development of new methods, algorithms, and models for the exploitation of gravity field observations to be made by GRACE, GRACE-FO, and future space-based gravity field missions for the broad spectrum of Earth system science challenges. This program element also seeks the development of techniques and algorithms capable of bridging gravity field observation across different gravity missions. Proposals are encouraged which are multidisciplinary in scope and which address the Earth System Science questions related to NASA's Strategic Goal 2.1 to "Advance Earth System Science to meet the challenges of climate and environmental change". (See A.1 The Earth Science Research Overview).

Due to the extreme sensitivity of the GRACE-FO measurement technique and its resolution, ground calibration of the mission is problematic. This program element, therefore, seeks proposals that provide predictive models for the static and time varying gravity field that can be verified through both ground and GRACE/GRACE-FO space-borne observations. This program element seeks improved models for the static gravity field and its short term and secular variations and their influence upon the terrestrial reference frame.

This program element seeks proposals for the identification and quantification of atmospheric, oceanographic, hydrospheric, cryospheric and solid Earth structure and dynamics manifested in the GRACE-FO observations. The analysis effort can include other data sources that complement the GRACE-FO measurements, such as Earth rotation and temporal and static gravity field measurements and other innovative approaches, including the use of data from other satellite missions such as CHAllenging Minisatellite Payload (CHAMP) and Laser Geodynamics Satellite (LAGEOS) gravity, radar, and laser altimetry missions (Jason 1-3 and ICEsat and ICEsat2, and Shuttle Radar Topography Mission). Proposers are advised to limit their proposals involving GPS occultation to the improvement and/or validation of GRACE gravity field models only.

The focus of the proposals should be upon the GRACE and GRACE-FO data sets though multidisciplinary and multisensor studies as well as studies that will utilize the GRACE-like mission data base to develop new measurement strategies to improve measurements of the Earth's gravity field. In particular, NASA is interested in efforts to advance measurement concepts and algorithms that would utilize other NASA missions, as well as other observing systems, to enhance our understanding of the Earth System through improved accuracy and spatial resolution.

2. Programmatic Information

After the May 22, 2018 launch, ground stations acquired signals from both GRACE-FO spacecraft. Initial telemetry showed the satellites performing as expected. On July 19, 2018 after 56 days of successful operation, the Instrument Processing Unit (IPU-B) within the Microwave Instrument (MWI) on GRACE-FO Spacecraft #2 (GF2) failed to properly recover from a reboot and was powered down by the spacecraft due to a low current fault response. After a full investigation by an anomaly response team, the mission switched over to the redundant side of the MWI. The GRACE-FO K-band ranging (KBR) system has been fully operational since October 22, 2018. The Laser Ranging Interferometer (LRI) technology demonstration operated for a short period of time prior to the MWI IPU anomaly. The LRI resumed collecting data concurrently with data from the Microwave Instrument late in 2018. NASA will produce two 30-day gravity field maps prior to the official beginning of the science phase of the mission early in 2019.

In addition, NASA has approved extended science data operations for GRACE through September 30, 2019. The authoritative GRACE science data, covering the period from April 2002-September 2017, will result from a post-mission reprocessing to incorporate final calibrations. The data will be archived at NASA's Physical Oceanography Distributed Active Archive Center (PO.DAAC) and the GFZ Information System and Data Centre (ISDC) in Germany for use by the science community.

Four advanced gravity field missions have been launched since 2000. These missions include CHAMP (launched July 15, 2000), GRACE (launched March 17, 2002), ESA's Earth Explorer Gravity Field and Steady-State Ocean Circulation (GOCE) (launched March 17, 2009) and GRACE-FO. Proposers to this program element may consider the use of multiple satellite data sources and they are required to include GRACE and GRACE-FO data.

The investigators associated with the selected proposals will become members of the GRACE-FO science team for the term of their grants.

Continuation of studies funded by existing GRACE and GRACE-FO science team grants will be considered, but proposers are urged to describe accomplishments achieved and carefully articulate the progress to be made in the continuation efforts.

3. Summary of Key Information

Expected total program budget for new awards	~ $3M per year
Number of new awards pending adequate proposals of merit	~ 15 - 20
Maximum duration of awards	4 years
Due date for Notice of Intent to propose (NOI)	See Tables 2 and 3 of ROSES
Due date for proposals	See Tables 2 and 3 of ROSES
Planning date for start of investigation	6 months after proposal due date.
Page limit for the central Science-Technical-Management section of proposal	15 pp; see also Table 1 of ROSES *Summary of Solicitation* and the *NASA Guidebook for Proposers*
Relevance to NASA	This program is relevant to the Earth Science questions and goals in the NASA Science Plan. Proposals that are relevant to this program are, by definition, relevant to NASA.
General information and overview of this solicitation	See the *ROSES Summary of Solicitation*.
Detailed instructions for the preparation and submission of proposals	See the *NASA Guidebook for Proposers* at http://www.hq.nasa.gov/office/procurement/nraguidebook/.
Submission medium	Electronic proposal submission is required; no hard copy is permitted.
Web site for submission of proposal via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Web site for submission of proposal via Grants.gov	http://grants.gov/ (help desk available at support@grants.gov or (800) 518-4726)
Funding opportunity number for downloading an application package from Grants.gov	NNH19ZDA001N-GRACEFO
NASA point of contact concerning this program	Lucia Tsaoussi Earth Science Division Science Mission Directorate National Aeronautics and Space Administration Washington, DC 20546-0001 Telephone: (202) 358-4471 Email: Lucia.S.Tsaoussi@nasa.gov

A.29 Rapid Response and Novel Research in Earth Science

NOTICE: Before any work is begun on a proposal to this program, potential proposers should read the first section entitled Important Caveat to Potential Proposers.

0. Important Caveat to Potential Proposers

Before any effort is expended in preparing a proposal, potential proposers should:

- Read this solicitation in its entirety. It has a number of specific requirements. Failure to meet them will result in a proposal being returned without review.
- Understand that NASA reserves the right to return or decline proposals to this solicitation based on internal review with limited feedback to the proposers.
- The Earth Science Division (ESD) has not reserved any funds dedicated to this solicitation, but anticipates that its individual programs will consider support of a very small number of meritorious proposals each year.
- Prior to proposal submission, contact the most relevant NASA program officer (http://science.nasa.gov/researchers/sara/program-officers-list/#earth) and the current Rapid Response and Novel Research in Earth Science (RRNES) program officer (listed below). Proposers that forego this step run an increased risk of having their proposals declined or returned without review.
- Proposals should normally be for support of one year or less, under the assumption that further work will be proposed to another program.
- This solicitation is not intended to support mitigation of active disasters or immediate hazards. Contact the Disasters Program Manager in NASA's Applied Sciences Division and/or the other most relevant NASA program manager directly to discuss expedited options (http://science.nasa.gov/researchers/sara/program-officers-list/#earth).
- While the ESD does its best to review proposals quickly, because of the funding nature of this solicitation sometimes a response may take longer than anticipated.
- Note that support for "limited duration opportunity for an unanticipated research collaboration," which had been included in earlier versions of the RRNES solicitation, has been eliminated. Proposers interested in support for such activities should contact their NASA program manager directly to see if support can be arranged by another method.

1. Introduction

In order to address its strategic goals and objectives (see Section I of the *ROSES Summary of Solicitation*), the ESD of the Science Mission Directorate (SMD) acknowledges that there are important and highly relevant research topics and opportunities that cannot be anticipated in the annual ROSES solicitation. In particular, it is usually not possible to solicit the following two types of activities:

- Immediate research activity to take advantage of a target of opportunity due to an unforeseen event in the Earth system,

- Exceptionally novel and innovative ideas to advance Earth remote sensing that do not fit within ESD's current slate of solicitations and/or programs.

ESD has not reserved any funds dedicated to this solicitation, but anticipates that its individual programs will consider support of a very small number of meritorious proposals each year.

2. Scope of Program

This program element solicits proposals that advance the goals and objectives of NASA's Earth Science Division by conducting unique research to investigate 1) unforeseen or unpredictable Earth system events and opportunities that require a rapid response, and 2) novel ideas of potential high merit and relevance for ESD science to advance Earth remote sensing that have not otherwise been solicited by NASA in the past three years.

2.1 Rapid Response to Earth System Events

This subelement is focused on research proposals having great urgency for action involving quick-response research on natural or anthropogenic extreme events and/or similar unanticipated or unpredictable events that fall outside the norm. Examples are major fires, volcanic eruptions, 100-year floods, episodes of severe and large-scale environmental pollution, harmful algal blooms, coral bleaching events, and other unexpected large-scale events causing rapid environmental change.

The research activities proposed must require rapid, near-term data acquisition, field work, and/or other such research activities. Given the significance of these events, rapid sharing of data and results are expected. Proposers are strongly encouraged to contact the NASA program officer(s) whose expertise best matches the proposal topic before submitting a proposal, in order to determine whether the proposed work is appropriate for this ROSES program element and if funding is likely to be available for a meritorious proposal.

The proposal must include clear statements as to 1) why the proposed research is of an urgent nature, 2) why the proposed research is of high significance and likely to have a long-lasting impact, 3) why this ROSES program element is the only feasible mechanism to request NASA support for the proposed work, and 4) a detailed plan on data dissemination and sharing.

Please note that this element is not intended to support mitigation of active disasters or immediate hazards. Please contact the Disasters Program Manager in NASA's Applied Sciences Division and or the other most relevant NASA program manager directly to discuss expedited options (http://science.nasa.gov/researchers/sara/program-officers-list/#earth).

2.2 Novel Ideas in Earth Remote Sensing

This subelement is intended to provide an open, systematic, competitive process for NASA's ESD to consider proposals for exceptionally novel scientific research that includes remote sensing of the Earth which cannot be considered relevant to any other NASA solicitation. ESD recognizes that such proposals offer the possibility for major scientific breakthroughs and new approaches to remote sensing and knowledge of the Earth system. ESD offers this subelement as a mechanism for researchers to develop their ideas and justify near-term investment through an important new capability or scientific application that will advance ESD goals and objectives.

Proposals must focus on topics that offer fundamental scientific research to advance Earth remote sensing, including new ways of interpreting remote sensing data or improving knowledge of the Earth system and its processes. Proposals may include calibration and validation work, as appropriate.

Proposals that focus on instrument or technology development, data and information systems research, or educational activities are strongly discouraged.

If the topic is relevant to any other ESD ROSES program element(s), it should not be submitted here, but should be submitted to the relevant element. In addition, in order for a proposal to be considered responsive as novel Earth science, the topic and approach must not have been solicited or have been considered responsive under any NASA solicitations during the past three years (this includes ROSES-2016–ROSES-2018, NASA Announcements of Opportunity, etc.). Any proposal that contains research that in the view of cognizant NASA managers violates one or both of these requirements will be considered as nonresponsive and declined without further review.

NASA anticipates that only a very small number of proposals will meet these criteria each year and that selection and funding of such proposals will be a rare, but a strategically important occurrence.

3. Relevance to SMD's Goals and Objectives

Proposals submitted in response to this solicitation must demonstrate the relevance of the proposed activity to ESD by showing how the Scientific/Technical area(s) to be covered will advance not only high-level ESD goals and objectives, but also specific (existing or anticipated) outcomes identified in ROSES program elements, ESD roadmaps, other ESD program documents, the *NASA Science Plan*, findings in decadal surveys, or the reports of NASA advisory bodies or groups relevant to NASA. Proposers must explicitly state from what source (e.g., ROSES program element, roadmap, or decadal survey) the claim of relevance derives. Proposers are referred to the *Earth Science Overview* in Appendix A.1 of this solicitation for a description of the scope of NASA Earth Science activities and the research programs areas and topics of interest. To be relevant under this program element, proposals must take into consideration ESD's defined scope and its focus on the use of airborne and/or space-based measurements to provide information about the Earth system.

4. Programmatic Information and Additional Requirements

4.1 Proposal Structure, Content, and Budget Requests

Prior to any submission, proposers are encouraged in the strongest possible terms to contact the ESD program managers (http://science.nasa.gov/researchers/sara/program-officers-list/#earth) whose expertise are most germane to the proposal topic to determine the appropriateness of the work for consideration under this program element. This may include consideration of whether funding is potentially available.

4.1.1 *Proposals for Rapid Response to Earth System Events*

The Technical Plan for proposals submitted for rapid response is limited to a maximum of five pages and must include clear statements as to why the proposed research is of an urgent nature and why this solicitation is the only feasible mechanism to request NASA support for the proposed work, as well as the other requirements listed in the text of the subelement. The bulk of the Technical Plan should be devoted to describing the core scientific objectives and anticipated scientific return, the research work to be done, and the timetable for rapid actions. If NASA facilities will be required to conduct the research (e.g., NASA aircraft or airborne sensors), proposers should contact the relevant facility managers to develop feasibility and cost estimates in parallel with the preparation of their proposal. Feasibility and cost estimates should be submitted as part of the budget justification.

Questions regarding the NASA flight request system or processes should be addressed to Marilyn Vasques, Flight Request Manager (Marilyn.Vasques@nasa.gov or 650-604-6120).

To ensure timely processing of the submitted proposal, "Rapid Response" must be selected as the Primary Investigation Type on the proposal cover sheet. On the cover sheet, the relevant program manager/program under which the proposal should be considered should also be indicated.

NASA will initially conduct an internal review of each proposal that may result in a decision, and there may be limited feedback to the proposer. Some proposals may be declined simply for lack of available funding. However, proposals may also be subject to external peer review at the discretion of NASA. The larger the requested funding, the more comprehensive (e.g., the use of external mail review) the review is likely to be.

Budget requests should be commensurate with the nature of the rapid response work to be conducted and, if no other research projects are being leveraged, include sufficient funding for processing of the data and its public distribution, as well as minimal data analysis to achieve the core, near-term objectives of the rapid response. Full exploitation of a successfully acquired data set can be included in future competitive ROSES disciplinary program elements and should not be requested here.

Proposals should normally be for support of one year or less, under the assumption that further work will be proposed to one of the ongoing research programs or one of the other periodic ROSES elements (e.g., competed mission science teams, Interdisciplinary Science, etc.). Up to three years of funding may be requested, but proposals requesting more than one year of funding must provide specific and compelling justifications as to why the core, rapid response science objectives require a longer duration for completion.

4.1.2 *Proposals for Novel Ideas in Earth Remote Sensing*

The Technical Plan for Novel Ideas in Earth Remote Sensing proposals is limited to a maximum of 15 pages and must include clear statements as to why the proposed scientific research is novel and not responsive to any other NASA solicitations released in the past three years. The technical plan should emphasize the initial research activities needed to explore the feasibility of the new idea, prove the concept, and/or provide a first demonstration of the potential utility and benefits to NASA Earth science, as well as the other requirements listed in the text of the subelement. Potential proposers are encouraged to pay close attention to the types of research that are discouraged for this area as noted in Section 2.2 ("instrument or technology development, data and information systems research, or educational activities").

It is anticipated that most such studies will be conducted in one year at modest cost (e.g., ~$75-$150K), and that continued funding would be sought from proposals submitted to open research programs or periodic ROSES elements (e.g., competed mission science teams, Interdisciplinary Science, etc.). However, up to three years may be requested, but the proposal must fully justify the need for that length of time. In addition, all proposals must describe plans for the publication/documentation/dissemination of their results at the earliest possible date.

NASA will initially conduct an internal review of each proposal that may result in a decision, and there may be limited feedback to the proposer. Some proposals may be declined simply for lack of available funding. In some cases, NASA will, at its discretion, conduct a full peer-review of the proposal, most likely involving individual evaluations submitted through NSPIRES. However, if sufficient proposals are received, NASA reserves the right to convene a peer review panel. NASA's standard evaluation criteria will be used in reviewing these proposals. The uniqueness of the research proposed and the degree of innovation will be weighed heavily under the intrinsic merit criterion, as well as under relevance.

4.2 Availability of Funding

No specific budget is identified for this program element; selected proposals will be funded by the ESD program managers in the disciplines most closely related to or benefitting from the proposed work. The number of proposals selected will be dependent on the availability of funds, as well as the number and quality of proposals submitted.

Potential proposers should contact both the NASA Point of Contact for this solicitation and the ESD Program Officers in the disciplines and programs most germane to the proposed investigations to discuss the proposed work and the availability of funds. Contact information for SMD Program Officers is available at http://science.nasa.gov/researchers/sara/program-officers-list/#earth or in the Summary Information table at the end of a ROSES program element description.

4.3. Award Instruments

Awards selected under this solicitation will only be supported as a grant, a cooperative agreement, an interagency agreement, or internal funding to a NASA Center. Contracts will not be used for these awards.

5. Summary of Key Information

Expected annual program budget for new awards	No specific budget is identified; selected proposals will be funded by the relevant program(s).

Number of new awards pending adequate proposals of merit	The number of proposals selected will be dependent on the availability of funds from the relevant program(s), as well as the number and quality of proposals submitted.
Maximum duration of awards	3 years (but see Sections 4.1.1 and 4.1.2)
Due date for Notice of Intent to propose (NOI)	No Notices of Intent are requested for this program element.
Due date for proposals	Proposals may be submitted at any time until 11:59 PM (Eastern time) on March 27, 2020.
Planning date for start of investigation	No sooner than 1 ½ months after proposal receipt for Rapid Response, and 6 months after proposal receipt for Novel Earth Science.
Page limit for the central Science/Technical/Manageme nt section of proposal	5 pp for Rapid Response and 15 pp for Novel Earth Science; see also Table 1 of ROSES *Summary of Solicitation* and the *Guidebook for Proposers*.
Relevance	See Section 3. Proposals that are relevant to this program are, by definition, relevant to NASA.
General information and overview of this solicitation	See the *ROSES Summary of Solicitation*.
Detailed instructions for the preparation and submission of proposals	Please see *ROSES Summary of Solicitation* Section I(g) Order of Precedence and the *NASA Guidebook for Proposers*.
Submission medium	Electronic proposal submission is required; no hard copy is required or permitted.
Web site for submission of proposal via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Web site for submission of proposal via Grants.gov	http://grants.gov (help desk available at support@grants.gov or (800) 518-4726)
Funding opportunity number for downloading an application package from Grants.gov	NNH19ZDA001N-RRNES
NASA point of contact concerning this program	Laura Lorenzoni Science Mission Directorate NASA Headquarters Washington, DC 20546-0001 Telephone: (202) 358-0917 Email: laura.lorenzoni@nasa.gov

A.30 AIRBORNE INSTRUMENT TECHNOLOGY TRANSITION

This program requires a Notice of Intent (NOI). Proposals that are not preceded by the mandatory NOI may be returned without review. No feedback will be provided in response to the NOI.

1. Scope of Program

NASA's Earth Science Research Program is a comprehensive effort that as part of its role in the Earth Science Division (ESD), develops observational techniques and partners with the Earth Science Technology Office in developing the instrument technologies needed to implement them. These instruments are operated in the laboratory and from suborbital (i.e., surface, balloon, and aircraft) and, in some cases will transition to space-based platforms to support science investigations. In many cases, airborne data are used to increase basic process knowledge and, in other applications, airborne data products, utilized in the development of improved process models and/or parameterizations, are incorporated into complex computational models that characterize the present state and future evolution of the Earth System.

Within the Earth Science Division, the Airborne Science Program is responsible for providing airborne platform and associated systems (e.g., data, power) that together with the instruments from the R&A program are capable of delivering data products that advance science and that complement other observing assets, such as satellites. This is accomplished primarily through focused field experiments for process studies, evaluation and risk retirement of new instrument concepts, and calibration and validation of space-based sensors.

This announcement seeks to upgrade airborne remote sensing instruments developed under NASA's Instrument Incubator Program (IIP, Program element A.49), or by similar NASA or externally-supported (e.g., corporate, other Federal agency, internal institution funding) programs or activities. This opportunity provides for engineering -focused activities leading to the integration of an instrument to an airborne platform that will ultimately be deployed as part of organized airborne science campaigns which typically involve multiple instruments and/or platforms. The goal is to upgrade recently-developed operating aircraft instruments coming from IIP or other such development programs that are not ready to be used in a Research and Analysis project to campaign-ready airborne configuration. No funding is available under this announcement for:

- research and development of new airborne instrumentation;
- instruments that make *in situ* observations;
- downsizing existing airborne instruments;
- upgrades to existing airborne instruments;
- transitioning existing airborne instruments from one airborne platform to another.

Proposals submitted to this announcement shall support the objectives of one or more of the Earth science focus areas. Earth science focus areas are: Carbon Cycle and Ecosystems, Climate Variability and Change, Water and Energy Cycle, Atmospheric Composition, Weather, and Earth Surface and Interior (see Appendix A.1 for descriptions of the focus areas). Relevance to these focus areas is indicated by the degree to which instrument products (i.e., science and engineering data) support the goals and activities of existing and future (both those currently being planned and those that are still in the conceptual stage) field campaigns sponsored by the NASA Research and Analysis program; activities that support both one or more of the focus areas and can contribute to the goals and activities of the NASA's Applied Science Program[1] are encouraged. Examples of previous field campaigns can be found at the Airborne Science Website.[2]

Proposers may find information on selections from previous calls for this element at NASA's NSPIRES web site.[3]

The following documents identify the relevant missions and programs for this program:

1. *Thriving on Our Changing Planet: A Decadal Strategy for Earth Observation from Space (2018)* may be accessed on the web at https://www.nap.edu/read/24938/chapter/1. This report is hereinafter referred to as the "*Decadal Survey*."
2. The NASA 2014 Science Plan accessible on the web at https://smd-prod.s3.amazonaws.com/science-pink/s3fs-public/atoms/files/2014_Science_Plan_PDF_Update_508_TAGGED_1.pdf.
3. NASA missions listed in the table found at http://science.nasa.gov/earth-science/missions/.

2. Programmatic Information

2.1 Data Management and Data Access

NASA supports a data policy of open access to scientific data. Scientific advancement is generally enhanced by broad access to and use of scientific data. Therefore, proposers should specify how the instrument and its products would be made available for use by, or in concert with, a broad community of Principal Investigators (PI), and address any issues concerning data access. Proposers should provide this information in the mandatory data management plan text box on the NSPIRES cover pages at the time of submission. Please refer to the NASA ESD data policy[4] for more information.

2.2 Available Funding and Period of Performance

Yearly funding guidance is given in the "Summary of Key Information" (Section 3) of this announcement. Funding for subsequent use, maintenance, repair, and/or upgrading of AITT "graduates" should be requested by proposing to future ROSES elements for research and analysis (R&A) programs and/or calibration/validation activities. Since it is expected that the AITT program element will support the full transition of airborne instruments into the regular research and analysis program(s), successor proposals to the AITT for those funded once are very strongly discouraged unless there will have been significantly enhanced technical development to the underlying instrument concept

[1] http://appliedsciences.nasa.gov/
[2] http://airbornescience.nasa.gov/
[3] http://nspires.nasaprs.com/external/
[4] http://science.nasa.gov/earth-science/earth-science-data/data-information-policy/

in the period since completion of the AITT-funded work, e.g., through additional support under NASA's Instrument Incubator Program (IIP) or other technology development activities. Under no circumstances are "consecutive" proposals to AITT contemplated.

Proposals will be accepted for two-year projects. It is expected that at project conclusion the instrument will be complete and ready for campaign deployments.

2.3 Program Element Specific Requirements

In addition to the standard rules of the ROSES solicitation, which includes reference to the *Guidebook for Proposers*, proposals submitted in response to this program element are subject to the following additional requirements:

To be eligible to submit a proposal to this program element, one must have submitted a Notice of Intent (NOI) by the due date given in See Tables 2 and 3 of ROSES. Proposals that are not preceded by the mandatory NOI may be returned without review. No feedback will be provided in response to the NOI.

Proposals must provide a description of the existing instrument and a clear assessment of what it will take to make the instrument suitable for reliable and regular airborne operation. This means the instrument will perform under a wide variety of airborne-deployment scenarios, with high reliability, including in "campaign" mode in which multiple flights would be made over short duration periods, potentially from remote locations with limited time and resources available to make modifications and/or repairs between flights. Moreover, flights sometimes take place under challenging weather conditions (extreme cold, turbulence, etc.) and Airborne Instrument Technology Transition (AITT) instruments must withstand the rigor of regular airborne operations and should allow accommodation as part of multi-instrument payloads without interfering with other instrument systems.

Besides clearly stating its relevance to one or more of the Earth Science Focus Areas, the proposal's narrative must provide one or more scenarios for potential use of the instrument including objectives, location(s), duration, candidate platform(s), other synergistic instruments that could be constructively co-manifested; and, other information that illustrates how the proposed instrument operations would further NASA objectives. The proposers should identify what science parameters would be produced by the instrument and how the instrument output would be processed to produce these parameters. Where such observations and measurements are made of localized phenomena, concepts which involve using instrument output to re-direct the instrument, aircraft or spacecraft to an advantageous observing point or angle should be described.

All proposals must include a description of the process that will be followed to be in compliance with Chapter 2 of NPR 7900.3D[5] *Aircraft Operations Management, Airworthiness and Maintenance.*

[5] http://nodis3.gsfc.nasa.gov/displayDir.cfm?t=NPR&c=7900&s=3D

2.4 Technical Reporting Requirements

Management of the tasks selected in response to these Airborne Instrument Technology Transition calls is carried out in conjunction with the Earth Science Technology Office (ESTO)[6].

ESTO will provide assistance in managing performance of the awards made under this program element. Therefore, all status information, presentation materials, and reports deliverable for this program element shall be submitted through the ESTO web-based AITT-19 Award Administration e-Book (herein after called e-Books). Reporting submissions to e-Books shall be made in Microsoft PowerPoint (preferred), Adobe PDF (unlocked, searchable PDF files are required), Microsoft Word, or Microsoft Excel. User accounts for e-Books will be provided to the Principal Investigator (PI) upon award.

The following deliverables are required of awarded proposals:

- Initial plans and Reports;
- Quarterly Technical Reports;
- Interim Reviews, Annual Reviews, and a Final Review; and
- Final Report (a ~20 page narrative paper)

More information on these reporting requirements can be found at https://esto.nasa.gov/AITT_reportingrequirements.html.

In cases where Co-Investigators (Co-I), partnerships, or subcontract arrangements exist in a Project Team, the submission of consolidated reports is the responsibility of the PI. The proposed budget should provide for these reporting requirements.

3. Proposal Content

Proposal style formats shall be in accordance with Section 2.2 of the *Guidebook for Proposers*. The "Scientific/Technical/Management Section" of the proposal shall be limited to 15 nonreduced, single-spaced typewritten pages. Scientific/Technical/Management Section write-ups that exceed this limit will be truncated at 15 pages prior to the Proposal's review.

For consistency of the evaluation process, proposals shall include the content described here formatted in sections that follow the outline and titles used below. Failure to provide any of this material may be a cause for the proposal being judged as noncompliant and returned without further review.

3.1 Proposal Summary

The proposal summary is an abstract pasted into the mandatory 4000 character limited Proposal Summary field in the NSPIRES cover pages that provides an overview of the proposed investigation that is suitable for release to the public should the proposal be selected. The proposal abstract shall discuss the:

- Relevant Earth Science Focus Area(s), Decadal Survey Designated Observable or other NASA mission(s);
- Proposed work and methodology; and,

[6] http://esto.nasa.gov/

- Proposed period of performance.

3.2 Scientific/Technical/Management Section

Each proposal must address the following in the Scientific/Technical/Management Section:

1. Relevance to Earth Science Measurements in the Reference Documents - Clearly state the relevance to one or more of the Earth Science Focus Areas. The proposal narrative must provide one or more scenarios for potential use of the instrument, including objectives, location(s), duration, candidate platform, other synergistic instruments that could be constructively co-manifested and other information that would illustrate how the proposed instrument would further NASA objectives. Proposals that fail to include a relevancy scenario will be considered noncompliant and will be returned without review.
2. Description of Proposed Development - Describe the work to be performed. Include a description of the instrument, a description of its current status (including a summary of the recent advances through IIP or some other activity that make the instrument appropriate at this time for enhancement through the AITT), and a clear assessment of what it will take to make it suitable for reliable, regular airborne use by research and analysis programs and/or satellite calibration/validation activities.
3. Description of Proposed Aircraft Test Flights – Describe the required engineering work needed for integration onto the proposed airborne platform(s). Also include a description of the proposed flight tests and a clear articulation of goals for various flights and systems being tested.
4. Aircraft Operations Maintenance Compliance **-** Include a description of the process that will be followed to comply with Chapter 2 of NPR 7900.3D.
5. Statement of Work and Schedule – Provide a statement of work that concisely describes each task or milestone to be accomplished in the course of the research and development. Define the success criteria associated with each task or milestone. Also, include a schedule chart that identifies project activities and critical milestones. Subcontracting portions of the project is acceptable and is the responsibility of the Principal Investigator and the sponsoring organization.
6. Personnel – Include a list of key personnel and identify experience related to the proposed activity. Proposers should be sure to demonstrate science, technology development, and instrument development skills on the team. The key personnel list is included in the overall page count and must include, as a minimum, the PI. Optionally, one-page resumes for Key Personnel may be supplied; these resumes are not included in the overall page count.
7. Facilities and Equipment – Describe significant procurements, facilities, and equipment required to complete the work. (Note: Sections 7 and 8 do not count towards the 15-page limit)
8. Special Matters – Proposers should include a brief description of the organization, existing facilities, and previous work experience in the field of the proposal.

4. Proposal Evaluation

Proposals submitted to NASA in response to this program element will be evaluated using the standard criteria described in the *ROSES Summary of Solicitation* Section VI (a) with the following additions:
The evaluation of Relevance will be based upon the applicability of the proposed investigation to Earth Science Focus Area(s), Decadal Survey, and other science measurements and technology needs and specifically includes:

- The degree to which the proposed investigation specifically supports the objectives of at least one of the Earth Science Focus Areas (see Appendix A.1 for a description of the Earth Science Focus Areas)

The evaluation of intrinsic merit also includes the feasibility of the proposed technical effort for integration onto the proposed airborne platform(s) and the adequacy of proposed flight tests or demonstrations. Qualifications and capabilities of key personnel and the organization include strong science, technology, and instrument integration skills.

The evaluation of Cost also includes the adequacy and realism of proposed milestones and associated success criteria.

Cost sharing is not part of the peer review evaluation but cost sharing may be taken into account by the selecting official when deciding between proposals of otherwise equal scientific and technical merit.

5. Summary of Key Information

Expected program budget for new awards	~ $2.2M/year for two years
Number of awards anticipated	~ 3 - 4
Maximum duration of awards	24 months
Due date for Mandatory Notice of Intent to propose (NOI)	See Tables 2 and 3 of ROSES
Due date for proposals	See Tables 2 and 3 of ROSES
Planning date for start of investigation	6 months after proposal due date.
Page limit for the central Science/Technical/Management section of proposal	15 pp; see also Table 1 of the ROSES *Summary of Solicitation* and the *Guidebook for Proposers*
Relevance to NASA	This program is relevant to the Earth Science questions and goals in the NASA Science Plan. Proposals that are relevant to this program are, by definition, relevant to NASA.
General information and overview of this solicitation	See the *ROSES Summary of Solicitation*.

Detailed instructions for the preparation and submission of proposals	See the *Guidebook for Proposers* at http://www.hq.nasa.gov/office/procurement/nraguidebook/.
Submission medium	Electronic proposal submission is required; no hard copy is permitted.
Web site for submission of proposal via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Web site for submission of proposal via Grants.gov	http://grants.gov/ (help desk available at support@grants.gov or (800) 518-4726)
Funding opportunity number for downloading an application package from Grants.gov	NNH19ZDA001N-AITT
NASA point of contact concerning this program	Barry Lefer Earth Science Division Science Mission Directorate National Aeronautics and Space Administration Washington, DC 20546-0001 Telephone: (202) 358-3857 Email: barry.lefer@nasa.gov

A.31 EARTH SCIENCE U.S. PARTICIPATING INVESTIGATOR

NOTICE: The Earth Science U.S. Participating Investigator (USPI) program will not be competed in 2019. The Earth Science USPI program is tentatively scheduled to next solicit proposals in ROSES-2020.

1. Scope of the Program

The Earth Science U.S. Participating Investigator (USPI) program facilitates participation on a non-NASA space mission as a Co-Investigator (Co-I) for an instrument, experiment, or technology demonstration that is being built and flown by a sponsor agency other than NASA. The Co-I role can include, but is not limited to, instrument design, modeling, and simulation of the instrument's operation and measurement performance; calibration of the instrument; and/or development of innovative data analysis techniques. A USPI may also serve as a member of a non-NASA space mission science or engineering team and participate in science team activities such as mission planning, mission operations, data processing, data analysis, and data archiving. No matter what the nature of the USPI role, an investigation proposed under this category must be for a science or technology investigation and must include a meaningful contribution to the development of products, including, but not limited to, algorithm development and/or testing, calibration/validation, and/or requirements definition (especially as may be carried out in Observing System Simulation Experiments). Proposals were last received in July 2018, and it is anticipated that proposals will be solicited again in ROSES-2020.

For information on this program, contact:

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A.32 INTERDISCIPLINARY RESEARCH IN EARTH SCIENCE

1. Scope of the Program

This solicitation is for new and successor interdisciplinary research investigations within NASA's Interdisciplinary Research in Earth Science (IDS) program. Proposed research investigations will meet the following criteria: a) offer a fundamental advance to our understanding of the Earth system; b) be based on remote sensing data, especially satellite observations, but including suborbital sensors as appropriate; c) go beyond correlation of data sets and seek to understand the underlying causality of change through determination of the specific physical, chemical, and/or biological processes involved; d) be truly interdisciplinary in scope by involving traditionally disparate disciplines of the Earth sciences; and e) address at least one of the specific themes listed this solicitation:

- Volcanoes in the Earth System;
- Interactions Between Sea Ice and the Atmosphere;
- Polar Ocean/Biology/Biogeochemical Coupling;
- The Life Cycle of Snow;
- Impacts of urbanization on local and regional hydrometeorology;
- Space Archaeology: Using the Past to Inform the Present and Future;
- Exploring the Microbial Biodiversity of the Atmosphere.

The results of these investigations will improve our capability for both prognostic predictions and retrospective simulations of the Earth system. They will also advance our understanding of the vulnerabilities in human and biogeophysical systems and their relationships to climate extremes, thresholds, and tipping points. Meeting these goals requires approaches that integrate the traditional disciplines of the Earth sciences, as well as innovative and complementary use of models and data.

1.1 Context and History

Since its inception more than a decade ago, NASA's IDS program has advanced the goal of understanding the Earth system by promoting interdisciplinary research and exploiting the vast wealth of data from NASA satellite and airborne sensors. The program's focus has generally aligned with the goals of the U.S. Global Change Research Program (http://globalchange.gov/). Substantial contributions have also been made to Earth system model development, training the next generation of interdisciplinary scientists, and developing the necessary infrastructure to take full advantage of NASA satellite data.

The specific topics of the program have varied through time (see prior program elements and awards at nspires.nasaprs.com), and this program element represents the development of new elements and the continuation of others. In its most recent prior incarnation IDS (ROSES 2016) these topics were:

- Understanding the Global Sources and Sinks of Methane;
- Ecology at Land/Water Interfaces – Human and Environmental Interfaces;
- Understanding the Linkages Among Fluvial and Solid Earth Hazards;
- Life in a Moving Ocean;
- Partitioning of Carbon Between the Atmosphere and Biosphere.

1.2 Potential for Acquisition of Additional Field Data as Part of IDS Investigations

Proposals are expected to utilize existing remote sensing and *in situ* datasets. While NASA expects IDS investigations typically to be accomplished using publicly available data, NASA also recognizes that some additional data collection through small scale field work may add significantly to the proposed work. Thus, unless otherwise noted in the specific subelement, proposals may include some small-scale field work. The cost for such field work should not exceed 20% of the total project budget. Consistent with NASA Earth Science data policy, all data collected must be made freely and publicly available with no period of exclusive use beyond calibration and validation.

Proposals requiring data from airborne sensors must detail in their budget all costs for acquiring the new data sets, including costs for aircraft hours, deployment costs, mission peculiar costs, data processing costs, and other costs associated with deploying the sensors and aircraft (this includes NASA and non-NASA sensors and platforms). In addition, for any proposed activities requiring NASA aircraft or NASA facility sensors, proposers should submit a Placeholder Flight Request to the Airborne Science Flight Request system at https://airbornescience.nasa.gov/. If the instrument or aircraft are not NASA facilities, proposers must take responsibility for making all arrangements to secure the availability of the needed sensors and aircraft and explain these plans in the proposal.

2. Interdisciplinary Research Themes, Proposal Details, and Review information

Specific scientific topics and questions are identified as separate subelements within any given year's program element. These topics and questions constitute the complete set of scientific research topics solicited by the IDS program, and no priority should be construed from their relative order. Proposals submitted in response to this element MUST address at least one of these subelements, and proposals MUST identify clearly which subelement or subelements are addressed. Proposed research investigations must also meet all of the following criteria, and each of these should be specifically addressed in the proposal:

- offer a fundamental advance to our understanding of the Earth system;
- be based on remote sensing data, especially satellite observations, but including suborbital sensors as appropriate;
- go beyond correlation of data sets and seek to understand the underlying causality of change through determination of the specific physical, chemical, and/or biological processes involved;
- be truly interdisciplinary in scope by involving traditionally disparate disciplines of the Earth sciences; and
- address at least one of the specific subelements listed in the program element.

Proposals developing significant new datasets must include a data management plan. NASA expects to have separate peer review panels for each subelement, and proposals will be assigned to one or more panels based on the proposer's identification of the appropriate subelement, as well as NASA's assessment of proposal content. While NASA expects to select proposals in each of the subelements, NASA reserves the right to select proposals in none, some, or all of these depending on the nature and distribution of proposals received and the outcome of the peer review process.

In this program element, there are two classes of elements – Subelements 1-5 "large," each with a total selection of ~ $2M/year contemplated, while Subelements 6-7 are "small," each with a total selection of ~$750K/year contemplated.

Note that for these subelements, numerous potential topics are included. Given the number of such topics and the funding limitations, no commitment is made to fund proposals related to each of the subtopics listed. Balance among these potential topics will be considered as part of the programmatic considerations being made during the review process.

2.1 Subelement 1: Volcanoes in the Earth System

Volcanic emissions fundamentally connect processes in the Earth's interior and atmosphere. SO_2, CO_2, ash, and associated aerosols can provide telltale signs of magmatic processes and volcanic system evolution, state of unrest, and eruption characteristics; while delivering important atmospheric forcing with implications for radiative budget, cloud formation, ozone depletion and other changes to atmospheric composition, and short- to long-term climate variations. While advancements have been made on these topics through improved spectral imaging, lidar, radar, modeling, and other techniques, further exploring connections between near-source volcanic and atmospheric processes stands to yield a step change in understanding these coupled systems. This subelement seeks proposals from teams of volcanologists and atmospheric scientists that bridge top-down perspectives of atmospheric processes and properties with bottoms-up perspectives of magmatic systems and erupted products towards this goal.

SO_2 is the volcanic gas most readily measured from space, and it is also responsible for much of the impact of eruptions on climate. Satellite measurements of SO_2 are useful for detecting eruptions, estimating global volcanic fluxes and recycling of other volatile species, and tracking volcanic clouds that may be hazardous to aviation in near real time. Techniques for measuring volcanic CO_2 from space have been developed, especially for OCO-3, and could lead to earlier detection of pre-eruptive volcanic degassing. Since current satellite-based remote sensing observations of volcanic gases are dominated by SO_2, obtaining a complete volatile inventory for explosive eruptions required for a full chemistry simulation of volcanic plumes is still a major challenge.

Recommendations from the recent National Academies of Sciences, Engineering, and Medicine report *Volcanic Eruptions and Their Repose, Unrest, Precursors, and Timing* (ERUPT; NASEM, 2017; https://doi.org/10.17226/24650) and *Thriving on Our Changing Planet: A Decadal Strategy for Earth Observation from Space* (Decadal Survey; NASEM, 2018; https://www.nap.edu/catalog/24938) identify a number of priorities for understanding volcanoes in the Earth system. The ERUPT report identified advances in experimental and computational models for volcanic processes, combined with enhanced monitoring (including spatially and temporally enhanced remote sensing of gas emissions), as the pathway to enable model-based forecasting, which would constitute a paradigm shift for volcano science. The largest-volume explosive eruptions have yet to be observed with modern instruments and characterized quantitatively. It remains uncertain how effectively observations of volcanic plumes from relatively small eruptions scale up to very large eruptions. For example, the rate and processes of radial spreading of large plumes in the atmosphere may vary with the scale of the eruption, and the role of transient behavior of emissions in the largest volcanic eruptions are uncertain. Most dispersal models treat fine volcanic particles and gases as passive tracers in the atmosphere such that the plume itself has no impact on atmospheric temperature and wind patterns, an assumption that may be violated in moderate to large eruptions. These challenges suggest physics-based modeling as a primary need. Retrospective analyses of well-known systems with sufficient observations could play a key role here. Volcanic aerosol and gas concentration measurements are a high priority. For the short-lived forcers in particular, the precursor emissions together with a self-consistent meteorology are needed to obtain accurate global distributions and thus the spatially-dependent forcings.

NASA has also developed a Major Volcanic Eruption Response Plan (NASA, 2018; https://acd-ext.gsfc.nasa.gov/Documents/NASA_reports/), to include satellite, airborne, balloon, and ground-based observations, together with modeling in order to capture and interpret scientifically relevant data as close to event initiation as possible. The paucity of well-observed large eruptions poses a number of challenges. There is only about a 1 percent chance that a Volcanic Explosivity Index (VEI) ≥ 6 event will happen in a given year. Though such events are relatively infrequent, the consequences of these large eruptions are significant, both from hazards and climate perspectives. Thus, it is critical that the science community prepare to make comprehensive and high-quality observations of the next major eruption, regardless of where on Earth it is located. It is likely that the next major eruption will occur at a completely unmonitored and poorly characterized volcano, because (1) instrumentally monitored volcanoes tend to be those which have erupted in recent history, and (2) long periods of repose may be directly correlated with erupted volume. Thus, the initial detection of precursory unrest prior to a major eruption is likely to be made via satellite. Developing observing and analysis practices applied to current passively degassing and erupting volcanoes could help establish best practices to leverage in the event of a major eruption.
A suite of spaceborne instruments are needed to observe various stages and components of erupted products. Example observations and their capabilities include:

- Hyperspectral UV, near infrared, and TIR data are used to measure SO_2, H_2S, CO_2, and ash emissions;
- Space-borne lidar and radar are used to estimate plume altitude;
- Multispectral TIR data from ASTER have been used to quantify passive SO_2 degassing at scales less than 1 km;
- MODIS and OMI data to calculate gas fluxes and lava-discharge rates;
- OCO-2 data to successfully identify point-source volcanic CO_2 plumes;
- MISR to retrieve gas and ash plume height and thickness;
- CALIPSO to detect volcanic ash plumes; CALIPSO is used in support of commercial aviation operation;
- Global Navigation Satellite System (GNSS) signal-to-noise ratio to detect the timing and height of ash-laden plumes;
- The 2017-2018 HyspIRI Hawaii preparatory airborne campaigns including data from the AVIRIS, MASTER, PRISM, and HyTES instruments onboard the NASA ER-2 aircraft to measure the Kilauea volcano SO_2 plumes; and

- ECOSTRESS, launched in June, 2018, which could provide an SO_2 imaging capability analogous to ASTER, but with a much shorter repeat interval.

Combined, these and other tools offer a range of possibilities to connect the observed volcanic and atmospheric processes.

In this subelement, NASA requests interdisciplinary proposals that pose connected scientific hypotheses addressing both magmatic and atmospheric processes and/or properties. Given the large number of relevant topics and the limited number of selections planned, NASA may not fund proposals addressing all areas of interest. Potential areas of consideration include, but are not limited to:

- Eruptive source distribution and transient behavior, and their impacts on the atmosphere;
- Large, persistent volcanic eruptions and their effect on local weather and precipitation patterns at scales of weeks to months;
- Refining fluxes of volcanic gases and aerosols for improved predictions from weather forecasting, climate, and air-traffic control models;
- Inter-annual and decadal variations of the natural radiative forcings of volcanic aerosols;
- Observing and analysis approaches applied to current passively degassing and erupting volcanoes that could help establish best practices to leverage in the event of a major eruption.

In addressing this subelement, proposals are expected to:

- Make significant use of space-based remote sensing;
- Be interdisciplinary in scope and specifically address magmatic system-atmosphere connections; proposals that address only a single component will be considered nonresponsive; and
- Include both volcanologist and atmospheric scientist investigators.

2.2 Subelement 2: Interactions Between Sea Ice and the Atmosphere

Conditions in the Earth's polar regions are changing rapidly. While some of these changes are well-characterized by remote sensing, their drivers and subsequent impact on other components of the Earth system are poorly understood. Notz and Stroeve (2016) [see Notz, D. and J. Stroeve, 2016, *Observed Arctic sea-ice loss directly follows anthropogenic CO2 emission*, Science, 354(6313):747-750, DOI: 10.1126/science.aag2345.] observed a linear relationship between cumulative CO_2 emissions and September Arctic sea ice area. This empirical relationship depends on the persistence of the currently poorly understood processes and feedbacks in the Arctic sea ice-ocean-atmosphere system. Changes in the processes regulating the Arctic energy budget must be better understood to improve our predictive modeling capability.

Among the largest unknowns are the couplings between sea ice and different components of the atmospheric system. Some of the connections are straightforward. For example, atmospheric temperatures are the primary driver of sea ice formation and sea ice, in turn, moderates the flux of mass and energy between the atmosphere and ocean. Weather, especially clouds, wind, and precipitation affect sea ice characteristics directly while also driving sea ice motion, setting its extent, and affecting its seasonal survival. However, other critical processes are not well characterized. In particular, the relationships between fluxes of moisture, gases, and aerosols from sea ice leads and the impact on the local radiative energy balance through clouds, fog and other forcings.

Over the last decade, significant advances have been made in remote sensing of the polar regions. Observations from many satellite and suborbital sensors are now available that could help constrain the relationships between sea ice and the atmosphere. Sea ice concentration, motion, freeboard, and other properties are available from passive microwave (DMSP), radar (SAR and altimetry), imagery (MODIS and others), lidar (ICESat, ICESat-2 and IceBridge), and other products. Extensive atmospheric, radiation, cloud and other data sets are also available from a range of satellites and sensors, especially CloudSat, CALIPSO, TERRA and AQUA, as well as the ARISE suborbital mission and NASA's AERONET and MPLNET surface-based installations. Derived products (e.g. sea ice thickness, lead locations) and reanalyses (e.g. MERRA-2) are also available to infer other information about the Arctic system, such as precipitation, wind speeds, and temperatures.

Combined, these tools offer a range of possibilities to connect the observed changes in sea ice with the atmosphere.

In this subelement, NASA requests interdisciplinary proposals to study any aspect of the connection between the polar sea ice and the atmosphere. Potential areas of consideration include, but are not limited to:

- Causes of Arctic amplification;
- Flux of mass and energy to the atmosphere through ice;
- Atmospheric moistening and changes in sea ice;
- Interactions of sea ice, cloud properties, and the polar energy budget;
- Sea ice leads and boundary-layer and cloud processes;
- Aerosol particle impact on cloud properties and ice extent;
- Precipitating ice radiative effects;
- Impacts on polar weather on sea ice extent, growth and loss.

In addressing this subelement, proposals are expected to have the following characteristics:

- Make significant use of space-based remote sensing;
- Be interdisciplinary in scope and specifically address ice-atmosphere connections; proposals that address only a single component (e.g., changes in ice cover or ice dynamics) will be considered unresponsive; and
- Go beyond correlation of datasets and, wherever possible, gain new insight into the physical processes and underlying causality.

Strong preference will be given to proposals that:

- identify at least one testable hypothesis and describe the process and data to be used to test the hypothesis; and
- address weaknesses in existing models.

Oceanographic science will be considered only if specifically connected to ice-atmosphere interaction. Influences of sea ice change on global weather will be considered only if it is specifically connected to quantifying the mechanisms by which sea ice influences the polar atmosphere.

Proposals are expected to utilize existing remote sensing and *in situ* datasets. Major new fieldwork will not be considered (note the limitation on fieldwork expenses for the overall Interdisciplinary Science element in section 1.2 above). Utilization of observations collected by the *MOSAIC Observatory* (http://www.mosaicobservatory.org/) is appropriate.

2.3 Subelement 3: Oceans, Ice, Climate, and Life

The global economy depends upon polar regions for climate regulation and natural resources, as well as support for a range of ecosystems not only critical to Earth's biodiversity and overall health but to economics around the world. The Arctic region, including Greenland and Alaska, is at the forefront of rapid climate, environmental, and socio-economic changes that are testing the resilience and sustainability of its communities and ecosystems. Arctic and Antarctic sea ice, ice sheets, and their resultant changes due to climate pressures influence local ocean physics, ocean biology and biogeochemistry, and local ecosystems differently. The Southern Ocean and the Antarctic are subject to similar climate pressures but support different ecosystems than the Arctic, driven largely by differing geography and landmass effects. Research to increase fundamental understanding of changes in Arctic (including Greenland and Alaska) and Antarctic sea ice and ice sheets, and the influence of ocean dynamics (i.e., resulting ocean physics) on local biology, biogeochemistry and ecosystems, is needed to inform sound, science-based decision- and policy-making and to develop appropriate solutions to a changing climate in these regions. This program element welcomes small-scale, targeted and well-justified field observations and projects (proposed field observations must be consistent with the guidance provided in section 1.2), analyses of existing data sets, and/or modeling proposals to explore and understand the influence of climate and environmental changes on ice, ocean physics, and on life in Earth's polar regions. Studies must combine research on the cryosphere, ocean physics, and biology/biodiversity/ecosystems on the ice or in the ocean. Illustrative research questions can be found at the end of this program element.

Sea ice is one on the largest biomes on Earth. It is also a unique habitat for assemblages of biota within and under ice, from bacteria to vertebrates. In and around these habitats conditions are dominated by strong gradients in temperature, salinity, nutrients, and ultraviolet, visible, and short-wave radiation. Physiological adaptations allow these organisms to thrive in and around ice as a key component of polar ecosystems. Sea ice algae are an important component of the polar trophic structure, providing energy and a nutritional source for invertebrates such as krill. Sea-ice algae also support a significant component of primary and fuel secondary production in ice-covered waters. Algae, including phytoplankton, the ocean's primary producers, and zooplankton, the ocean's primary consumers and the larvae of many higher-level consumers, make up plankton. Plankton support all levels of marine life, including commercial fish species and protected marine mammals. Beyond the in-ice biota, changes in sea ice will alter the seasonal distributions, geographic ranges, patterns of migration, nutritional status, reproductive success, and ultimately the abundance and balance of species in polar regions. The Intergovernmental Panel on Climate Change Working Group 2 reports have identified climate change as likely to produce long-term changes in the physical oceanography and ecology of the Southern Ocean. Projected reductions in sea-ice extent will alter under-ice biota and spring blooms in the sea-ice marginal zone, impacting all levels of the food chain, from algae and primary production to krill, fisheries and whales. The proliferation of Arctic melt ponds has also impacted under ice production and ecosystem dynamics. Marine mammals and birds, which have life histories that tie them to specific breeding sites, will be severely affected by shifts in their foraging habitats and migration of prey species. Recent NASA-funded research, such as Oceans Melting Greenland (OMG, https://omg.jpl.nasa.gov/portal/), has focused on quantifying to what extent the oceans are melting ice masses such as Greenland from below, suggesting to what extent ocean dynamics contribute to changes in Antarctic ice masses and associated impacts to local ecosystems.

A combination of current and planned NASA satellite, field campaign, and other *in situ* data can be used to address the dynamics of climate change, ice sheets and sea ice, ocean physics and life in the ocean, including organisms on and within the ice, at Earth's poles. Proposals submitted to this subelement must involve interdisciplinary teams of satellite researchers, cryospheric scientists, oceanographers, and investigators with modeling expertise appropriate to the science questions proposed. Proposers must use NASA satellite data (non-NASA satellite data products—in addition to NASA satellite data products—are also welcome) as a primary research tool to provide observations and estimates used in answering the research questions posed. Datasets may include but are not limited to:

- ice properties from missions such as ICESat-2;
- ocean physics such as currents from satellite and/or airborne instruments, for example Advanced Very High Resolution Radiometer (AVHRR), the Jason series, QuikSCAT/SEAWINDS, and MODIS along with other satellite and airborne platforms;
- and properties of ocean biology, ecosystems, biogeochemistry, and biodiversity from missions/instruments such as CALIPSO, MODIS, Suomi-NPP, along with other satellite and airborne platforms.

Given the critical role of ocean salinity in controlling air-sea gas exchange in polar regions, the use of salinity data and data-derived products is also encouraged, including *in situ* and satellite observations from Argo, SMAP, Aquarius, and SMOS, as well as data-driven ocean/sea-ice state estimates such as SOSE (the Southern Ocean State Estimate) and ASTE (the Arctic Subpolar gyre sTate Estimate). Upcoming NASA missions (e.g., SWOT) will resolve energetic scales of motion in the ocean that have never been sampled globally. The planned Plankton, Aerosol, Cloud, ocean Ecosystem (PACE) mission will make unprecedented observations of ocean ecology and biogeochemistry. These missions will provide an opportunity to make available global high-resolution observed ocean currents for co-registration with ocean ecosystem data. Studies that promote efforts to better understand measurements associated with these two missions, particularly with complex high latitude retrievals and observations are encouraged.

This subelement seeks proposals to address the following high-level question: How does climate and/or environmental variability and change affect Earth's polar systems, particularly through the interplay of ice, ocean physics, biogeochemistry and local ecosystems?

Notional examples of specific proposal topics—meant only to be exemplary and not definitive or exhaustive, include:

- What are the impacts of polar warming on ice extent and associated changes in ocean dynamics on local fisheries and/or primary production?
- How are shifts in climate affecting polar ocean dynamics and any feedbacks to air/sea carbon fluxes?
- What are the impacts of the increased freshwater transport by sea-ice and consequent freshening of the Antarctic waters on ocean's stratification, uptake of carbon dioxide by the Southern Ocean, and Antarctic ecosystem?
- What are the environmental drivers of harmful algal bloom (HAB) evolution in polar seas?
- Are there changing biogeographies of ice-dependent flora and fauna?
- Are impacts of climate change and associated changes in ice affecting the livelihoods of humans who rely on the use of polar ecosystems for subsistence?
- Can changes in polar currents affect local trophic dynamics and energy flows within high-latitude ecosystems, including connections from primary producers to primary and secondary consumers to top predators and megafauna?

2.4 Subelement 4: The Life Cycle of Snow

The lifecycle of snow from evaporation of water into the atmosphere, precipitation to the surface, surface snowpack evolution (e.g., snow grain metaporphism, melt and refreeze), and dissipation through evaporation or melting are important scientifically and societally for climate, geology, agriculture, ecosystems, and more. For example, snowpacks store freshwater, insulate and impact vegetation growth, reflect incoming radiant energy (until they may be covered with dark dust), and contribute to formation of glaciers. The transport and lifecycle of snow/water through precipitation, evaporation, winds, and melt also influences other components of the Earth system, and yet, the drivers and interactions of snow in these systems are poorly understood. The 2017 Decadal Survey for Earth Science and Applications from Space fully recognized the need to better understand snow.

Over the last decade, significant advances have been made in remote sensing and modeling of snow, and yet the retrieval uncertainties are still relatively large. Data from many satellite (e.g., GPM, CloudSat, AMSR, Aqua, LandSat, Terra ICESat-2), suborbital, aircraft, and ground-based sensors are now available that could help elucidate the lifecycle of snow. Field campaigns (e.g., SnowEx, GCPEX, etc.) have provided localized snow datasets. Extensive atmospheric, radiation, cloud, surface feature, and other data sets are also available from a range of satellites, sensors, and models. Combined, these observations offer a range of possibilities to connect the lifecycle of snow to interdisciplinary studies.

In this subelement, NASA requests interdisciplinary proposals to study the connections among and.or interactions between the different elements of the lifecycle of snow (e.g., proposals that address only ONE of the steps in the life cycle of snow will be considered non-responsive).

Topics of interest to this subelement include, but are not limited to:

- Snow's linkages to environmental, societal, and climate change;
- Relationships between snow depth and coverage as they impact terrestrial ecology, vegetation growth, food sources for animals, and/or ecosystem diversity;
- Consistent modeling of both falling and fallen snow at global, regional, and/or microphysical scales;
- Interactions of snow and the distribution, transport, and transformation of water and energy within the hydrological and/or energy budgets;
- Snow as it connects land cover/land use, boundary-layer, and cloud processes;
- Precipitating snow and snow pack radiative effects via albedo investigations;
- Interdisciplinary science to reduce uncertainties in falling snow and snowpack retrieval products;
- Snow's impact on the Earth surface and interior, the cryosphere, and/or the oceans, including the impact of melting snow on soil moisture;
- The role of aerosols, carbons, and pollution in instigating changes in snow precipitation patterns and their transport and surface pack metamorphism.

Strong preference will be given to proposals that identify at least one testable hypothesis and describe the process and data to be used to test the hypothesis.

2.5 Subelement 5: Impacts of urbanization on local and regional hydrometeorology

There is strong evidence that urban environments modify local microclimates, with implications for regional and global climate change. Urban systems affect various climate attributes, including temperature, rainfall intensity and frequency, winter precipitation (snowfall), and flooding. New observational capabilities, data sets and regional coupled land–surface–atmospheric modeling systems for urban systems have been used to evaluate how the urban environment impacts the seasonality and changes in the type of precipitation (rain or snow), the amount and distribution of precipitation, and the significance of the size of metropolitan areas in hydrometeorological studies. For instance, urban-induced wind convergence can determine storm initiation; aerosol concentrations and composition then influence the amount of cloud water and ice present in the clouds. Aerosols can also influence updraft and downdraft intensities, their life span, and surface precipitation totals. For more recent information on assessed research on this topic, see Chapter 2 of the *Climate Change and Cities* Second Assessment Report of the Urban Climate Change Research Network (https://doi.org/10.1017/9781316563878) and Chapter 10 of the *National Climate Change Assessment*, Volume I (https://science2017.globalchange.gov/chapter/10/).

Proposals submitted in response to this sub-element MUST make a connection between the properties of and/or changes in the properties of the land surface AND hydrometeorological impacts. It is expected that successful proposals will include explicit consideration of both of these components, and make use of quantitative models to connect variation and/or changes in the land surface with local hydrometeorology. Proposals that address only one aspect of this (i.e. either land cover or hydrometeorology) will be considered non-responsive.

Topics of interest to this subelement include, but are not limited to:

- Urban Heat Island (UHI) and surrounding environmental gradients (e.g., forests, shrublands, peri-urban, rural) ecosystem impacts on regional hydrometeorology;
- The fate of precipitation and how the fraction of, and/or spatial patterns of impervious surfaces influences overland runoff;
- Changes in the UHI diurnal cycle along settlement pattern gradients (e.g., urban to rural);
- Interactions between temporal/spatial patterns of urban settlements and climate system variables, including hydrologic, carbon cycle, and aerosols, insofar as how they affect hydrometeorological properties;
- Urban-induced winds and storms, aerosols, clouds and water/ice presence in clouds;
- Moisture convergence in urban areas and their impacts on storm initiation and precipitation dynamics.

Proposals for this subelement must focus on more than one urban system and include data/model based comparisons between these systems. Proposals that focus on a single urban system will be considered non-responsive to this sub-element.

2.6: <u>Subelement 6: Space Archaeology: Using the Past to Inform the Present and Future</u>

It is widely recognized that current Earth system changes are strongly associated with changes in the coupled human-environment system, making the integration of human history and Earth system history a timely and important task. The IDS Space Archaeology subelement seeks to utilize existing remote sensing observations and data sources to discover archaeological evidence of human settlements. A secondary goal is to produce an integrated account and attribution of how changes in relevant environmental processes (e.g., climate, atmospheric chemistry and composition, ecosystem distribution, material and water cycle dynamics, biodiversity) have impacted human system dynamics (e.g., land-use systems, historical and pre-historical human settlement patterns, technologies, patterns of disease, patterns of language and institutions, conflicts and alliances). To achieve this ambitious goal, it will be necessary to integrate innovative remote sensing observations with perspectives, theories, tools and knowledge from a variety of disciplines spanning the full spectrum of natural and social sciences.

Cultures have blossomed, flourished, and then faded, sometimes abruptly, as societies have sought to optimize exploitation of the natural environment (climate, weather, physiography, hydrology, and biotic and mineral resources). A better understanding of how these cultures have flourished or transformed in response to local, regional, and global change is of profound significance to the present as societies grapple with possible adaptations to our changing world. In addition, past cultural practices often had profound impacts on the landscape by altering land-cover through land-use and modifying the hydrologic regime with associated potential consequences for biodiversity and climate. Thus, a better understanding of our past and how interactions between human and environmental systems have impacted and fed back into new, transformed societies might better inform current and future human-environmental interactions.

Space-based and suborbital observations, coupled with advances in digital image analysis, Geographic Information Systems (GIS), Global Positioning System (GPS) technology, and computer modeling provide the opportunity for the archeologist to discover, understand, and protect the world's human legacy that is threatened by both accelerating land cover/land use changes and ongoing climate variability and change. Remote sensing has been used by archaeologists to survey potential archaeological sites and to better understand the spatial relationships of cultural features to each other and the natural environment. The traditional use of optical data acquired from aircraft or balloons is now supplemented by a vast quantity of data routinely provided by numerous satellites launched and operated by NASA, other international space agencies, and private industry. In addition, NASA archives contain large quantities of potentially useful data from specialized airborne campaigns. While private commercial satellites tend to provide high-resolution spaceborne surrogates for airborne optical data, the NASA research satellites (https://www.nasa.gov/content/earth-missions-list) and those of other international space agencies generally collect data over a very broad range of the electromagnetic spectrum and at a coarser spatial resolution covering a broader spatial extent (regional-scale). The aerial vantage point lays out the spatial organization of archeological sites within the context of their environmental settings and leads to the realization that everything in an ancient landscape has meaning and interconnection. These data sets and their derived products can be used at the regional level to: (1) identify and explore the extent and nature of historical and pre-historical human settlement patterns, (2) model the ecological context and dynamics of past settlements as cultures modified and reacted to changes in the natural environment, and (3) provide critical information for improved preservation and sustainable development of cultural heritage sites.

The NASA Space Archaeology subelement has the scientific objective to use the unique vantage point of space to improve our understanding of past human settlement patterns and the relationships between the natural environment and cultural adaptations as functions of time and space. Major research topics solicited are:

- To accelerate archaeological discovery and understanding through access to and analysis of remotely-sensed data obtained from space borne and airborne platforms;
- To facilitate the infusion of technological expertise and capacity in remote sensing into archaeological research by fostering multidisciplinary collaborative relationships;
- Regional landscape analysis and modeling relating historic and pre-historic human settlement patterns and subsistence strategies to environmental factors derived from remote sensing.

Additional topics from previous program elements are of additional interest:

- Identification and exploration of the extent and nature of past human settlement patterns;
- Protection and preservation of cultural heritage sites and/or planning for the sustainable development of cultural resources.

Substantive connection to remote sensing data is required in all proposals. Proposers are encouraged to utilize existing or planned ground, airborne, and space-based observational capabilities and their associated data sets. These resources include, but are not limited to the existing high-resolution SRTM dataset, ongoing satellite and airborne LIDAR, and spectral imaging such as ASTER and MODIS that provide structural and compositional models. Geodetic observations utilizing vegetation penetrating SAR (i.e. Sentinel-1, ALOS-2) including the airborne platform UAVSAR (L- and P- band: Pol-SAR and InSAR), provide insights in sub-canopy and sub-surface features. In addition, passive sensors, including thermal infrared and visible/shortwave data, such as the ECOsystem Spaceborne Thermal Radiometer Experiment on Space Station (ECOSTRESS), Landsat, MODIS/VIIRS that that provide images of current vegetation status (water stress, greening, browning, etc) and highlight anomalous productivity patterns lending insight into archaeological discovery and environmental processes (e.g., net primary productivity, etc) are encouraged.

Ongoing and future missions such as ALOS-2, Sentinel-1, TerraSAR-X, COSMO-SkyMed, SAOCOM, GEDI, OCO2/OCO3 and NISAR provide additional and upcoming opportunities in this realm. These and other NASA datasets are cataloged in the Earth Observing System Data and Information System (EOSIDS, https://earthdata.nasa.gov) and provided by the DAACs.

This subelement continues with and expands upon foci in past program elements for Space Archaeology. Information about the specifics of prior program elements released and proposals selected in response to previous NASA program elements may be found on NSPIRES by searching for "Archaeology" in "Closed/Past Selected" solicitations at https://nspires.nasaprs.com/external/solicitations/solicitations!closedPastInit.do.

This subelement may support limited fieldwork as needed to verify and validate remotely sensed results, but requests for extensive excavation are considered nonresponsive. See section 1.2 above for overall restriction on costs of fieldwork for this IDS ROSES element.

2.7: Subelement 7: Exploring the Microbial Biodiversity of the Atmosphere

Like Earth’s landmasses and oceans, the atmosphere teems with life. Much of this atmospheric life is microbial, making its detection and tracking difficult. An understanding of atmospheric microbial life’s interactions with and impacts upon the broader Earth system is similarly challenging. Atmospheric microorganisms are often physically associated with aerosol particles, e.g., dust. Thus, microorganisms can travel thousands of miles in winds aloft, launching from one continent with deposition on another. NASA has an extensive suite of observation tools for characterizing atmospheric aerosols and understanding their impacts on climate and other phenomena. These include surface-based, airborne, and satellite instruments.

This IDS sublement solicits proposals that integrate existing observations from NASA sensors (combining observations from surface-based, airborne, and satellite instruments) with microbiological tools (including culture-based, metagenomic, and other molecular approaches) to characterize the aerosolized microbial biodiversity of the atmosphere. The inspiration and some of the questions for this topic arose from a recently-concluded scoping study funded by the NASA Biological Diversity Program entitled *A Transoceanic Aerobiology Biodiversity Study (TABS) to Characterize Microorganisms in Asian and African Dust Plumes Reaching North America* and a recent associated publication (Schuerger, A.C., Smith, D.J., Griffin, D.W. et al. Aerobiologia (2018) 34: 425. https://doi.org/10.1007/s10453-018-9541-7).

Proposals must address one or more of the following questions while using the observations and tools noted above (these questions are not in priority order):

- Are transported microorganisms metabolically active during long-range (e.g., transoceanic) transport, (i.e., Is the atmosphere a superhighway or a functioning ecosystem or both?)?
- What factors influence the viability of microorganisms during long-range transport and their survival to the site of deposition?
- Can we determine the source regions of aerosolized microorganisms and also differentiate these microorganisms from extant microorganisms at deposition sites?
- With regard to atmospheric microbial biogeography, are microbial taxa global in distribution (i.e., is everything everywhere?) or are there biomes or ecoregions of the atmosphere, characterized by unique atmospheric microbial communities?
- What are the major atmospheric pathways for transporting microorganisms at continental to global scales?
- What are the ecological consequences of long-range transported microbial deposition on downwind terrestrial or marine ecoystems?
- Are viable human, animal, or plant pathogens transported in long-range (e.g., transoceanic) dust plumes?
- How can remote sensing measurements and models used to track atmospheric aerosols and their impacts be combined and leveraged to develop or improve models specifically focused on the global dispersal and survival of atmospheric microorganisms?
- What fraction of the organic and total aerosol loads are made up of living organisms?
- What is the upper (altitudinal) limit of the atmospheric biosphere?
- What are the radiative impacts of biological aerosol particles?
- How effective are bioaerosol microorganisms in serving as cloud condensation nuclei and as ice nuclei?

Proposers are reminded that this subelement is not seeking proposals for new observations of life in the atmosphere, but calls for the use of existing observations to address these questions. This restriction supercedes the limit for fieldwork expenses noted in section 1.2 above. Proposals for this subelement with expenses for data acquisition will be considered non-responsive.

Applications must use both a) NASA satellite remote sensing data and b) *in situ* assesments of aerosolized microbial biodiversity as integral components of their proposed work and, furthermore, proposers are asked to document how they are using these two data types on the cover page of the proposal. For the purposes of this subelement, "NASA satellite remote sensing data" includes data from NASA on-orbit satellites and simulated measurements from planned NASA satellites. In addition, the use of measurements from commercial, foreign, and other U.S. remote sensing data products in the overall mix of data products proposed is welcome, although proposals must include specific NASA satellite remote sensing data products in the overall mix of data products proposed. The use of outputs and predictive capabilities from models associated with NASA products, NASA algorithms, NASA visualizations, and other NASA geospatial products, including airborne products, is also welcome.

Since this topic is a subelement of the 2019 Interdisciplinary Research in Earth Science program element, proposals should bring together interdisciplinary teams of individuals working in the disciplines of aerosol remote sensing, aerosol modeling, and microbiology, and seek to use the full suite of tools available for understanding microbial life.

3. Summary of Key Information

Expected program budget for new awards	~ $11.5M Total ~$2.0M/year each for subelements 1-5; ~$0.75 M/year each for subelements 6 and 7
Number of awards anticipated	~ 4-5 each for subelements 1-5; 2-5 each for subelements 6 and 7
Maximum duration of awards	3 years
Due date for Notice of Intent to propose (NOI)	See Tables 2 and 3 of ROSES
Due date for proposals	See Tables 2 and 3 of ROSES
Planning date for start of investigation	No earlier than 6 months after the proposal due date.
Page limit for the central Science/Technical/Management section of proposal	15 pp; see also Table 1 of the ROSES *Summary of Solicitation* and the *Guidebook for Proposers*
Relevance to NASA	This program is relevant to the Earth Science questions and goals in the NASA Science Plan. Proposals that are relevant to this program are, by definition, relevant to NASA.
General information and overview of this solicitation	See the *ROSES Summary of Solicitation*.
Detailed instructions for the preparation and submission of proposals	See the *Guidebook for Proposers* at http://www.hq.nasa.gov/office/procurement/nraguidebook/.
Submission medium	Electronic proposal submission is required; no hard copy is permitted.

Web site for submission of proposal via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Web site for submission of proposal via Grants.gov	http://grants.gov/ (help desk available at support@grants.gov or (800) 518-4726)
Funding opportunity number for downloading an application package from Grants.gov	NNH19ZDA001N-IDS
Main point of contact concerning this program. See POCs for specific subelements below.	Jack A. Kaye Earth Science Division Science Mission Directorate National Aeronautics and Space Administration Washington, DC 20546-0001 Telephone: (202) 358-2559 Email: Jack.A.Kaye@nasa.gov

General questions about the IDS Program should be directed to the point of contact above. Questions about specific subelements should be directed to those listed below, all of whom share the same mailing address, listed below.

Earth Science Division
Science Mission Directorate
National Aeronautics and Space Administration
Washington, DC 202546-0001

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A.33 EARTH SCIENCE RESEARCH FROM OPERATIONAL GEOSTATIONARY SATELLITE SYSTEMS

NOTICE: Amended on September 16, 2019. This amendment releases the final text for this program element. Notices of intent to propose are requested by October 25, 2019, and the due date for proposals is January 10, 2020. Data management plans shall be included in the main proposal PDF, rather than given on the NSPIRES cover pages, see Section 3.2.5.

1. Scope of Program

NASA and NOAA seek proposals for advanced research and practical applications using data derived from instruments aboard U.S. and international geostationary satellites. These include NOAA's Geostationary Operational Environmental Satellite R series (GOES-R) of satellites and international geostationary satellites, such as the JMA Himawari and Korean GEO-KOMPSAT-2A. Research and applications proposals must be geared toward addressing an unmet need of the research or operations communities, respectively.

The GOES constellation has been a key component of the Earth and solar observing system for more than 40 years. The satellite system is sometimes referred to as our sentinel in space as it provides life-saving observations of high impact environmental phenomena such as severe storms, hurricanes, fires, and volcanic eruptions across the Earth's western hemisphere throughout the day and night. Simultaneously, it observes the sun and provides warning of attendant space weather effects on orbiting satellites, communications, the electric grid, and even astronauts exposed to solar storm radiation while living and working on the International Space Station. The GOES data are used qualitatively in image interpretation and quantitatively as derived geophysical products.

NOAA currently has two operational satellites in its GOES-R series in geostationary orbit: GOES-16 in the GOES-East position and GOES-17 in the GOES-West position (http://www.goes-r.gov). Data from its Earth-pointing instruments, the Advanced Baseline Imager (ABI) and the Geostationary Lightning Mapper (GLM), are providing a wealth of new information on many weather- and land-based applications. GOES-R also carries the Solar Ultraviolet Imager (SUVI), the Extreme Ultraviolet and X-Ray Irradiance Sensors (EXIS), the Space Environment In-Situ Suite (SEISS), and a Magnetometer whose primary task is to monitor space weather activity.

Himawari-8 and Himawari-9, the new generation Japanese geostationary meteorological satellites, were successfully launched by the Japan Meteorological Agency (JMA) on October 7, 2014 and November 2, 2016, respectively. The Advanced Himawari Imager (AHI) on-board Himawari-8/9, which is similar in design to ABI on GOES-R, has 16 observation bands at 0.5 or 1 km for visible and near-infrared bands and 2 km for infrared bands, providing images covering the East Asia-Western Pacific region. Though AHI and ABI are similar in many respects, JMA included a green band (0.51 microns) in place of the cirrus band (1.38 microns) on AHI. The Himawari-8/9 AHI is an advanced sensor in terms of number of bands, spatial resolution, and temporal frequency compared to previous geostationary sensors (e.g., IMAGER onboard

Himawari-7). Most of all, the shortened revisit times are around 10 minutes for full disk and 2.5 minutes for Japan and target areas.

GEO-KOMPSAT-2A, a new generation Korean geostationary meteorological satellite, was successfully launched by the Korean Meteorological Agency (KMA) on December 4, 2018. GEO-KOMPSAT-2A will continue the Communication, Ocean and Meteorological Satellite (COMS) mission of strengthening South Korea's capability to monitor the atmospheric environment around the Korean Peninsula. The Advanced Meteorological Imager (AMI) on-board GEO-KOMPSAT-2A, which is similar in design to ABI/GOES-R, has 16 observation bands with a 0.5 or 1 km nadir footprint for visible and near-infrared bands and 2 km for infrared bands, providing full disk images centered over Korea. Though AMI and ABI are quite similar in many respects, KMA included a green band (0.51 microns) in place of a mid-infrared band (2.2 microns) on AMI. Data acquisition modes include full-disk at 15 minute, North Hemisphere only at 5 minute, and local areas around Korea at 30 second intervals.

2. Areas of Proposals Solicited

2.1 Background

The new generation of sensors on geostationary satellite platforms has similar spectral coverage as the polar orbiting sensors that have been in orbit for many years, for example: ABI is comparable to Moderate Resolution Imaging Spectroradiometer (MODIS) and Visible Infrared Imaging Radiometer Suite (VIIRS), and GLM is comparable to Lightning Imaging Sensor (LIS). It is of particular interest to expand the research or operational algorithms that were developed in the past 20 years for these instruments aboard the polar orbiting satellites to the geostationary satellites to produce new but similar quality data products with higher temporal resolution than is possible with the polar orbiting satellites. The increased temporal resolution may allow new investigations into fast changing phenomena, including their diurnal variations and trends on the variations.

This program element solicits two types of investigations:

Type 1: Data product creation from operational geostationary satellite systems for research or operational opportunities and for the type 2 investigations below.

Type 2: Data analysis to better characterize and understand environmental (land, ocean, and atmosphere) phenomena and processes and the utilization of the data in research and operations.

2.2 NASA Earth Science Research

The overall goals for NASA's Earth Science program are documented in NASA's Strategic Plan (http://science.nasa.gov/about-us/science-strategy). The NASA Earth Science Research from Operational Geostationary Satellite Systems program element provides an opportunity for the Earth science research community to develop additional research data products from the new generation of operational geostationary satellites (e.g., Japan's Himawari-8/9, Korea's GEO-KOMPSAT-2A, NOAA's GOES-R series) beyond those produced by the operational agencies that implement them. These products could be for Earth system parameters not produced by those agencies or the long-term climate data product modified from the operational data products. In particular, NASA recognizes that the constellation of Himawari-8/9, GEO-KOMPSAT-2A, GOES-16 and -17, and the upcoming EUMETSAT Meteosat Third Generation may provide a unique opportunity to observe Earth system parameters with nearly global coverage. For this reason, NASA invites proposals with the goal to develop multi-satellite composite products once this near-global coverage becomes available.

NASA invites type 1 proposals to create high-spatial-and-temporal environmental (land, ocean, and atmosphere) data products from the geostationary satellite observations. These may be long-term data products for trend analysis and slowly varying process studies or short-term focused data products for fast varying process and trend investigations. Proposals that exploit the synergy between observations from polar and geostationary orbits and the synergy between modeling and high-spatial-and-temporal resolution geostationary observations, especially fast changing and short life cycle phenomena, are also encouraged. NASA is also interested in data products that may support the formulation of measurement of 2017 Decadal Survey (https://science.nasa.gov/earth-science/decadal-surveys) targeted observables.

Proposals that seek to improve operational products will not be considered by NASA.

Type 2 proposals must primarily use the products that were not available from previous generations (prior to Himawari-8, GEO-KOMPSAT-2A and GOES-16) of operational geostationary satellites to answer novel scientific questions. When the necessary data product(s) is(are) available, NASA may support meritorious studies that utilize this (these) new data product(s) to characterize and to understand fast changing or high frequency phenomena and processes in the Earth system that until now are not sufficiently observed by the low Earth orbit (LEO) satellites.

2.3 NOAA Geostationary Satellite Science

NOAA seeks type 1 and 2 proposals that provide support to develop products (type 1) and/or applications (type 2) to enhance the utilization of the GOES-R sensors. Priority will be given to proposals most likely to lead to significant improvements in data products and/or applications for weather forecast and environmental monitoring operations. In addition, NOAA is interested in science products from the sister imagers on the JMA Himawari and the Korean GEO-KOMPSAT-2A new generation geostationary satellites. These applications may include improvements to existing products (https://www.goes-r.gov/products/baseline.html) first conceived of more than ten years ago, the development of new products (e.g., https://www.goes-r.gov/products/option2.html) that may eventually mature and become operational, or utilization of the data as inputs to other tools, such as data assimilation for use by Numerical Weather Prediction (NWP) models (e.g., https://www.goes-r.gov/users/risk-reduce/index.html). NOAA also seeks proposals that make new and innovative use of GLM data, perhaps by extrapolating findings learned from the use of the Lightning Imaging Sensor (LIS) on board of NASA's International Space Station to the geostationary orbit.

Proposals should clearly describe a potential user community of the proposed applications and the unmet need that application would address. Projects that fuse information from multiple sources (multi-satellites including GEO+LEO and NOAA+NASA, radar, *in situ* data including surface meso-networks, model data, etc.) will be given additional positive assessment, although the GOES-R data should be a central component. Proposers are encouraged to include travel for user engagement activities.

Project goals should be consistent with the NESDIS strategic plan (https://www.nesdis.noaa.gov/sites/default/files/asset/document/the_nesdis_strategic_plan_2016.pdf), specifically the goal of User-Inspired Science detailed on pages 17-19.

3. Programmatic Information

All proposals will be peer reviewed in accordance with the guidelines provided in this program element, the *ROSES Summary of Solicitation*, and *the NASA Guidebook for Proposers*. NASA and NOAA will collaborate in the planning and conduct of the peer review. This peer review will be followed by a programmatic review during which NASA and NOAA program officers will assess program balance across the highly rated proposals and evaluate any logistical, implementation, cost, or management concerns. The NASA and NOAA program officers will recommend for selection the proposals that best address the objectives of this program element within resource constraints. The program officers will also recommend the division of funding responsibilities between the agencies consistent with each agency's mission. NASA and NOAA reserve the option of funding Co-Investigator institutions either as subawards of the Principal Investigator institution's award or as separate awards directly to the Co-Investigator institutions. The funding recommendations will be forwarded to each participating agency's Selection Official for confirmation. The NASA Selection Official is the Associate Director for Research, Earth Science Division. The NOAA Selection Official is the NESDIS GOES-R Program Senior Scientific Advisor. NASA will announce the official selection of proposals for award, recognizing the agency that has agreed to be responsible for funding.

Proposals that NOAA has agreed to be responsible for will be forwarded to NOAA for final negotiation and implementation of awards. Respondents selected for funding by NOAA will be required to submit additional documentation. If NOAA selects a proposal from a NOAA Cooperative Institute (CI), that CI may need to revise its budget to reflect the pre-arranged indirect cost rate. Additional information will be provided to applicants selected for funding by those agencies.

3.1 Proposal Submission

Proposals shall be submitted electronically via NASA Solicitation and Proposal Integrated Review and Evaluation System (NSPIRES) or via Grants.gov. See Section 4.

When making the submission, it is critical to respond to the cover page questions indicating the section (2.2 or 2.3) and type (1 or 2) of investigation being proposed. The section and type of proposal may determine how the proposal is evaluated.

3.2 Preparation of Proposals

Proposals must identify the unmet need of the research or operations communities and address the goals of NASA or NOAA specified in Section 2. In addition, proposals must follow the data and software policies in the following subsections and are encouraged to utilize the specified resources. NASA and NOAA will not consider any funding requests for building specialized private IT infrastructure for data processing and data archive purposes. When preparing the proposal, pay special attention to the different NASA and NOAA data policies and evaluation criteria described in Sections 3.2.5 and 3.3.

3.2.1 *Earth Science Data Information Policy and Rights in Data*

All proposers should review the Earth Science Data and Information Policy (http://science.nasa.gov/earth-science/earth-science-data/data-information-policy/).

3.2.2 *Open Data, Services, and Software Policies*

This program element requires all data product and software developed to be made available to the public as open data and open source software. See the existing Open Data, Services, and Software Policies (https://earthdata.nasa.gov/collaborate/open-data-services-and-software) established through the Earth Science Data Systems program (https://earthdata.nasa.gov).

3.2.3 *Utilizing GeoNEX Platform and Resources*

NASA maintains a NASA Earth Exchange (NEX) data processing platform that includes a data archive and selected data algorithms. One specific instance in the geostationary satellite data processing pipeline is Geo-NASA Earth Exchange (GeoNEX) at https://www.nasa.gov/geonex. GeoNEX is a collaborative effort for generating Earth monitoring products from the new generation of geostationary satellite sensors. In collaboration with scientists at NOAA, NASA, and other international organizations, GeoNEX serves as a platform for scientific partnership, knowledge sharing, and research for the Earth science community. GeoNEX currently offers an archive of gridded top-of-atmosphere, Bidirectional Reflectance Factor data product from the GOES-16 and -17 Advanced Baseline Imagers (ABI) and the Advanced Himawari Imager (AHI). NASA and NOAA encourage proposers to use and expand the GeoNEX platform for data processing and analysis purposes.

GeoNEX is not designed for permanent data archive purposes, and the data collection may not be comprehensive enough to cover all potential research needs. If certain data are not available on GeoNEX, NOAA satellite datasets are available for download from the Comprehensive Large Array-Data Stewardship System (CLASS) archive at https://www.class.noaa.gov/. For foreign satellite data not available on NASA and NOAA systems, proposers must make their own arrangements to access the data and the data should be made available through NASA or NOAA systems for future projects following the open data policy described in Section 3.2.2.

3.2.4 *Utilizing Cloud Computing Resources*

Besides GeoNEX, this program encourages proposals that use commercial cloud-native environments. NASA, along with other government agencies, has increasingly been looking to commercial cloud vendors for secure, maintainable, cost-effective, and versatile computing infrastructure. Recent NASA Earth Observing System Data and Information System (EOSDIS) prototype efforts look to leverage commercial cloud resources for such activities as data storage, processing, and simple data analysis. Proposers should research ongoing activities in this space (https://earthdata.nasa.gov/cloud) and consider how to best leverage or build off of these efforts in the cloud to ensure their submission will be well-positioned for future integration and adoption by the Earth Science Data Systems (ESDS; https://earthdata.nasa.gov/esds) program.

3.2.5 *Data Management Plan*

Proposals submitted to this program element must include a Data Management Plan (DMP), not to exceed two pages in length, immediately following the References and Citations section for the Scientific/Technical/Management section of the proposal. Proposals responding to Section 2.2 must follow the NASA data management policy requirements (see 3.2.5.1, below) and those responding to Section 2.3 must follow the NOAA data policy requirements (see 3.2.5.2, below).

3.2.5.1 NASA Data Requirements

In keeping with the NASA Plan for Increasing Access to Results of Federally Funded Research, proposals must include a Data Management Plan (DMP). Proposals for work that will not generate any data or qualify for an exemption, as defined in the NASA Plan, must demonstrate this in the DMP. The DMP requirement is described in detail in section 3.11 of the *NASA Guidebook for Proposers*. NASA's Earth Science data policy is available at: http://science.nasa.gov/earth-science/earth-science-data/data-information-policy/ and http://earthdata.nasa.gov/data/data-centers.

3.2.5.2 NOAA Data Requirements

NOAA's Data and Publication Sharing Directive, which includes Data Management Guidance, is available at:
https://nosc.noaa.gov/EDMC/documents/Data_Sharing_Directive_v3.0.pdf

NOAA Data Policy:

1. Environmental data and information collected or created under NOAA grants or cooperative agreements must be made discoverable by and accessible to the general public, in a timely fashion (typically within two years), free of charge or at no more than the cost of reproduction, unless an exemption is granted by the NOAA Program. Data should be available in at least one machine-readable format, preferably a widely-used or open-standard format, and should also be accompanied by machine-readable documentation (metadata), preferably based on widely-used or international standards.
2. Proposals submitted in response to this Announcement must include a Data Management Plan of up to two pages describing how these requirements will be satisfied. The Data Management Plan should be aligned with the Data Management Guidance provided by NOAA in the Announcement. The contents of the Data Management Plan (or absence thereof), and past performance meeting such plans, will be considered as part of proposal review. A typical plan should include descriptions of the types of environmental data and information expected to be created during the course of the project; the tentative date by which data will be shared; the standards to be used for data/metadata format and content; methods for providing data access; approximate total volume of data to be created; and the proposers' prior experience in making such data accessible. The costs of data preparation, accessibility, or archiving may be included in the proposal budget unless otherwise stated in the Guidance. Accepted submission

of data to the NOAA National Centers for Environmental Information (NCEI) is one way to satisfy data sharing requirements; however, NCEI is not obligated to accept all submissions and may charge a fee, particularly for large or unusual datasets. The PI should contact NCEI and secure a letter of support or budget accordingly.

3. NOAA may, at its own discretion, make publicly visible the Data Management Plan from funded proposals, or use information from the Data Management Plan to produce a formal metadata record and include that metadata in a Catalog to indicate the pending availability of new data.
4. Proposal submitters are hereby advised that the final pre-publication manuscripts of scholarly articles produced entirely or primarily with NOAA funding are required to be submitted to NOAA Institutional Repository after acceptance, and no later than upon publication. Such manuscripts shall be made publicly available by NOAA one year after publication by the journal.

3.3 Evaluation and Selection of Proposals

3.3.1 *NASA Criteria*

The three primary evaluation criteria (Merit, Relevance, Cost) are defined in Appendix D of the *NASA Guidebook for Proposers* and information about how proposals are evaluated to these criteria is included in Section VI.(a) of the *ROSES-2019 Summary of Solicitation*. Type 1 and 2 proposals may be grouped and evaluated in separate panels. Proposals responding to Section 2.2 and those addressing NASA's Strategic Plan are considered relevant to NASA.

3.3.2 *NOAA Criteria*

NOAA proposals will be evaluated based on the following factors at the indicated weights:

1) Scientific and Technical Quality – To what extent does the proposed work have a sound scientific rationale, a reasonable timeline, and the potential to produce results that will have a meaningful impact? (40%)
2) Relevance to the NESDIS Strategic Plan and the NOAA Data Management Plan – Is the proposed work consistent with the goals outlined in the Strategic Plan and the Data Management Plan? (20%)
3) Feasibility – Are the proposed objectives attainable? (25%)
4) Cost – Is the proposed budget consistent with the tasks? (15%)

3.4 Funding and Awards

Consistent with Section 1 of the Earth Science Research Overview, awards to non-governmental organizations will be made as grants or cooperative agreements, whichever is most appropriate based upon the nature of the work solicited. NASA and NOAA will not award contracts for this solicitation. Awards internal to the government will be made through the usual agency processes. The Government's obligation to make award(s) is contingent upon the availability of appropriated funds from which payment can be made and the receipt of proposals that NASA determines are acceptable for award under this program element. No additional funds beyond the negotiated award value will be available. NASA does not allow for payment of profit or fee to commercial firms under grant awards.

3.5 Period of Performance

Awards resulting from this call are limited to a maximum performance period of 36 months. Proposals must define clear, measurable milestones to be achieved for each year of performance to warrant continuation into the second and subsequent years.

3.6 Reporting

In addition to the standard annual report, NASA and NOAA program officers may require semiannual project review meetings for the selected projects, covering the preceding six months' efforts. If required, each semiannual project review shall address:

1. Scientific or Technical status: The PI shall summarize accomplishments for the preceding six months, including scientific or technical accomplishments (milestone reached, study results, scientific findings, etc.), data product development results, presentations and publications.
2. Schedule status: The PI shall address the status of major tasks and the variance from planned versus actual schedule, including tasks completed, tasks in process, tasks expected to be completed later than planned, and tasks delayed in starting, with rationale for each, and recovery plans, as appropriate.
3. Financial status: The PI shall report the financial status (e.g., invoicing the Government against the budget) and compare to the budget plan.

The semiannual project review reports shall be submitted in PowerPoint compatible formats prior to the review meeting. The review meeting is typically in the form of a teleconference.

3.7 Travel

Proposers are highly encouraged to include travel to one professional conference (e.g., AMS or AGU) annually to present the research and product development results.

4. Summary of Key Information

Expected program budget for first year of new awards	NASA: \$1.6M NOAA: \$2.0M
Number of new awards pending adequate proposals of merit	NASA: ~6-10 projects NOAA: ~8-13 projects
Maximum duration of awards	3 years
Due date for Notice of Intent to propose (NOI)	See Tables 2 and 3 of this ROSES NRA
Due date for proposals	See Tables 2 and 3 of this ROSES NRA
Planning date for start of investigation	No earlier than 6 months after the proposal submission date
Page limit for the central Science-Technical-Management section of proposal	15 pages; see Table 1 of ROSES and Section 3 of the *NASA Guidebook for Proposers*

Relevance	Proposals relevant to this program are, by definition, relevant to NASA. Proposals for NOAA funding must address one or more of the NOAA-specific objectives listed in Section 2 of this Program element.
General information and overview of this solicitation	See the *ROSES Summary of Solicitation*
General requirements for content of proposals	See Section 3 of the *NASA Guidebook for Proposers* and Section IV and Table 1 of *the ROSES Summary of Solicitation*
Detailed instructions for the submission of proposals	See https://nspires.nasaprs.com/tutorials/ Sections 3.22-4.4 of the *NASA Guidebook for Proposers* and Section IV(b) of *the ROSES Summary of Solicitation*
Submission medium	Electronic proposal submission is required; no hard copy is permitted
Web site for submission proposal via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Web site for submission of proposal via Grants.gov	http://grants.gov (help desk available at support@grants.gov or (800) 518-4726)
Funding opportunity number for downloading an application package from Grants.gov	NNH19ZDA001N-ESROGSS
NASA point of contact concerning this program	Tsengdar Lee Earth Science Division Science Mission Directorate National Aeronautics and Space Administration Washington, DC 20546-0001 Telephone: (202) 358-0860 Email: tsengdar.lee@nasa.gov
NOAA point of contact concerning this program	Daniel T. Lindsey NOAA Senior Scientific Adviser for GOES-R Fort Collins, CO 80523 Telephone: (970) 491-8773 Email: dan.lindsey@noaa.gov

A.34 NEW (EARLY CAREER) INVESTIGATOR PROGRAM IN EARTH SCIENCE

NOTICE: The New Investigator Program (NIP) in Earth Science will not be competed in 2019. NIP is moving to a 3-year cycle and is scheduled to solicit proposals next in ROSES-2020. Eligibility will be extended to six years after award of PhD in order that potential proposers continue to have two opportunities to propose. The full text of the most recent call can be found in A.36 of ROSES-2017.

1. Scope of Program

The New (Early Career) Investigator Program (NIP) in Earth Science is designed to support outstanding scientific research and career development of scientists and engineers at the early stage of their professional careers. The program aims to encourage innovative research initiatives and cultivate scientific leadership in Earth system science. The Earth Science Division (ESD) places particular emphasis on the investigators' ability to promote and increase the use of space-based remote sensing through the proposed research.

The NIP supports all aspects of scientific and technological research aimed to advance NASA's mission in Earth system science (http://science.nasa.gov/about-us/science-strategy/). In research and analysis, the focus areas are:

- Carbon Cycle and Ecosystems,
- Climate Variability and Change,
- Water and Energy Cycle,
- Atmospheric Composition,
- Weather, and
- Earth Surface and Interior.

In Applied Sciences, the ESD encourages efforts to discover and demonstrate practical uses of NASA Earth science data, knowledge, and technology (see http://appliedsciences.nasa.gov). In technological research, the ESD aims to foster the creation and infusion of new technologies into space missions in order to enable new scientific observations of the Earth system or reduce the cost of current observations (see http://esto.nasa.gov). The ESD also promotes innovative development in computing and information science and engineering of direct relevance to ESD.

The proposed research project must be led by a single, eligible investigator serving as the Principal Investigator (PI). Indeed, this individual must be the only essential team member; no Co-Investigators (Co-Is), paid or unpaid, are permitted. The NIP does not accept proposals with Co-PIs nor two types of PIs, such as Science PI and Institutional PI. Students and postdoctoral fellows may participate as paid team members. The proposed research may include collaborations. See the *Guidebook for Proposers* at http://www.hq.nasa.gov/office/procurement/nraguidebook/ for the definitions of Collaborator vs. Co-Investigator and descriptions of China-related restrictions.

2. NASA point of contact concerning this program

Allison Leidner
Earth Science Division
Science Mission Directorate
NASA Headquarters
Washington, DC 20546-0001
Telephone: 202-358-0855
Email: Allison.K.Leidner@nasa.gov

A.35 THE SCIENCE OF TERRA, AQUA, AND SUOMI NPP

NOTICE: NASA will not solicit research proposals under The Science of Terra, Aqua, and Suomi NPP program element in ROSES-2019. The next estimated release of the program element is ROSES-2020.

1. Scope of Program

NASA's Earth Science Research Program aims to utilize global measurements to understand the Earth system and interactions among its components as steps toward prediction of Earth system behavior. To achieve this goal, a combination of shorter-term process-oriented measurements is complemented by longer-term satellite measurements of certain environmental properties. A key requirement for the latter is the provision of well-calibrated, multi-year and multi-satellite data and product series.

The Earth Observing System (EOS) was intended to provide global observations needed to advance Earth System Science and to initiate a number of improved long-term global data sets. NASA has completed the development and implementation of the EOS satellites, and successfully operates a comprehensive EOS Data and Information System (EOSDIS) to acquire, process, archive, and distribute these observations and data products (https://earthdata.nasa.gov/about). Among the EOS satellites that were most critical in initiating new, high quality long-term Earth system data records were the Terra and Aqua satellites, launched in 1999 and 2002, respectively.

The Suomi National Polar-orbiting Partnership (Suomi NPP, formerly the NPOESS Preparatory Project) satellite was launched on October 28, 2011, to extend more than 30 high-quality time series data records initiated by earlier NASA satellites (most notably Terra and Aqua, but also Aura, launched in 2004). Its observations should allow scientists to extend a continuous record of satellite data of sufficient quality to detect and quantify global environmental changes. For example, Suomi NPP continues measurements of land surface vegetation, sea surface temperature, and atmospheric ozone that began more than 25 years ago with earlier satellites and that were enhanced with the new instrumentation aboard the EOS satellites. The NASA time series of global observations is continued for certain data records by the on-orbit Suomi NPP program sensors (https://jointmission.gsfc.nasa.gov).

Suomi NPP serves as a bridge between NASA's Earth Observing System (EOS) of satellites and the next-generation Joint Polar Satellite System (JPSS), a National Oceanic and Atmospheric Administration (NOAA) program that will collect data for both weather and climate. NASA is bridging the mission capabilities to continue a set of the Earth System Data Records begun with the EOS missions using the Suomi NPP mission data.

2. Programmatic Information

Questions or comments may be directed to The Science of Terra, Aqua, and Suomi NPP Program Manager at the address given below:

Paula Bontempi
Earth Science Division
Science Mission Directorate
NASA Headquarters
Washington, DC 20546-0001
Telephone: (202) 358-1508
Email: paula.bontempi@nasa.gov

A.36 STUDIES WITH ICESAT-2

NOTICE: September 4, 2019. One of the points of contact in Section 9 has been changed: Hank Margolis has been replaced by Thorsten Markus. New text is in bold, deleted text is struck through.

Amended June 10, 2019. This amendment announces that Studies with ICESat-2 has been released in ROSES-2019 as this program element, A.36 Studies with ICESat-2. Notices of intent are requested by August 1, 2019 and the due date for proposals is October 8, 2019. Minimal changes have been made to the text since its preliminary release as a "TBD" placeholder in ROSES-2018.

Note to proposers about new requirements: Read this program element in its entirety. It has a range of specific, new requirements that will be considered during proposal evaluation. Proposers are also encouraged to consider the broad range of scientific opportunities enabled by ICESat-2 observations, the challenges of working with large volumes of photon-counting lidar data, and the program element's requirement for Open Science approaches.

1. Overview

NASA solicits proposals for Earth science research using observations from the Ice, Cloud, and land Elevation Satellite-2 (ICESat-2), which was launched on September 15, 2018. The Advanced Topographic Laser Altimeter System (ATLAS) instrument on ICESat-2 is the most advanced, highest-resolution altimetry instrument ever placed in Earth orbit. ATLAS is a photon-counting lidar with six beams and ICESat-2's near-polar orbit is optimized to enable it to characterize elevation changes in Earth's polar ice. The mission collects measurements globally – away from the poles – particularly to enable independent determination of vegetation height, but also to support research in hydrology, oceanography, atmospheric sciences, and other Earth and applied sciences.

Given the exciting scientific opportunities presented by the mission's unprecedented volume of high-resolution Earth observations, for proposers to this program element NASA requires *Open Science* approaches to accelerate the pace of scientific advancement (see section 5.2). NASA also encourages researchers to utilize emerging methods in scientific data analysis, including but not limited to: machine learning, cloud-based processing, and integration of ICESat-2 results with advanced Earth system models. Low-cost, highly experimental proposals are especially encouraged.

Principal Investigators (PI) of the proposals selected under this program have additional responsibilities as members of the ICESat-2 Science Team (I2ST).

2. Background: ICESat-2, ICESat, IceBridge, and CryoSat-2

ICESat-2 (https://icesat-2.gsfc.nasa.gov/) was developed based on recommendations from the National Academies of Science, Engineering and Medicine's report *Earth Science and Applications from Space National Imperatives for the Next Decade and Beyond (2007)* (https://www.nap.edu/catalog/11820/earth-science-and-applications-from-space-national-imperatives-for-the) to continue the satellite laser altimetry studies of Earth's polar ice begun by ICESat. The Academies' successor report, *Decadal Survey for Earth Science and Applications from Space (2017-2027)* (http://sites.nationalacademies.org/DEPS/esas2017/index.htm), requires an ongoing commitment to existing and planned instruments and satellites in the *Program of Record* that includes ICESat-2.

ICESat-2's single instrument, the Advanced Topographic Laser Altimeter System (ATLAS), is a six-beam, photon-counting lidar operating at 10 kHz. Each beam has a ground-footprint of ~17 meters in diameter, offset by 0.7 meters along-track. The six beams are organized into three pairs - consisting of strong and weak beams offset by 90 meters - that are separated from adjacent pairs by 3.3 kilometers. In addition to providing more observations than a single beam, the multibeam/pair configuration enables direct measurement of instantaneous surface slope over the land ice of Greenland and Antarctica. With an orbital inclination of 92 degrees, ICESat-2 has a 91-day repeat orbit for observations over the polar regions. Nearer the equator, off-pointing by the satellite is used to create a global map with tracks less than 4-km apart for global vegetation height assessments.

2.1 ICESat and IceBridge

ICESat-2's predecessor is the original Ice, Cloud, and land Elevation Satellite (ICESat) mission that launched in January 2003 and ceased operations in 2009 (http://icesat.gsfc.nasa.gov/). The ICESat instrument was the Geoscience Laser Altimeter System (GLAS), a single beam, full-waveform lidar operating at 40 Hz with ground-footprints of 70 meters diameter offset by 170 meters along-track. With an orbital inclination of 94 degrees, ICESat observations provided critical insight into the thinning of the Arctic sea ice cover, ice loss from the continental ice sheets of Greenland and Antarctica, and the global distribution of above-ground biomass. Limitations on ICESat laser lifetime led to a revised measurement-strategy. It was originally intended that GLAS would operate continuously with a 91-day repeat orbit—similar to the approach now used by ICESat-2 - but to extend GLAS's diminished laser life, this approach was altered to discrete campaigns with a 33-day near-repeat subcycle of the 91-day orbit surveyed at six-month intervals. ICESat data are available at http://nsidc.org/data/icesat/.

The gap between ICESat and ICESat-2 has been bridged by NASA's Operation IceBridge Mission (http://www.nasa.gov/mission_pages/icebridge/index.html), a series of aircraft campaigns deploying lidar and other instruments over land and sea ice in both polar regions. The IceBridge instrument suite and flight plans are designed to specifically extend the record of ICESat to ICESat-2, and offer some calibration and validation of ICESat-2 and the European Space Agency's CryoSat-2, launched on April 8, 2010. IceBridge also deploys radars for mapping snow cover and the underlying bed, as well as gravimeters and other instruments. IceBridge data and instrument descriptions are available at http://nsidc.org/data/icebridge/.

2.2 CryoSat-2

A key, on-orbit satellite altimetry mission relevant to ICESat-2 is the European Space Agency's CryoSat-2. A radar altimetry mission, CryoSat-2 also measures sea ice freeboard, land ice elevation, and makes other geophysical measurements. Details about the Cryosat-2 mission are available at http://www.esa.int/esaMI/Operations/SEM36Z8L6VE_0.html.

3. ICESat-2 Data Products and Cloud-based Resources

ATLAS is a photon-counting lidar that determines surface elevations using the time-of-flight of a single photon. Data processing differs from that for traditional full-waveform lidar systems and results in very large volume products.

3.1 ICESat-2 Data Products

To facilitate research with ICESat-2, algorithms and data products (https://icesat-2.gsfc.nasa.gov/science/data-products) have been developed to support a range of users, from those requiring base telemetry through to modelers requiring gridded geophysical data. Included among these are fifteen separate science-specific products - ATL06 to ATL21 - covering land and sea ice, vegetation and ecosystem structure, inland water height, sea surface topography, and various aspects of the atmosphere.

ICESat-2 data can be accessed from the NASA Distributed Active Archive Center (DAAC) at the National Snow and Ice Data Center (NSIDC) at http://nsidc.org/data/icesat-2/.

3.2 Cloud-based Resources

ICESat-2's photon counting approach is a data-intensive observation technique that collects ~1 Terabyte (Tb) of data per day globally. While the processed data products are smaller (ATL03, for example, is ~0.5 Tb per day), moving, processing, and analyzing such volumes of data are challenging. Cloud-based computing may offer critical efficiencies to proposed investigations and should be considered.

To facilitate such work, NASA's Advanced Data Analytics Platform (ADAPT) (https://www.nccs.nasa.gov/services/adapt) will be made available to investigations selected under this element. ADAPT offers cloud storage and access to high-performance computing resources. To minimize data movement, ADAPT hosts all ICESat-2 data products (https://icesat-2.gsfc.nasa.gov/science/data-products), as well as related satellite and aircraft altimetry products, including data from ICESat and IceBridge.

Proposers who would like to use ADAPT are encouraged to incorporate it in their proposed work plans.

4. Scope of Program

This program element solicits proposals to pursue any research topic using ICESat-2 observations and advancing the Earth Science goals articulated in the *NASA 2018 Strategic Plan* and *2014 Science Mission Directorate Science Plan* (both of which may be found at http://science.nasa.gov/about-us/science-strategy/).

NASA recognizes that ICESat-2's global, high-resolution data stream presents an exciting opportunity to utilize emerging methods in data analytics, including but not limited to artificial intelligence, machine learning, and data mining with applications to analysis, data fusion, and coupling-models-with-observations. The program welcomes proposals that team computer scientists and Earth system scientists. In addition, NASA recognizes that some of the initial applications of these approaches to Earth science may be exploratory, and a portion of the budget has been reserved for low-cost, highly experimental proposals of varying duration. The estimated budget in Section 9, *Summary of Key Information,* provides guidance for scoping proposal budgets.

Overall priority will be given to investigations focused on land and sea ice in the Earth's polar regions. Other areas of Earth science research will be considered at a lower priority, but NASA anticipates supporting several such investigations.

4.1 Polar Ice Research

For polar ice research, the program is open to the consideration of any type of Earth science research based on ICESat-2 observations. Data products (https://icesat-2.gsfc.nasa.gov/science/data-products) developed by the ICESat-2 Project to support such work include:

- Ice elevation (ATL06 and 07);
- Sea ice freeboard and ice height (ATL10 and 11);
- Gridded geophysical data derived from these products (ATL14, 15, 20, and 21); and
- Polar cloud fraction, blowing snow frequency, ground detection frequency (ATL16/17).

Investigations that may particularly be enabled by ICESat-2 include but are not limited to:

- Using observations of elevation change to characterize physical processes controlling growth and retreat of polar ice, including connections to climate forcings;
- Gaining insight into ice surface mass balance, especially to improve representations of polar precipitation and surface melting/sublimation in Earth system models;
- Characterizing the dynamic processes controlling ice motion and elevation change, especially to improve land ice models for sea level rise projections or sea ice models to understand couplings to the Earth system; and
- Integrating ICESat-2 with other satellite and airborne altimetry observations to create multidecadal records that offer insight into the drivers of polar change.

Investigators are encouraged to use other geophysical data and integrate their results with Earth system models as appropriate, including:

- Altimetry observations from ICESat, IceBridge, and CryoSat-2;
- Other remote sensing observations that complement ICESat-2, such as those from GRACE-FO, InSAR, and other satellite missions; and
- Outputs and refinements to Earth system models, such as NASA's GEOS5 (https://gmao.gsfc.nasa.gov/GEOS/), ISSM (https://issm.jpl.nasa.gov/), ECCO (https://ecco.jpl.nasa.gov/), and other non-NASA models.

4.2 Research Foci Outside of Polar Ice

Beyond polar ice studies, this program element welcomes proposals based on ICESat-2 observations on any research topic that advance the Earth Science goals articulated in the *NASA 2018 Strategic Plan* and *2014 Science Mission Directorate Science Plan* (both of which may be found at http://science.nasa.gov/about-us/science-strategy/).

Potential topics include but are not limited to:

- Ecosystem structure and estimation of biomass;
- Change in the major glacial systems of Alaska, Canada, and High Mountain Asia;
- Atmospheric processes, especially precipitation and cloud properties relevant to interpretation of polar processes and affecting interpretation of ICESat-2 observations;
- Altimetry of the polar and global oceans;
- Bathymetry of oceans and inland-water;
- Inland-water hydrologic information, such as river and lake heights;
- Snow volume estimates;
- Aquatic retrievals related to ecology or biogeochemistry;
- Land surface studies; and
- Any area of *Applied Sciences* as defined in the *2014 Science Mission Directorate Science Plan*.

To facilitate such research with ICESat-2, algorithms and data products (https://icesat-2.gsfc.nasa.gov/science/data-products) have been developed to support a range of users, including:

- Land and water elevation, including forest canopy height and other surface properties:
    - Along each beam (ATL08)
    - Gridded (ATL18);
- Cloud characteristics (ATL09);
- Polar cloud fraction, blowing snow frequency, ground detection frequency (ATL16/17);
- Ocean elevation (ATL12);
- Mean Sea Surface (ATL19); and
- Inland water Height (ATL13).

5. Proposal Requirements

Proposers are encouraged to address each of the following four sections (5.1-5.4) separately in their proposals.

5.1 ICESat-2 Science Team: Membership, Meetings, and Team Leader

5.1.1 *Team Membership and Expectations*

In addition to their proposed research activities, Principal Investigators (PI) selected under this program have additional responsibilities as members of the *ICESat-2 Science Team* (I2ST). The team will:

- Accelerate ICESat-2 science by Open Science approaches (Section 5.2) ;

- Report to NASA Headquarters on the impacts to ICESat-2 science resulting from any propblems with mission operations;
- Provide guidance to the ICESat-2 Project Office for mission planning, as requested; and
- For proposals focused on research outside of polar ice, the PI/Team Member will serve as representative of the mission to their primary scientific community.

All proposers must describe anticipated I2ST contributions and their approach to *Open Science* (see Section 5.2). For investigations focused on research outside of polar ice, proposals should describe specific plans to represent the mission to non-polar ice scientific communities and may include these activities in the proposal budget.

5.1.2 *Meetings*

There will be at least two in-person, 3-day meetings of I2ST each year in varying locations within the United States. It is expected that at least some portion of these team meetings will be open, and other members of the proposer's team will be welcome to attend and participate. Proposers should include support in their proposal budget for themselves and critical team members to attend these meetings.

5.1.3 *Team Leader*

The I2ST will be led by a Team Leader who will organize the team meetings, support the Project Science Office, report to NASA Headquarters, and be responsible for producing a yearly team report. Proposers wishing to serve as Team Leader must state so in their proposal, and are allowed up to two (2) additional pages to describe their qualifications, interests, and approaches to leadership, including facilitating Open Science approaches. These two addional pages should be set aside as a separate Appendix at the end of the proposal and appropriately titled. Team Leader activities should not be included in the proposal budget. The Team leader will receive an additional $80,000 per year to support his/her leader activities, and the successful proposer will revise the budget during final award negotiations.

5.2 Open Science

This program element requires proposers to implement *Open Science* (OS) approaches consistent with the recommendations of the report *Open Science by Design: Realizing a Vision for 21st Century Research* from the *National Academies of Science, Engineering and Medicine* (https://www.nap.edu/catalog/25116/open-science-by-design-realizing-a-vision-for-21st-century). Some key recommendations from the report that are particularly relevant to research using ICESat-2 include but are not limited to:

- Developing proposals using Findable-Accessible-Interoperable-Reusable (FAIR) principles;
- Conducting research using tools compatible with open sharing;
- Preparing data and tools for reproducibility;
- Documenting approaches in electronic research notebooks; and
- Depositing research output in FAIR archives.

NASA recognizes that fully implementing OS approaches will be challenging and entail additional cost. However, NASA sees great benefit to these approaches for accelerating

ICESat-2 research, and proposers are *required* to include OS in their work plans to achieve the following goals:

- Progress is accelerated to the maximum extent possible by sharing advances during the conduct of investigations, not just at the publication stage. This sharing:
    - Includes scientific results and analytic approaches to ICESat-2 observations;
    - Occurs within and across disciplines; and
    - Happens openly and frequently via team meetings, contributions to open repositories, and other communications with colleagues.
- Workflows are documented to facilitate sharing of advances and validating results, by:
    - Utilizing open-source digital notebooks—such as Jupyter Notebook (http://jupyter.org/) - that document and demonstrate workflow;
    - Regular uploads to appropriate open code repositories—such as Github (https://github.com/) - of digital notebooks and other codes, either by using these repositories as continuous, open development environments or by making separate uploads to these repositories at intervals of no more than six months during conduct of the investigation; and
    - Ensuring critical ancillary datasets are available in ready-to-use subsets and formats via open archives and/or the relevant NASA Distributed Active Archive Center (https://earthdata.nasa.gov/).
- Crediting individuals making similar pre-publication contributions wherever possible through co-authorship and other methods.

NASA requires proposals to specifically address each of these goals and will evaluate proposals with regards to their likelihood for success.

5.3 Open Source Software

Awards made under this program element must follow NASA's Earth Science Data Systems (ESDS) *Open Source Software Policy* (https://earthdata.nasa.gov/earth-science-data-systems-program/policies/esds-open-source-policy).

In addition, all software developed under this program element is to be designated and distributed to the public as *open source software* using *Apache License 2.0* (https://www.apache.org/licenses/LICENSE-2.0) or a less restrictive license. Software developed under this program may be created to operate in conjunction with commercial or other restricted-use software (such as MATLAB, ENVI, and ArcGIS), but must be licensed separately from that software.

5.4 Data Policies

Proposals developing significant datasets must include in the data management plan a clear description of the dataset development, including delivery to the NASA DAAC at the National Snow and Ice Data Center (https://nsidc.org/daac) in compliance with NASA data standards (https://earthdata.nasa.gov).

6. Fieldwork and Aircraft

This program element will not support major field deployments. Small field programs to improve calibration and validation of ICESat-2 data products may be considered, but proposers should review and consider the estimated budget in Section 9, the Summary of Key Information, when scoping such plans. Proposed investigations involving fieldwork must describe the field activities in the body of the proposal and include the full costs to NASA within the proposal budget.

Proposed investigations that would utilize logistics support provided by the National Science Foundation's Office of Polar Programs must follow the instructions in their current Arctic and Antarctic research solicitations (https://www.nsf.gov/funding/programs.jsp?org=OPP) for planning fieldwork and estimating costs. For Arctic fieldwork, this includes obtaining and submitting a separate cost estimate document to be uploaded with the proposal budget.

Investigators proposing activities involving aircraft must contact Mr. Bruce Tagg (Bruce.Tagg@nasa.gov), SMD's Airborne Science Program Manager, during proposal preparation to discuss aircraft selection, budgeting, and airworthiness. NASA's airworthiness requirements and assessment processes apply to any aircraft activities supported by NASA, including those that use non-NASA aircraft. Proposals must include the costs to NASA of aircraft operations in the budget.

7. Additional Evaluation Criteria

The primary evaluation criteria are given in Section IV.(a) of the *ROSES-2019 Summary of Solicitation.* In addition to the definition of Merit given in Appendix D of the *NASA Guidebook for Proposers* , the evaluation criterion Intrinsic Merit specifically includes the following factors to apply to the requirements of Sections 5.1 through 5.4:

- Approach to *Team Membership and Expectations* (Section 5.1);
- Likelihood of achieving *Open Science* goals (Section 5.2);
- Compliance with *Open Source Software* requirements (Section 5.3); and
- Compliance with Data Policy for new data products (Section 5.4).

Proposers are encouraged to address each of these sections separately in the proposal.

8. Programmatic Information

Results from investigations supported under this ROSES element are expected to advance the Earth Science goals articulated in the *NASA 2018 Strategic Plan* and *2014 Science Mission Directorate Science Plan*, as well as associated Federal Research Objectives; especially those of:

- The *U.S. Global Change Research Program* (http://www.globalchange.gov/); and
- The *Interagency Arctic Research Policy Committee's* Arctic Science Research Plan (https://www.iarpccollaborations.org/plan/index.html).

9. Summary of Key Information

Expected program budget for first year of new awards	$3.5M; up to $750K/year in total will be reserved for small, highly-experimental proposals, as discussed in *Section 4. Scope of Program*, subject to NASA receiving sufficient proposals suitable for selection.
Number of new awards pending adequate proposals of merit	~18 of varying size and scope. It is anticipated that NASA will support ~12 large (~$200k/year) awards and ~6 small (~$125K/year) awards of varying duration.
Maximum duration of awards	3 years
Due date for Notice of Intent (NOI) to propose	See Tables 2 and 3 of this ROSES NRA
Due date for proposals	See Tables 2 and 3 of this ROSES NRA
Planning date for start of investigation	6 months after proposal due date.
Page length for the Science/Technical/Management section of proposal	15 pages; see Section 3 of the *NASA Guidebook for Proposers*. 2 additional pages for team leader proposals.
Relevance	Proposals that are relevant to this program are, by definition, relevant to NASA. See Section VI(a) of the *ROSES Summary of Solicitation*
General information and overview of this solicitation	See the *ROSES Summary of Solicitation*.
General requirements for content of proposals	See Section 3 of the *NASA Guidebook for Proposers* and Section IV and Table 1 of *the ROSES Summary of Solicitation*.
Detailed instructions for the submission of proposals	See https://nspires.nasaprs.com/tutorials/ Sections 3.22-4.4 of the *NASA Guidebook for Proposers* and Section IV(b) of *the ROSES Summary of Solicitation*.
Web site for submission of proposal via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or 202-479-9376).
Web site for submission of proposals via Grants.gov	http://grants.gov/ (help desk available at support@grants.gov or 800-518-4726).
Funding opportunity number for downloading an application package from Grants.gov	NNH19ZDA001N-ICESAT2

Points of contact concerning this program both of whom share this postal address: Science Mission Directorate NASA Headquarters Washington, DC 20546-0001	Colene Haffke Telephone: (202) 358-0065 Email: colene.m.haffke@nasa.gov **Thorsten Markus** **Telephone: (202) 358-3860** **Email: thorsten.markus@nasa.gov** **[POC Change September 4, 2019]** ~~Hank Margolis~~ ~~Telephone: (202) 358-4760~~ ~~Email: hank.a.margolis@nasa.gov~~

A.37 GLOBAL NAVIGATION SATELLITE SYSTEM RESEARCH

NOTICE: May 14, 2019. The point of contact for this program element has changed. The new main point of contact is Gerald Bawden, see Section 4. New text is in bold. The due dates remain unchanged.

1. Scope of Program

This announcement seeks innovative approaches to the development and use of Global Navigation Satellite System (GNSS) data, remote sensing techniques, and algorithms to advance Earth system science objectives. Significant growth in the number of GNSS satellites and the expansion of signals and frequencies available to civil applications are providing new opportunities for Earth science research. The GNSS constellations include the United States' Global Positioning System (GPS), Europe's global satellite navigation system GALILEO, Russia's GLObal NAvigation Satellite System (GLONASS), and China's BeiDou. Regional Navigation Satellite Systems (RNSS) provide enhanced regional coverage with optimized orbits and include Japan's Quasi-Zenith Satellite System (QZSS) and India's NAVigation with Indian Constellation (NAVIC). The combined GNSS/RNSS constellations along with the growth of Satellite-Based Augmentation Systems (SBAS) and the anticipated launch of the GPS block III (GPS III) satellites will provide opportunities for remote sensing of the Earth system with new ground-based systems and relatively simple and robust space-borne GNSS receivers.

2. Description of Solicited Research

NASA's Earth Science program as described in Appendix A.1; the National Academy of Sciences, Engineering, and Medicine Decadal Survey, *Thriving on Our Changing Planet: A Decadal Strategy for Earth Observation from Space* (2018) (https://www.nap.edu/catalog/24938), and NASA's *Challenges and Opportunities for Research in ESI (CORE) Report* (2016) (http://go.nasa.gov/2hmZLQO) includes many questions on which GNSS data can be brought to bear. Proposals that use GNSS data and algorithms to advance our understanding of the Earth system; develop new processing and analysis approaches; improve positioning, navigation, and timing (PNT) using GNSS/RNSS signals; and develop truly multi-GNSS capabilities are encouraged. Potential areas of consideration include, but are not limited to:

- Combining GEO (Geosynchronous and geostationary) and LEO (traditional GNSS orbits) GNSS data streams to rapidly characterize transient processes;
- Advancing the understanding of geological hazards by probing the ionosphere using GNSS;
- Expanding the use of GNSS signal and receiver technology to improve the precision of multi-technique geodetic positioning and the international terrestrial reference frame (ITRF);
- Enhancing GNSS research with Signals of Opportunity (SoOp);
- GNSS reflectometry (GNNS-R) for recovery of Earth surface or atmospheric characteristics;
- GNSS radio occultation (GNSS-RO) for recovery of atmospheric structure.

The expansion of the GNSS satellite constellation from Low Earth Orbit (LEO) to GEO (geosynchronous and geostationary) orbits provides opportunities to advance GNSS Earth Science research. This element welcomes proposals that explore research topics that exploit the strengths of multi-GNSS where the combined approach is expected to provide improvement over a single constellation approach. Proposals that explore innovative approaches that combine GEO (Geosynchronous and geostationary) and LEO (traditional GNSS orbits) GNSS data streams to rapidly characterize dynamic and transient processes are encouraged. The propagation of atmospheric gravity waves associated with geological hazards also presents opportunities for GNSS remote sensing of associated signals in the ionosphere.

ESI's Space Geodesy Program (SGP) produces observations that enable the establishment and maintenance of a precise terrestrial reference frame that is foundational to many Earth missions and location-based observations. The GNSS space and ground systems are a critical component of the broader geodetic observing system. A growing number of GNSS satellites have retroreflectors that provide an opportunity to combine Satellite Laser Ranging (SLR) and GNSS space geodesy techniques to improve ITRF solutions. As the number of retroreflector-carrying satellites increases, the ability to collect SLR data for each satellite will become increasingly more challenging. Proposals that seek to improve the ITRF through the joint combination of SLR/GNSS measurements, or develop SLR optimization strategies for GNSS satellites that improve the ITRF while supporting the International Laser Ranging Service operational services (ILRS: https://ilrs.cddis.eosdis.nasa.gov/index.html) are encouraged. Other approaches that seek to improve collocation of GNSS and other geodetic observations are also welcome.

NASA is interested in exploring innovative research that leverages Signals of Opportunity (SoOp) to augment GNSS signals and associated Earth science. Ubiquitous electromagnetic signals including analogue and digital radio and television, Wi-Fi, and cellular communications can be leveraged to provide robustness to augment PNT solutions or additional information to bolster characterization of properties and processes of interest. Proposals to this element that explore the utility of SoOp must present an approach that is still substantively coupled to the use of GNSS signals.

NASA also encourages the use of reflected GNSS signals for the characterization of the Earth's surface and natural hazards. The reception of GNSS reflected signals on airborne and spaceborne receivers have been demonstrated in studying our planet using both low and high incident angle reflections. Furthermore, GNSS data combined with other remote sensing observations have proven valuable for advancing our understanding of the dynamics of the solid Earth within its fluid envelope. Proposals are encouraged that further develop and demonstrate algorithms for the recovery of surface characteristics including, but not limited to; land elevation; soil moisture, snow depth, snow-water equivalent, firn density, and permafrost changes; vegetation characteristics; and ocean circulation, topography, and coastal sea level. The *Decadal Survey* noted that such surface reflections could also provide inexpensive validation data for space-borne sensors such as Ice, Cloud, and land Elevation Satellite 2 (ICESat-2), NISAR, and Surface Water and Ocean Topography (SWOT). Since NASA has already competed for data analysis focused on the CYGNSS mission (see ROSES-2017

Appendix A.52 CYGNSS Competed Science Team) and has a number of competitively-selected tasks already in place, proposals that focus exclusively on CYGNSS data will be considered to be of lower priority than those that address analysis and interpretation of other data sources that have not been the subject of focused solicitations.

The increase in open GNSS signal structures will significantly increase measurement accuracy and utility. Current applications of GNSS remote sensing focus upon the utilization of refracted GNSS signals via occultation measurement schemes for the characterization of the atmosphere and ionosphere, for example tropospheric temperature and water vapor. The *Decadal Survey* specifically identified the need for GNSS-RO combined with microwave and hyperspectral infrared sounding to provide 3D temperature and humidity measurements required for characterizing the Planetary Boundary Layer (PBL). Proposals are encouraged that further develop occultation techniques with a focus upon the broader utilization of existing GNSS signals. The existing Constellation Observing System for Meteorology, Ionosphere & Climate (COSMIC-1) data base, planned COSMIC-2a constellation, commercial, and other satellites may provide GNSS-RO data to support these goals.

Substantive connection to remote sensing data is required in all proposals. Proposers are encouraged to utilize existing or planned ground, airborne, and space-based GNSS observational capabilities and their associated data sets. NASA's space geodesy data are archived at the Crustal Dynamics Data Information System (CDDIS) (https://cddis.nasa.gov). Other NASA datasets are cataloged in the Earth Observing System Data and Information System (EOSIDS) (https://earthdata.nasa.gov) and provided by the other DAACs.

3. Programmatic Guidelines

3.1 Proposals Requesting NASA High-End Computing Resources

Interested proposers should consult Appendix A.1 Earth Science Research Overview, Section 5.4 High-End Computing, Networking, and Storage; and the *Summary of Solicitation*, Section I(d), for a summary of HEC offerings and guidance on requesting computing time.

3.2 Documenting Work Effort and Current and Pending Support

Work Effort and Current and Pending Support for PIs and Co-Is must be documented using the templates available on the SARA webpage (https://science.nasa.gov/researchers/templates-for-earth-science-division-appendix-a-roses-proposals).

4. Summary of Key Information

Expected annual program budget for new awards	~$1.5M
Number of new awards pending adequate proposals of merit	~8-10
Maximum duration of awards	3 years

Due date for Notice of Intent to propose (NOI)	See Tables 2 and 3 of ROSES
Due date for proposals	See Tables 2 and 3 of ROSES
Planning date for start of investigation	March 1, 2020
Page limit for the central Science-Technical-Management section of proposal	15 pp; see also Table 1 of the ROSES *Summary of Solicitation* and the *NASA Guidebook for Proposers.*
Relevance	This program is relevant to the Earth science questions and goals in the NASA Science Plan. Proposals that are relevant to this program are, by definition, relevant to NASA.
General information and overview of this solicitation	See the *ROSES Summary of Solicitation*.
Detailed instructions for the preparation and submission of proposals	See the *NASA Guidebook for Proposers* at http://www.hq.nasa.gov/office/procurement/nraguidebook/.
Submission medium	Electronic proposal submission is required; no hard copy is permitted.
Web site for submission of proposal via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Web site for submission of proposal via Grants.gov	http://grants.gov (help desk available at support@grants.gov or (800) 518-4726)
Funding opportunity number for downloading an application package from Grants.gov	NNH19ZDA001N-GNSS
Point of contact concerning this program	**Gerald Bawden [Updated May 14, 2019]** Earth Science Division Science Mission Directorate National Aeronautics and Space Administration Washington, DC 20546-0001 Telephone: (202) 358-**3922** Email: **gerald.bawden@nasa.gov**

A.38 PACE SCIENCE AND APPLICATIONS TEAM

1. Scope of the Program

The Plankton, Aerosol, Cloud, ocean Ecosystem (PACE) mission is part of NASA's implementation of the National Academies of Sciences, Engineering and Medicine (NASEM) report, *Thriving on Our Changing Planet: A Decadal Strategy for Earth Observations from Space* released in early 2018 (herein referred to as the "Decadal Survey". The PACE mission (https://pace.gsfc.nasa.gov) remains part of the Program of Record, to be executed as planned in the new Decadal Survey. In summer 2019, PACE will reach its Key Decision Point-C (KDP-C) to codify observational requirements and enter its Final Design and Implementation phase (Phase C). Technical documents and presentations related to the mission, including its Science Definition Team report and an emerging series of NASA Technical Memoranda, can be found on the PACE Web site (https://pace.oceansciences.org/documents.htm).

Global observations of the ocean, such as those from PACE, are critical to NASA's support of Executive Orders (EO) of the US government, including the EO Oceans (https://www.whitehouse.gov/presidential-actions/executive-order-regarding-ocean-policy-advance-economic-security-environmental-interests-united-states/). NASA is a member of the White House National Science and Technology Council's Subcommittee on Ocean Science and Technology (SOST). The PACE mission and its associated data products and observations are in support of the SOST report "*Science and Technology for America's Oceans: A Decadal Vision*" (https://www.whitehouse.gov/wp-content/uploads/2018/11/Science-and-Technology-for-Americas-Oceans-A-Decadal-Vision.pdf). This vision identifies five goals to advance U.S. ocean science and technology and the nation in the coming decade: (1) Understand the Ocean in the Earth System; (2) Promote Economic Prosperity; (3) Ensure Maritime Security; (4) Safeguard Human Health; and (5) Develop Resilient Coastal Communities. The PACE mission will provide observations that support strategic objectives, such as (1), in support of a blue economy and applied science objectives with societal benefits.

PACE's primary instrument (the Ocean Color Instrument; OCI) consists of two spectrometers that continuously span the ultraviolet to orange and orange to near-infrared spectral regions, with an additional seven discrete shortwave infrared bands. This instrument will be complemented by two small, multi-angle polarimeters with spectral ranges that span the visible to near-infrared region. Thus, the mission will be capable of performing radiometric and polarimetric ocean and atmosphere surveys, returning a range of geophysical data from which properties of the ocean and atmosphere can be produced to add to other critical climate and Earth system variables. As currently envisioned, the PACE mission has multiple scientific goals, including making climate-quality global ocean color measurements that are essential for understanding the carbon cycle and global ocean ecology and determining how the ocean's role in global biogeochemical (carbon) cycling and ocean ecology both affects and is affected by climate change. The PACE observatory also includes bands for aerosol and cloud studies, and, therefore, will extend key observations of atmospheric properties, focusing on reducing the largest uncertainty in radiative forcing of the Earth System. OCI will extend the oceanic and many of the atmospheric data records from the

Sea-viewing Wide Field-of-view Sensor (SeaWiFS) and Moderate Resolution Imaging Spectroradiometer (MODIS) that are not met or physically cannot be met by the Visible Infrared Imager Radiometer Suite (VIIRS) sensors. The polarimetric measurements will provide extended data records on clouds and aerosols, as well as complement the aforementioned ocean color observations, provide better quantitative estimates of aerosol type and height, improve our understanding of atmospheric dynamics and radiative sciences, and advance the atmospheric correction capabilities for ocean color remote sensing.

Key characteristics of the PACE observatory include:

- The Ocean Color Instrument (OCI), built at Goddard Space Flight Center
- The Hyper Angular Research Polarimeter (HARP-2), contributed by the Earth and Space Institute at the University of Maryland Baltimore County
- The Spectro-polarimeter for Planetary Exploration (SPEXone), contributed by a Netherlands-based consortium consisting of the Netherlands Institute for Space Research (SRON) and Airbus Defence and Space Netherlands
- 675.5 km altitude and 13:00 local Equatorial crossing time
- Sun synchronous, polar, ascending orbit with 98º inclination
- Fall 2022 launch, three-year design life, 10-years of fuel

See also https://pace.oceansciences.org/mission.htm. The OCI design follows that of SeaWiFS, with a rotating telescope, a half angle mirror, and a depolarizer. OCI will also acquire monthly lunar observations that illuminate all science detector elements for a lunar calibration time-series, as well as perform daily instrument characterizations using solar diffusor(s). HARP-2 is a hyper-angular imaging polarimeter that will see Earth simultaneously from multiple viewing angles using a modified Philips prism design to collect simultaneous measurements of linear polarization in three orientations. SPEXone uses a spectral modulation technique that encodes the degree and angle of linear polarization into a modulation of the radiance spectrum. Additional instrument specifications for OCI, HARP-2, and SPEXone include:

	OCI	**HARP-2**	**SPEXone**
UV-NIR range [bandwidth]	Continuous from 345-890* nm in 5 nm steps [5]	440, 550, 670 [10] nm and 870 [40] nm	Continuous from 385-770 nm in 2-4 nm steps
SWIR range [bandwidth]	940 [45], 1038 [75], 1250 [30], 1378 [15], 1615 [75], 2130 [50], and 2260 [75] nm	None	None
Polarized bands	None	All	Continuous from 385-770 nm in 15 to 45 nm steps

Number of viewing angles [degrees]	Fore-aft instrument tilt of ±20° to avoid Sun glint	10 for 440, 550, 870 nm; 60 for 670 nm [spaced over 114°]	5 [-57°, -20°, 0°, 20°, 57°]
Swath width	±56.5° [2663 km at 20° tilt]	±47° [1556 km at nadir]	±4° [100 km at nadir]
Global coverage	1-2[+] days	2 days	~1 month
Ground pixel	1 km at nadir	3 km	2.5 km
Heritage	N/A	AirHARP, cubesat	AirSPEX
Institution	GSFC	UMBC	SRON

* The mission carries a goal of extending the shortest wavelength to 320 nm.
+ 2 day coverage when limited to solar and sensor viewing angles of 75° and 60°, respectively.

A core PACE mission requirement is development of the following data products (with corresponding uncertainties) from OCI alone:

Data Product	Uncertainty
Water-leaving reflectances from 350 to 400 nm	0.0057 or 20%
Water-leaving reflectances from 400 to 600 nm	0.0020 or 5%
Water-leaving reflectances from 660 to 710 nm	0.0007 or 10%
Total aerosol optical depth at 380 nm	0.06 or 40%
Total aerosol optical depth at 440, 500, 550 and 675 nm over land	0.06 or 20%
Total aerosol optical depth at 440, 500, 550 and 675 nm over oceans	0.04 or 15%
Fine mode fraction of aerosol optical depth over oceans at 550 nm	±25%
Cloud layer detection for optical depth < 0.3	40%
Cloud top pressure of opaque (optical depth > 3) clouds	60 hPa
Optical thickness of liquid clouds	25%
Optical thickness of ice clouds	35%
Effective radius of liquid clouds	25%
Effective radius of ice clouds	35%

Each uncertainty is defined as the maximum of the absolute and relative values when both are provided and for Level-2 satellite data processing (geophysical values in the original satellite coordinate system). The water-leaving reflectance requirements are defined for ≥50% of the observable deep ocean (depth ≥ 1000 m). The other requirements are defined for ≥65% of the observable atmosphere. PACE will produce a large suite of additional geophysical products from OCI including, but not limited to, spectral marine inherent optical properties (e.g., absorption and scattering coefficients), phytoplankton pigment concentrations, metrics related to phytoplankton physiology and carbon stocks, water paths for liquid and ice clouds, and data products to support ocean and atmospheric applications studies (see the PACE Science Definition Team report, https://pace.oceansciences.org/documents.htm). The inclusion of multi-angle polarimetry on the observatory should enable production of atmospheric and oceanic data products that exceed the capabilities of OCI alone, such as aerosol and hydrosol refractive indices, and further facilitate coupled ocean-atmosphere retrievals (see the PACE Science Definition Team report). While terrestrial applications are not the mission focus, PACE's observations will also provide information on radiative properties of land surfaces and characterization of the vegetation and soils that dominate their reflectance.

While the first goal of PACE mission science is to open new vistas in aquatic biogeochemistry by measuring non-chlorophyll pigments, separate chlorophyll and colored dissolved organic matter (CDOM), and characterize plankton taxonomy and advance biogeochemical and new data products, PACE science will also follow aquatic biochemistry into ecosystems in coastal regions, estuaries, tidal wetlands, and lakes. PACE's second science goal is to extend aerosol and cloud data records begun by the passive EOS-era instruments, as an aerosol-cloud-climate continuity mission. NASA plans for multiangle radiometry to continue the MISR record, or for multiangle polarimetry to continue the PARASOL record, will be realized well into the future as the Designated Observable of the Aerosol and Cloud, Convection, Precipitation (A-CCP) concepts mature (A-CCP based on the Designated Observable from the report Thriving on Our Changing Planet: A Decadal Strategy for Earth Observations from Space) over the next five to ten years. A multi-angle polarimeter on PACE will reduce risk towards meeting the first goal and enable the realization of the second goal. The President's FY2018 budget request allows for a PACE Launch Readiness Date (LRD) as early as August 2022 to enable these critical climate measurements.

2. Science and Applications Team for the PACE Mission

The purpose of this solicitation is to formulate a Plankton, Aerosol, Cloud, ocean Ecosystem (PACE) Science and Applications Team (SAT) for a three -year period (FY20-22). The team will encompass basic and applied research and applications, using data from precursors to OCI, HARP-2, and SPEXone. This solicitation welcomes proposals from prospective Science and Applications Team members who wish to pursue one or more areas of basic and applied research including:

1. Theoretical and analytical studies associated with the use of *OCI-analog hyperspectral data* (see following paragraph for sample data streams) for the development of an algorithm or approach for one or more ocean color, aerosol, and/or cloud data product or suite of products from OCI;
2. Theoretical and analytical studies associated with the use of *HARP-2- and/or SPEXone-analog multi-angle polarimetric data* (see following paragraph for sample data streams) for the development of an algorithm or approach for one or more ocean color, aerosol, and/or cloud data product or suite of products;

3. Theoretical and analytical studies associated with the use of *OCI-analog hyperspectral data* and *HARP-2/SPEXone-analog multi-angle polarimetric data* for the development of one or more cross-instrument ocean color, aerosol, and/or cloud data products; and
4. Applications derived from *OCI-analog hyperspectral data and/or HARP-2/SPEXone-analog multi-angle polarimetric data* for societal benefit, addressing topics including but not limited to: management of marine ecosystems and resources (e.g., fisheries), water quality management (e.g., harmful algal blooms), hazard mitigation and response (e.g., volcanic ash and aviation safety, oil spills), air quality and public health, and improved adaptation and response to climate variability and change.

Desired data products encompass those listed above as well as others not listed, but producible using remotely-sensed data from OCI, HARP-2, and SPEXone. Example analog datasets include, but are not limited to, HICO (https://oceancolor.gsfc.nasa.gov/cgi/browse.pl?sen=hi), DESIS (https://directory.eoportal.org/web/eoportal/satellite-missions/content/-/article/iss-muses), AVIRIS (https://aviris.jpl.nasa.gov), AVIRIS-NG (https://aviris-ng.jpl.nasa.gov), PRISM (https://prism.jpl.nasa.gov), AirHARP (https://esi.umbc.edu/harp-polarimeters/), AirSPEX (https://www.sron.nl/earth-instrument-development/spex), MISR (https://eosweb.larc.nasa.gov/project/misr/misr_table), and PARASOL (https://parasol.cnes.fr/en/PARASOL/index.htm). In addition, researchers may utilize hyperspectral synthetic data sets developed prior to launch, the utility of which must be justified for the study, as well as the relevance to the PACE mission, instruments, and science.

Note that this solicitation seeks basic and applied research and applications that specifically exploit the unique capabilities of the PACE observatory. Proposals that do not consider the hyperspectral capabilities of OCI and/or multi-angle polarimetry will be considered non-responsive (for example, multi-spectral heritage approaches tuned to OCI wavelengths will not be considered).

It is expected that any selected Principal Investigators (PIs) or teams selected for the PACE science and applications team will deliver an implementable approach or algorithm for a given data product pre-launch (LRD August 2022) and work with the PACE Project Science team and Science Data Segment (SDS) co-located and integrated into the NASA Ocean Biology Processing Group to implement the approach or algorithm for a given data product pre-launch. As the LRD may change during mission development, proposals should consider required post-launch activities, including continuing to work with Project Science and the SDS for routine analysis and assessment of the quality, accuracy and precision of a proposed data product, including regular interaction to sort out instrument versus geophysical data challenges and validation of a given data product proposed. Uncertainties for each data product produced must be quantified in all proposals.

It is expected that proposals will explicitly describe one or more strategies for verifying approach and/or algorithm performance both pre- and post-launch. All strategies should include methodologies as well as both pre- and post-launch data sources to be incorporated into performance verification and science and applications data product validation activities. Regular reporting on these metrics will come in the form of required reports and regular (e.g., monthly) team telecons.

The science and applications team is expected to be composed of a diverse group of investigators who cumulatively bring end-to-end knowledge of different aspects of the breadth of basic and applied research and applications possible from the PACE observatory, as well as the scientific, algorithm, and modeling approaches of measurements and data products needed to address the science questions of the mission (see the PACE Web site and Science Definition Team report). End-to-end knowledge encompasses laboratory and field measurement protocols and quality assurance, radiative transfer modeling, remote sensing theory in the UV-to-SWIR spectral range, and ocean color, aerosol, and cloud algorithms, such as those currently applied in standard MODIS and VIIRS data processing.

As previously mentioned, it is expected that PACE data will be used to study a multitude of oceanic properties, including but not limited to:

- inherent optical properties, such as spectral absorption and scattering properties of phytoplankton, nonalgal particles, dissolved organic matter, and seawater itself;
- the relationship of marine optical properties to biogeochemical stocks in order to estimate biogeochemical properties of the ocean;
- ecological and biological properties, such as carbon stocks and fluxes, phytoplankton pigment concentrations, phytoplankton physiology, plankton community structure, including phytoplankton functional types (PFTs), primary productivity; and
- a host of other products, such as those derived from polarimetric observations and those that support applications, such as light attenuation and metrics of water quality.

It is also expected that PACE data will be used to study aerosol and cloud properties, including but not limited to, aerosol and cloud optical thicknesses and liquid and ice cloud water paths and effective radii; atmospheric correction of ocean color radiometry including, but not limited to, hyperspectral methods, modeling of bidirectional effects and non-negligible radiances in the near-infrared, and absorbing aerosols detection; and, methods for novel aerosol and cloud retrievals, including those that support applications, such as air quality data products. In addition, PACE data may support terrestrial community research and data products and this solicitation encourages proposals that develop data products, approaches, or measurements to answer any overarching PACE science question, including those at atmosphere/land, cryosphere/ocean, land/ocean, atmosphere/ocean, or other Earth system interfaces.

NASA welcomes proposals for a PI who wishes to be the science and applications team leader. NASA will select one science and applications team lead to oversee and coordinate activities for all measurement set groups (aerosols, clouds, and ocean color, including applications, from OCI and the polarimeters). A desire to serve as the PACE science and applications team leader should be clearly identified in a separate section of the proposal and will be allotted two extra pages for the submission of this section only. The science and applications team leader will organize, plan, and chair any needed meetings, coordinate all measurement groups, integrate the input of the various team members within the individual groups, and work to achieve consensus on the overall science and applications objectives and requirements of each group as well as the integrated science and applications team. NASA reserves the right to appoint a deputy team leader to assist the PACE lead to ensure the breadth of expertise is well represented. The PACE science and applications team leader (and possible deputy team leader) will act in close association with the PACE Project Scientists (Dr. Jeremy Werdell, Dr. Antonio Mannino, and Dr. Brian Cairns, NASA GSFC/GISS), Program and Deputy Program Scientists (Dr. Paula Bontempi and Dr. Hal Maring, NASA Headquarters), SDS leadership (Mr. Bryan Franz, NASA GSFC), as well as the Program Applications Lead (Mr. Woody Turner, NASA Headquarters) to achieve science and applications team goals. PIs interested in being the PACE science and applications team leader should budget accordingly and keep the budget for the team leader role and requirements separate from any proposed research and applications activities. PIs interested in being the PACE science and applications team leader should also contact the PACE Program Scientist, Dr. Paula Bontempi, before they apply to discuss the commitment and requirements for this role.

Each awarded PI will be expected to collaborate closely with other science and applications team members and will produce annual reports that detail recommended approaches for the given PACE data product(s) within their respective efforts. As a whole, the ultimate goal for the science and applications team is to achieve *consensus* and develop community-endorsed paths forward for the PACE data products on which they are working, as well as for the full spectrum of components within a given measurement suite (aerosols, clouds, and ocean color). The desire is to augment individual science and applications team member recommendations for measurement, algorithm, and retrieval approaches (historically based on the individual expertise and interests of PIs) with consensus input toward common goals, building on previous PACE science team consensus reports on, for example, inherent optical property retrievals and their gaps (https://pace.oceansciences.org/docs/werdell_et_al_2018_po.pdf and https://pace.oceansciences.org/docs/pace_gaps_iop.pdf), cloud retrievals (https://pace.oceansciences.org/docs/TM2018219027Vol.4.pdf), and polarimetry (https://pace.oceansciences.org/docs/TM2018219027Vol.3.pdf). Other supporting PACE science team publications are available on the PACE Web site (https://pace.oceansciences.org/science_team.htm).

ALL proposals must detail the science and applications questions to be addressed by the proposed approaches (i.e., the expected scientific and applications outcomes to be realized by implementing the proposed approaches), what theoretical or analytical analyses will be undertaken by the proposed activities and how these analyses will be used to quantify and reduce science and applications data product uncertainties, the measurement risk to be reduced as a result of the proposed activities, how the risk reduction will be assessed, and how (and with what data/tools) the performance of their activities will be assessed. In addition, all proposers should describe the methods or approaches by which they anticipate building consensus among the science and applications team members and outline methods for implementing their proposed approach and/or algorithm (as appropriate) into the data processing capabilities of the

NASA Ocean Biology Processing Group (OBPG) at Goddard Space Flight Center that will be serving as the PACE SDS (https://oceancolor.gsfc.nasa.gov). Proposers can include analysis of existing laboratory or field data, although only MINOR and well-justified laboratory and field data collection activities to support specific science and applications questions will be entertained.

PACE Project Science and SDS members will be available to interface with awarded science and applications team members for implementation, impact assessment (e.g., viability given computing resources), and testing of approaches and/or algorithms. Project Science and SDS staff will be charged to function as liaisons between the science and applications team and the NASA centers that currently handle the permanent data archival and distribution of aerosol, cloud, and ocean color missions at NASA, respectively. The PACE mission will adhere to a rigorous science data product selection, testing, and implementation plan (see the PACE Science Data Product Selection Plan available at https://pace.oceansciences.org/documents.htm). The Project Science and SDS designees will participate in all science and applications team activities, including scientific discussions, measurement discussions, algorithm development and retrieval activities, and associated algorithm/retrieval testing and implementation activities (as appropriate). This will be done to resolve any outstanding data processing and distribution issues for PACE mission data prior to launch and post-launch.

International PIs from institutions in countries outside the U.S. are free to propose to this solicitation on a no-exchange-of-funds basis. PIs from institutions outside the U.S., as interested, should indicate to the Points-of-Contact below their desire for participation.

All PACE Level-0, -1, -2, and -3 data products (http://science.nasa.gov/earth-science/earth-science-data/data-processing-levels-for-eosdis-data-products/) and science data processing software/source code/algorithms from all instruments on the observatory will be incorporated into the NASA OceanColor Web site (http://oceancolor.gsfc.nasa.gov) to be publicly distributed according to NASA SMD open data access policies (https://science.nasa.gov/earth-science/earth-science-data/data-information-policy). Proposers should expect all software and approaches to be open source and publicly distributed via SeaDAS (https://seadas.gsfc.nasa.gov) or equivalent.

2.1 Applications Proposals

Applications proposals must identify at least one specific management need to be addressed through the use of applications products generated through this solicitation. Applications proposals must further identify the end user(s) associated with the management need(s) and include an individual from the end-user organization as a team member on the proposal. Applications project teams should consider having the Principal Investigator (PI) be someone who is very familiar with the needs of the end-user (i.e., decision-making) organization(s). Proposals should clearly describe the need to be addressed by the method, tool, or product to be developed and explain how these products will be incorporated in the end-user's decision-making activity.

Furthermore, applications proposals must outline plans—along with a schedule—for the transition of applications data products to the end-user organization(s) for deployment and long-term sustained use by no later than the final project year and include an end-of-project event to announce results in this regard.

Applications proposals must also contain an assessment of the Applications Readiness Level (ARL) at the time of the proposal for any method, tool, or product to be developed through a proposed project as well as an expected end point ARL at the conclusion of the project. For information on NASA ARLs, please see http://www.nasa.gov/sites/default/files/files/ExpandedARLDefinitions4813.pdf.

3. Summary of Key Information

Expected program budget for first year of new awards	$3.2M
Number of new awards pending adequate proposals of merit	12-20
Maximum duration of awards	3 years
Due date for Notice of Intent to propose (NOI)	See Tables 2 and 3 of this ROSES NRA
Due date for proposals	See Tables 2 and 3 of this ROSES NRA
Planning date for start of investigation	October 1, 2019
Page limit for the central Science-Technical-Management section of proposal	15 pages; see also Table 1 of ROSES and Section 3.7 of the *Guidebook for Proposers*.
Relevance to NASA	This program is relevant to the Earth science strategic goals and subgoals in NASA's *Strategic Plan*. Proposals that are relevant to this program are, by definition, relevant to NASA.
General information and overview of this solicitation	See the *ROSES Summary of Solicitation*.
Detailed instructions for the preparation and submission of proposals	See the *NASA Guidebook for Proposers* at http://www.hq.nasa.gov/office/procurement/nraguidebook/
Submission medium	Electronic proposal submission is required; no hard copy is required. See also Section IV in the *ROSES Summary of Solicitation* and Chapter 3 of the *NASA Guidebook for Proposers*.
Web site for submission of proposal via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Web site for submission of proposal via Grants.gov	http://grants.gov (help desk available at support@grants.gov or (800) 518-4726)
Funding opportunity number for downloading an application package from Grants.gov	NNH19ZDA001N-PACESAT

NASA points of contact concerning this program all of whom share the following address: Earth Science Division Science Mission Directorate National Aeronautics and Space Administration 300 E Street, SW Washington, DC 20546	Paula Bontempi Ocean Biology and Biogeochemistry Program Telephone: 202-358-1508 Email: Paula.Bontempi@nasa.gov Hal Maring Radiation Sciences Program Telephone: (202) 358-1679 Email: hal.maring@nasa.gov Woody Turner Ecological Forecasting program element Applied Sciences Program Telephone: (202) 358-1662 Email: woody.turner@nasa.gov

A.39 THE PLANKTON, AEROSOL, CLOUD, OCEAN ECOSYSTEM (PACE) MISSION SYSTEM VICARIOUS CALIBRATION

NOTICE: NASA will not solicit research proposals under the PACE Vicarious Calibration program element in ROSES-2019. This program was solicited as a late ROSES-2018 program, with due dates in calendar year 2019. Interested proposers should see Appendix A.48 of ROSES-18.

1. Scope of the Program

The Plankton, Aerosol, Cloud, ocean Ecosystem (PACE) mission is part of NASA's implementation of the National Academies of Sciences, Engineering and Medicine (NASEM) report, *Thriving on Our Changing Planet: A Decadal Strategy for Earth Observations from Space* released in early 2018 (herein referred to as the "Decadal Survey". The PACE mission (https://pace.gsfc.nasa.gov) remains part of the Program of Record, to be executed as planned in the new Decadal Survey. In summer/fall 2019, PACE will reach its Key Decision Point-C (KDP-C) to codify observational requirements and enter its Final Design and Implementation phase (Phase C). Technical documents and presentations related to the mission, including its Science Definition Team report and an emerging series of NASA Technical Memoranda, can be found on the PACE Web site (https://pace.oceansciences.org/documents.htm).

PACE's primary instrument (the Ocean Color Instrument; OCI) consists of two spectrometers that continuously span the ultraviolet to orange and orange to near-infrared spectral regions, with an additional seven discrete shortwave infrared bands. This instrument will be complemented by two small, multi-angle polarimeters with spectral ranges that span the visible to near-infrared region. Thus, the mission will be capable of performing radiometric and polarimetric ocean and atmosphere surveys, returning a range of geophysical data from which properties of the ocean and atmosphere can be produced to add to other critical climate and Earth system variables. As currently envisioned, the PACE mission has multiple scientific goals, including making climate-quality global ocean color measurements that are essential for understanding the carbon cycle and global ocean ecology and determining how the ocean's role in global biogeochemical (carbon) cycling and ocean ecology both affects and is affected by climate change. The PACE observatory also includes bands for aerosol and cloud studies, and, therefore, will extend key observations of atmospheric properties, focusing on reducing the largest uncertainty in radiative forcing of the Earth System. OCI will extend the oceanic and many of the atmospheric data records from the Sea-viewing Wide Field-of-view Sensor (SeaWiFS) and Moderate Resolution Imaging Spectroradiometer (MODIS) that are not met or physically cannot be met by the Visible Infrared Imager Radiometer Suite (VIIRS) sensors. The polarimetric measurements will provide extended data records on clouds and aerosols, as well as complement the aforementioned ocean color observations, provide better quantitative estimates of aerosol type and height, improve our understanding of atmospheric dynamics and radiative sciences, and advance the atmospheric correction capabilities for ocean color remote sensing.

Questions related to this program may be directed to:

Paula Bontempi
Earth Science Division
Science Mission Directorate
NASA Headquarters
Washington, DC 20546-0001
Telephone (202) 358-1508
Email: paula.bontempi@nasa.gov

Parminder Ghuman
Science Mission Directorate
Earth Science Technology Office
Telephone: (301) 286-8001
Email: p.ghuman@nasa.gov

A.40 UNDERSTANDING CHANGES IN HIGH MOUNTAIN ASIA

NOTICE: Updated April 4, 2019. The point of contact for this program element has changed. The new main point of contact is Jared Entin. New text is in bold and deleted text is struck through.

Read this solicitation in its entirety. It has new requirements for Open Science.

1. Introduction

High Mountain Asia (HMA), extending from the Hindu Kush and Tien Shan in the west to the Eastern Himalaya, is the world's largest reservoir of perennial glaciers and snow outside of the Earth's polar ice sheets. The region is home to a range of unique landforms, ecosystems, hazards, and cultures; and HMA supplies water to more than a billion people. Changes in the region's glaciers, snow, permafrost, and precipitation patterns have altered this water supply, while also transforming regional ecology, land utilization practices, and the hazards associated with landslides and glacial-lake-outburst floods.

Satellite remote sensing observations have helped characterize these changes; gain insight into the Earth system processes that control them; and inform decisions, management actions, and policy development.

Offered initially as program element A.48 of ROSES-2015, this second offering of UNDERSTANDING CHANGES IN HIGH MOUNTAIN ASIA is intended to both advance from and build on outcomes from the first round of awards. The results of these investigations are available at the NASA's Distributed Active Archive Center (DAAC) at the National Snow and Ice Data center (https://nsidc.org/data/highmountainasia) which includes discussion of NASA's Glacial Melt Toolbox (GMELT). GMELT consists of new remote sensing products (such as DEMs and maps and snow cover), model output optimized for the region (such as precipitation, dust, and water) and other tools to assess and project change in the water, ice, snow, hazards, and related phenomena in HMA.

Potential proposers are also recommended to review other HiMAT resources at https://himat.org/, https://github.com/NASA-Planetary-Science/HiMAT, and the awards from the first round of funding at https://nspires.nasaprs.com/external/viewrepositorydocument/cmdocumentid=547891/solicitationId=%7B543B121B-9366-B564-9E67-F265368D1B03%7D/viewSolicitationDocument=1/HMA15 Abstractsupdated.pdf.

2. Scope of Program

This solicitation funds investigations into HMA's glaciers, snow, permafrost, and precipitation to improve our understanding of regional changes, water resources, and induced impacts, while furthering NASA's strategic goals in Earth system science and societal applications. Through expanded knowledge of the processes controlling change in HMA, the program intends to improve regional projections and address vulnerabilities in human and biogeophysical systems.

During the previous round of funding, tremendous gains were made in creating new remote sensing products, collecting base data, and developing regional models for climate and water (https://nsidc.org/data/highmountainasia). This next phase of the program will allow for continued work in these areas, but with the expectation of specifically advancing regional projections. In addition, this next phase requires very specific Open Science approaches, described in detail under Section 3.2 Proposal Requirements, with goals of accelerating advances, fostering transdisciplinary approaches, and communicating methods in greater to detail.

Proposers are also recommended to consider using NASA's newest Earth orbiting satellites and sensors, including GRACE-FO (https://gracefo.jpl.nasa.gov/), ICESat-2 (https://icesat-2.gsfc.nasa.gov/), and GEDI (https://gedi.umd.edu/).

2.1 Requirements

The program has the following requirements of all investigations:

1) Investigations must be based on satellite remote sensing observations (including both NASA and/or non-NASA assets), but should, as appropriate, be integrated with *in situ* measurements and models.
2) Every investigation must be framed to contribute to the development or refinement of tools to foster inter and transdisciplinary research, project change in the region, and/or support policy development and related work. Tools should be interoperable with the understanding that they are being linked as possible into the existing and developing GMELT (https://nsidc.org/data/highmountainasia).
3) GMELT development and utilization for science, projections, and assessments will be enabled by NASA's High Mountain Asia Team (HiMAT). Key investigators associated with each project selected under this solicitation will receive support to participate as members of HiMAT.
4) Development of GMELT components will be completed within two years to allow for integration of outputs among teams in the final year. GMELT components is defined broadly to include all new and derived remote sensing products, model output optimized for the region, and any other tools developed to assess and project change in HMA. Completed work is delivered to the NASA DAAC and or other open archive such as Github.
5) Understanding and projecting change in HMA requires the coordinated efforts of a diverse group of scientists. This program element encourages integrative, interdisciplinary proposals from groups of scientists of up to $1M per year.

2.2 Specific investigations

Specific investigations to be supported under this solicitation include, but are not limited to, the following three elements:

1) Earth Science research, including:
   - Satellite remote sensing studies aimed at better characterizing and understanding the processes controlling change of snow, glaciers, permafrost, precipitation, and ecosystems.
   - Modeling of these processes as applied to the HMA region to support Earth science research and regional projections.

- Obtaining and developing data sets to understand the underlying causality of change through determination of the specific processes involved, as well as to validate and support process and modeling studies.
- Optimizing and downscaling to national-levels of high-resolution meteorological models and satellite reanalyses products for HMA, preferably spanning the time period from 1980 to the present, aimed at understanding the drivers of change in the glaciers, snow, permafrost, and precipitation of the region.
- Assessing and developing early warning of regional geophysical hazards such as glacial outburst floods, landslides, debris flows, ecosystem and infrastructure impacts, and integrated assessments of cascading hazards to at least the national level.

2) Projections - through the development and/or utilization of GMELT - of changes in the HMA's:
   - Cryosphere;
   - Precipitation;
   - Water resources; and
   - Geophysical hazards.

3) Impact to Decisions and Actions It is intended that investigations under Earth Science and Projections will have outcomes sufficient to have Impact to Decisions and Actions of the HMA region, especially:
   - Construction of decision support tools to projection of regional change in water resources over the next 1-100 years; and
   - Application of hazard assessments to support regional planning.

3. Proposal Details and Review information

Proposed research investigations must meet the following criteria, and each of these should be specifically addressed in the proposal:

- Proposals must address at least one of the areas listed - Earth Science, Projections, or Impact to Decisions and Actions - and must identify clearly which area or areas are being addressed.
- Proposals must be based on satellite observations (including both NASA and/or non-NASA assets), but should include suborbital sensors and *in situ* information, as appropriate.
- Earth Science proposals must go beyond creation or correlation of data sets and seek to understand the underlying causality of change through determination of the specific processes involved.
  - Impact to Decisions and Actions proposals must address the targeted end user(s), including their needs, use of the tools, and policies to be impacted. Encouraged are proposals that consider ways to link to support services provided by SERVIR Hindu Kush Himalaya (https://servirglobal.net/ and http://servir.icimod.org/).
- Proposals must explain how the research will be integrated into and/or benefit from GMELT tools, and how the tool will be documented to enable use by the

broader community in accordance with Open Science and Open Source standards discussed in the following sections.

- Proposals must discuss how the Principal and Co-Investigators (PIs and Co-Is) will work with the HiMAT team for regional projections, interdisciplinary research, and integrated development of GMELT.
- Proposals must include a schedule that completes the proposed investigation's individual contributions within two years to allow for integration with those of other teams in the final year.
- Studies that require a focus on small spatial scales, such as specific events or geographic regions, must describe how the results will be made scalable and extensible to the broadest possible areas, timescales, and projections.

3.1 GMELT contributions and development

It is expected that all proposals will contribute to or utilize GMELT. GMELT's form is open; at present it consists of:

- New remote sensing products, e.g. regionally optimized freeze-thaw maps from ASCAT and highly refined maps of snow cover from MODIS observations;
- Derived remote sensing products, e.g. digital elevation models (DEMs) derived from satellite imagery;
- Model output optimized for the region, such as high resolution atmospheric models for precipitation as well as optimized global models of dust deposition;
- Projections, such as expected changes in regional water resources and landslide potential; and
- Other tools, such as numerical models of glacially dammed lakes to assess Glacial Outburst Flood potential.

Proposals for Earth science research should be framed to contribute to GMELT. Proposers that strictly intend to use tools for Impact to Decisions and Actions must either use existing GMELT resources or develop collaborative relationships with proposers planning to develop tools, but may submit independent proposals.

GMELT requires development and documentation such that all tools can be used independently by the broader community. All investigations that will develop and/or refine GMELT tools must include explicit development and documentation plans in the proposal, including delivery of all relevant codes, algorithms, and documentation to the NSIDC DAAC (https://nsidc.org/data/highmountainasia/data-summaries), in compliance with NASA standards (https://earthdata.nasa.gov) as well as the Open Science and Open Source standards discussed below. Proposers are also strongly encouraged to develop within or at least submit codes to https://github.com/NASA-Planetary-Science/HiMAT.

3.2 Open Science approaches

This solicitation requires proposers to implement *Open Science* (OS) approaches in line with the recommendations of the report *Open Science by Design: Realizing a Vision for 21st Century Research* from the *National Academies of Science, Engineering and Medicine* (https://www.nap.edu/catalog/25116/open-science-by-design-realizing-a-vision-for-21st-century). Some key recommendations from the report that are particularly relevant to this element include, but are not limited to, the following:

- Developing proposals using the principles of FAIR (Findable-Accessible-Interoperable-Reusable);
- Conducting research using tools compatible with open sharing;
- Preparing data and tools for reproducibility;
- Documenting approaches in an electronic research notebook; and
- Depositing research outputs in FAIR archives.

NASA recognizes that fully implementing OS approaches will be challenging. However, NASA sees great benefit to these approaches for accelerating advances in HMA research and proposers are required to include OS in their work plans to achieve the following goals:

- Progress is accelerated to the maximum extent possible by sharing advances during the conduct of investigations, not just at the publication stage. This sharing:
  - Includes all aspects of investigations, including scientific results and work in progress, such as development of new models or data products; and
  - Happens openly and frequently via team meetings, contributions to open repositories, and other communications with colleagues.
- Transdisciplinary research is fostered to create a unity of intellectual frameworks beyond the disciplinary perspectives;
  - Specific efforts are made to make the investigation's goals, methods, and outcomes accessible and useful to teams from other disciplines; and
  - Regular updates are made to the HiMAT team's science traceability matrices for both content and delivery.
- Workflows are documented to facilitate sharing of advances and validating results, by:
  - Utilizing open-source digital notebooks - such as Jupyter Notebook (http://jupyter.org/) - that both document and demonstrate workflow;
  - Regular uploads (at least every 6 months) to appropriate open code repositories - such as Github (https://github.com/) - of digital notebooks and other codes; and
  - Ensuring critical ancillary datasets are available in ready-to-use subsets and formats via open archives and/or the relevant NASA Distributed Active Archive Center (https://earthdata.nasa.gov/).
- Crediting individuals making similar pre-publication contributions wherever possible through co-authorship and other methods.

NASA requires proposals to specifically address each of these goals and will evaluate proposals with regards to their likelihood for success.

3.3 Open Source Software

Awards made under this solicitation must follow NASA's Earth Science Data Systems (ESDS) Open Source Software Policy (https://earthdata.nasa.gov/earth-science-data-systems-program/policies/esds-open-source-policy).

In addition, all software developed under this solicitation is to be designated and distributed to the public as open source software using the *Apache License 2.0* (https://www.apache.org/licenses/LICENSE-2.0) or less restrictive license. Software developed may be created to operate in conjunction with commercial or other restricted use software (such as MATLAB, ENVI, ArcGIS), but must be licensed separately from that software.

3.4 Data Policies

Proposals developing significant datasets must include a data management plan, including delivery to the NASA DAAC at the National Snow and Ice Data Center (https://nsidc.org/daac) in compliance with NASA data standards (https://earthdata.nasa.gov).

3.5 Team Membership and Expectations

PIs and Co-Is on selected proposals will become members of HiMAT. The team will have a range of responsibilities and goals, including:

- Facilitating the collaborative development of GMELT.
- Fostering inter and transdisciplinary Earth system science.
- Utilizing GMELT for improved projections of HMA.
- Improving hazard assessments and identification of policy options for HMA.

Proposals must discuss their approach to collaboration within HiMAT, including details on their contributions to GMELT.

All proposals should include in their budget support to attend two meetings of HiMAT each year, one in the continental U.S. and another in Asia (e.g., Kathmandu, Nepal).

3.6 Team Leader

HiMAT will be led by a Team Leader who will facilitate the integration of the team's work and Open Science approaches; organize, plan, and chair HiMAT meetings; foster regional projections; and be responsible for producing a yearly team report. Proposers wishing to serve as Team Leader should state so in their proposal, and are allowed up to two (2) additional pages to describe their qualifications, interests, and approach to leadership. Team Leader activities should not be included in the proposal budget. Team leaders will receive an additional $80,000 per year to support their leader activities, and the successful proposer will revise their budget during final award negotiations.

4. Fieldwork and Aircraft

This solicitation is intended to support work based on available remote sensing observations and is not intended to support large field deployments to collect new observations. Small field programs to validate remote sensing observations or model output are appropriate, but must be fully justified. Please consider the estimated budget in Section 7. *Summary of Key Information* in developing work plans, and note that only proposals for up to a $1M per year are encouraged. Data collected by such programs will be considered mission data with no period of exclusive use; it must be released to the DAAC as soon as possible after collection.

Investigators proposing activities involving aircraft must contact Mr. Bruce Tagg (Bruce.Tagg@nasa.gov), NASA Earth Science Division's Airborne Science Program Manager, during proposal preparation to discuss aircraft selection, budgeting, and airworthiness. NASA's airworthiness requirements and assessment processes apply to any aircraft activities supported by NASA, including non-NASA aircraft. Proposals must include the cost of aircraft operations in their budget.

5. Collaborations and Co-Investigators

Given the broad scope of work required under this solicitation and the unique challenges of HMA, the solicitation is open to collaborative proposals with budgets that are larger than those traditionally supported for a solicitation at this funding level. However, proposers are reminded that the role and necessity for each Co-I must be specifically justified and integrated into the work plan.

5.1 International Collaboration

International collaborations are encouraged, but, as required by law, proposals to this solicitation may not involve bilateral collaboration with institutions in China, see the ROSES *Summary of Solicitation* Section III(c) and also the ROSES FAQ on this subject. This includes development, design, planning, promulgation, implementation, or execution in bilateral collaboration with Chinese entities, including participation in the NASA HiMAT team as PIs, Co-Is, or otherwise. However, it is NASA's intention that the progress and results from awards will be presented to parties working on similar issues, including those from the Chinese Academy of Sciences, at periodic meetings held in international locations.

6. Review Details and Additional Review Criteria

Given the range of topics solicited under this program element, NASA may have separate peer review processes and panels. Proposals will be assigned to one or more panels based on NASA's assessment of proposal content. While NASA expects to select proposals in each of the areas discussed under Section 2.2, NASA reserves the right to select proposals in none, some, or all of these depending on the nature, quality, and distribution of proposals received.

In addition to the factors given in the ROSES *Summary of Solicitation* and the *NASA Guidebook for Proposers* (https://www.hq.nasa.gov/office/procurement/nraguidebook/), the evaluation criterion Intrinsic Merit specifically includes the following factors to apply to the requirements of Sections 3.1 through 3.6:

- Approach to GMELT contributions and development (Section 3.1)
- Likelihood of achieving Open Science goals (Section 3.2)
- Compliance with Open Source Software requirements (Section 3.3)
- Compliance with Data Policy for new data products (Section 3.4)
- Approach to Team Membership and Expectations (Section 3.5)
- If applying to be Team Leader, qualifications, interests, and approach (Section 3.6)

Proposers are encouraged to address each of these sections separately in the proposal.

7. Summary of Key Information

Expected program budget for first year of new awards	~ $3.0M per year
Number of new awards pending adequate proposals of merit	~6-12 of varying amount and scope.
Maximum duration of awards	3 years
Due Date for Notice of Intent to Propose (NOI)	See Tables 2 and 3 of ROSES
Due date for delivery of proposals	See Tables 2 and 3 of ROSES
Planning date for start of investigation	August 1, 2019
Page length for the Science-Technical-Management section of proposal	15 pages; see also Table 1 of the ROSES *Summary of Solicitation* and the *Guidebook for Proposers*. Note: Proposals with a team leader section are allowed an additional two pages
Relevance to NASA	This program is relevant to the Earth science strategic goals and sub-goals in NASA's *Strategic Plan*. Proposals that are relevant to this program are, by definition, relevant to NASA.
General information and overview of this solicitation	See the *ROSES Summary of Solicitation*.
Detailed instructions for the preparation and submission of proposals	See the *NASA Guidebook for Proposers* at http://www.hq.nasa.gov/office/procurement/nraguide book/.
Submission medium	Electronic proposal submission is required; no hardcopy is permitted.
Web site for submission of proposal via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Web site for submission of proposals via Grants.gov	http://grants.gov/ (help desk available at support@grants.gov or (800) 518-4726)
Funding opportunity number for downloading an application package from Grants.gov	NNH19ZDA001N-HMA

Main point of contact concerning this program	**Jared Entin** Earth Science Division Science Mission Directorate National Aeronautics and Space Administration Washington, DC 20546-0001 Telephone: (202) 358-**0275** Email: **jared.k.entin@nasa.gov**

General questions about the Program should be directed to the point of contact above by email. Questions about specific sub-elements should be directed to those listed below by email.

NAME	PROGRAM RESPONSIBILITY	TELEPHONE	EMAIL
Nancy Searby	Policy Support	(202) 358-0395	nancy.d.searby@nasa.gov
David Green	Hazard Mitigation	(202) 358-4682	david.s.green@nasa.gov
Jared Entin	Earth Science, Hydrology and Snow	(202) 358-0275	jared.k.entin@nasa.gov
Jared Entin	**Earth Science, Glaciers**	**(202) 358-0275**	**jared.k.entin@nasa.gov**
~~Thomas Wagner~~	~~Earth Science, Glaciers~~	~~(202) 358-4682~~	~~thomas.wagner@nasa.gov~~

A.41 EARTH SCIENCE APPLICATIONS: WATER RESOURCES

NOTICE: The Water Resources program element will not be solicited in ROSES-2019. The NASA Applied Sciences Program plans to issue a new solicitation for Water Resources proposals in ROSES-2021.

1. Overview

Within the NASA Earth Science Division, the Applied Sciences Program solicits proposals that develop and demonstrate the integration of NASA Earth science data and models into water resource management applications and decision support tools that can be sustained by operational partners or stakeholders. Remote sensing data, in combination with hydrologic models, can provide important information to assist water resource managers working with a wide range of partners and stakeholders. In order to make the best decisions possible and develop strategies that enhance the security and sustainability of water supplies, water resource managers and their stakeholders need timely information on water quality, supply, and demand.

The Water Resources application area primarily focuses on water issues related to drought, streamflow, flood forecasting, water demand and supply, and water quality. The Water Resources applications area includes the Western Water Applications Office (WWAO) that targets Western U.S. water issues. The Water Resources applications area website is available at http://appliedsciences.nasa.gov/programs/water-resources-program.

NASA point of contact concerning this program	Bradley D. Doorn Applied Sciences Program Earth Science Division Science Mission Directorate NASA Headquarters Washington, DC 20546-0001 Telephone: (202) 358-2187 Email: Bradley.Doorn@nasa.gov

A.42 SERVIR APPLIED SCIENCES TEAM

NOTICE: NASA will not solicit proposals for the SERVIR Applied Sciences Team (SERVIR AST) program in ROSES-2019. The next estimated release of SERVIR AST solicitation is potentially ROSES-2021.

1. Introduction and Background

1.1 Overview

SERVIR, a joint initiative of NASA and the U.S. Agency for International Development (USAID), fosters applications of Earth observations to help developing countries assess environmental conditions to improve their planning and actions. SERVIR partners with regional, technical institutions around the globe, establishing SERVIR "hubs" within those institutions, to help them become stronger service providers to assist their member countries in improving the information used in development decision-making. Government policy makers and resource managers comprise the primary target audiences for SERVIR hubs.

1.2 Applied Sciences Program Objectives

Within the Earth Science Division (ESD) of NASA's Science Mission Directorate (SMD), the Applied Sciences Program discovers and demonstrates innovative uses and practical benefits of NASA Earth science and data from Earth-observing satellites. The Program partners with organizations from the public and private sector to apply scientific findings and satellite data in their decision-making activities. The Program has three primary areas of operations: applications, capacity building, and mission planning.[1] All Program activities support goals to deliver near-term uses of Earth observations, build capabilities to apply Earth science data, and contribute to satellite mission planning. By working with partners and continuing to build new collaborations, the Applied Sciences Program is identifying ideas and priorities for new applications.

Within the Applied Sciences Program, the Capacity Building program sponsors projects that improve the capabilities of decision makers, community leaders, and resource managers in the United States and abroad to access and apply Earth observations data, products, and tools. A variety of methods and approaches are employed and experimented with to better build capabilities in individuals and institutions. These activities build capacity within the United States and the developing world to expand the Earth observations user base, and build the capacity of nontraditional audiences to be aware of and able to use Earth observations in decisions and actions. The SERVIR program element is within the Capacity Building program. More information is available through the Applied Sciences Program's website at http://appliedsciences.nasa.gov/.

[1] The Program's applications themes align with the societal benefit areas of the international Group on Earth Observations: Biodiversity and Ecosystem Sustainability, Disaster Resilience, Energy and Mineral Resource Management, Food Security and Sustainable Agriculture, Infrastructure and Transportation Management, Public Health Surveillance, Sustainable Urban Development, and Water Resource Management. Applications refer to the use of remotely sensed observations and derivatives, modeling products, *in-situ* data or any combination thereof, to generate outcomes of relevance and utility to the end user or decision maker.

1.3 SERVIR Objectives

The goal of SERVIR is to improve environmental management and resilience by strengthening the capacity of governments to integrate Earth observation information and geospatial technologies into development decision-making. SERVIR has organized thematic priorities along four thematic service areas: Agriculture and Food Security, Water Resources and Hydroclimatic Disasters, Land Cover and Land Use Change and Ecosystems, Weather and Climate. Within each thematic service area, SERVIR provides services, which are comprised of any or all combinations of data, products, tools, applications, platforms, and training to meet the needs of users. SERVIR provides services to accomplish the following results in each region:

1. Building the capacity of analysts and decision makers to use Earth observation information and geospatial information technologies;
2. Improving awareness of and access to available services; and
3. Providing user-tailored services to inform development decision-making.

SERVIR Applied Sciences Team (AST) provides geographic and thematic applied science expertise to regions supported by the SERVIR global network. Each AST member co-develops application(s) with, and transfer them to, SERVIR regional hubs to strengthen capacity of hubs and their users to address users' decision-making needs. Team members also communicate, coordinate, and share expertise with each other and SERVIR hubs across thematic and regional interests.

2. Programmatic Information

Questions or comments about SERVIR or SERVIR Applied Sciences Team may be directed the NASA Applied Sciences Capacity Building Program Manager at the address given below:

Nancy Searby, Ph.D.
Applied Sciences Program
Earth Science Division
Science Mission Directorate
NASA Headquarters
Washington, DC 20546-0001
Telephone: (202) 358-0395
Email: Nancy.D.Searby@nasa.gov

A.43 EARTH SCIENCE APPLICATIONS: DISASTER RISK REDUCTION AND RESPONSE

NOTICE: NASA does not currently plan to solicit proposals for this program element in ROSES-2019.

1. Overview

The NASA Earth Science Division (ESD), Applied Sciences Program solicits proposals for user-centric applications research enabling risk-informed decisions and actions. Selected projects must use an earth system approach, where satellite and other Earth observations can provide a unique perspective. The expected result of this program element is that these projects will be used to constitute a portfolio of integrated disaster risk reduction and response tools comprising a decision-making toolbox that meets broad stakeholder needs. Successful projects and their work plans must be efficient, transparent, accountable and inherently collaborative. They must embrace and invest in coordination activities to deliver and accelerate results which strengthen disaster risk reduction and response to the next major disaster.

The ESD Disasters Application Program seeks multidisciplinary projects which harness the convergence[1] of expertise and collaborative partnerships. Trans-boundary projects which incorporate cultural, economic and political context are particularly encouraged. Hazards know no borders, and many of the most intensive disaster risks[2] and response challenges are complicated by the science of exposure and vulnerability. Our overall strategic research objective is to enhance disaster risk reduction and resilience decision making for preparedness, mitigation, response, and recovery phases of disasters and to transition their use to a public or private organization for sustained decision-making services to end-users. This is achieved through a user perspective and the optimal integration of Earth observations from the current and planned constellation of satellites, airborne assets, and ground stations as well as near-real time data and crisis informatics tools. This also includes improving the performance of existing decision-making capabilities or developing new ones that address unique geographical or demographic needs.

The ESD Applied Sciences Program promotes efforts to discover and demonstrate innovative and practical uses of Earth observations by funding applied science research and applications projects to enable near-term uses of Earth observations, formulate new

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[1] Convergence … integrates knowledge, and tools to form a comprehensive synthetic framework for tackling scientific and societal challenges that exist at the interfaces of multiple fields…the convergence of expertise necessary to address a set of research problems, and the formation of the web of partnerships involved in supporting such scientific investigations and enabling the resulting advances to be translated into new forms of innovation and new products. (NAS 2014. *Convergence*. Washington DC. DOI: https://doi.org/10.17226/18722)

[2] Intensive disaster risk refers to the risk associated with high-severity, mid to low-frequency disasters, (UNISDR, 2017; UNISDR, 2015). ... Intensive risk is therefore not only characterized by intense hazards, but also by the underlying risk drivers or vulnerability factors such as poverty and inequality (UNISDR, 2009) http://www.preventionweb.net/risk/intensive-extensive-risk and http://www.preventionweb.net/risk/bibliography.

applications, integrate Earth observations in decision-making, and transition the applications to end-user operation. This program element stresses the importance of public-private partnerships and cooperation in the communication and promotion of earth observations to ensure productivity and inclusiveness. Projects are carried out with public-sector and private-sector investments to achieve sustained use, durability, and societal benefits from the Earth observations[3].

The Applied Science Program[4] supports projects to develop and demonstrate improvements in decision-making and actions using a wide array of Earth observing systems. These include satellite measurements (NASA and other U.S. Government, foreign and commercial in-orbit and planned satellites), sub-orbital airborne systems, geodetic stations, related communication and data systems, as well as outputs and predictive capabilities from Earth science models, algorithms, visualizations, Earth system knowledge, and other geospatial products. Hereafter, these are collectively referred to as "Earth observations".

The Applied Sciences Program strongly encourages projects to consider the large source of open and available data and information including the comprehensive array of multi-sensor remote sensing capabilities (e.g. optical, microwave, and radar), networks and platforms (space, airborne, ocean, water and earth *in situ*) as well as socio-economic data. Projects should use these to provide validated tools (e.g. maps and models of disaster risk and resilience assessment, impact extent, damage, recovery and restoration analysis) and risk-based monitoring (e.g. supporting imagery and tracking of intensive risk for targeted early warning, enhanced crisis awareness or efficient recovery and restoration progress). This includes developing capabilities to incorporate analysis and data management approaches for data discovery, distribution, and use. Project proposals must demonstrate that they are informed by reports and frameworks such as those by the National Academy of Science, e.g., Decadal Survey on Earth Observations and Applications[5] or reports of the Disasters Roundtable,[6] Whitehouse Office of Science and Technology Policy (OSTP) Sub-committee on Disaster Reduction (SDR), e.g. Grand Challenges for Disaster Risk Reduction,[7] Sendai

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[3] Examples include companies, humanitarian organizations, regional associations, international organizations, government agencies, multinational financial institutions, philanthropic institutions, tribal organizations, and not-for-profit organizations.

[4] For more information visit the NASA Earth Science Division's Applied Sciences Program website, http://AppliedSciences.NASA.gov/.

[5] Decadal Survey for Earth Science and Application. See http://sites.nationalacademies.org/ssb/currentprojects/ssb_166359

[6] The National Academies' Disasters Roundtable. See http://dels.nas.edu/dr/

[7] Subcommittee on Disaster Reduction Grand Challenges. See http://www.sdr.gov/grandchallenges.html

Framework for Disasters,[8] National Response Framework,[9] the Sustainable Development Goals[10], etc.

The Applied Sciences Program's Applications themes are currently focused on four of the nine Societal Benefit Areas (SBA) of the U.S. Group on Earth Observations (USGEO): Health (including Air Quality), Disasters, Ecological Forecasting, and Water Resources[11]. The Program also includes energy, weather, agriculture, and climate-related influences (e.g. drought and wildfire) within each of these themes as appropriate. The Program has instituted a nine-stage Applications Readiness Level (ARL)[12] as an index to track the maturity of applications and applied research projects. This program element is for mature applications projects (ARL ≥ 4) and applied research to improve specific decision-making activities. Proposals that aim to conduct fundamental Earth science discovery or Feasibility Studies (projects at ARL 1-3) will be considered noncompliant.

2. Disasters Applications Area

The Applied Sciences Program's Disasters Response Application area promotes the integration of Earth science data and information for disaster risk reduction and resilience. Effective application decision tools for this purpose should address socio-economic challenges, sustainable development, environmental management, climate change adaptation, or humanitarian assistance, among others. The Disaster Program emphasizes information and tools for situational awareness and decision-making support for action, therefore integrated science that identifies linkages or leverages activities for risk reduction and resilience across the societal benefit areas are encouraged. These linkages may include, for example, the relationship to trans-boundary water stresses, extreme weather hazard impacts, energy-power outages, agriculture and food security, infrastructure impacts, disruptions to at-risk cities and municipalities, and other impacts of primary and secondary hazards across the themes discussed above.

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[8] The Sendai Framework. See http://www.unisdr.org/we/inform/publications/43291

[9] The FEMA National Response Framework. https://www.fema.gov/media-library/assets/documents/117791. The DISASTERS program places a priority on geospatial enablement including advancing Principal Investigator projects within a tool box consistent with the GeoPlatform, which provides shared and trusted geospatial data, services, and applications for use by the public and by government agencies and partners to meet their mission needs. For further reference see https://www.geoplatform.gov/ and for specific technical guidance on interoperability and the architecture please see https://www.fgdc.gov/what-we-do/develop-geospatial-shared-services/interoperability/gira

[10] The Sustainable Development Goals (SDGs) http://www.un.org/sustainabledevelopment/sustainable-development-goals/ and for disasters https://sustainabledevelopment.un.org/topics/disasterriskreduction

[11] The nine USGEO SBAs are: Agriculture, Climate, Disasters, Ecological Forecasting, Energy, Health, Oceans, Water Resources, and Weather.

[12] Application Readiness Level (ARL) is a nine-stage metric used in applications of Earth observations. The ARL assesses the maturity of applications projects and the advancement along a continuum from fundamental research to application and sustained operations. More information at: https://go.usa.gov/xNw9n

Reducing disaster risk and promoting resilience requires an understanding of the Earth as a system. Answering applied science and technology development questions requires rapid infusion of experimental information into disaster risk reduction plans and resilience assessments, and efficient open access to diverse information available from NASA and other public and private entities. The Disasters Response Application Area[13] applies modeling, mapping and analysis capabilities to improve the usage of this information.

The general themes of the Disasters Response Application area flow from the Office of Science and Technology Policy (OSTP) Subcommittee on Disaster Reduction (http://www.sdr.gov/), and the National Platform of the UN ISDR associated with the Sendai Framework. The Sendai targets on reducing disaster losses include mortality, numbers of affected people, economic losses, and damage to critical infrastructure. Accordingly, NASA's Disaster Application area recognizes the following types of hazards and their induced impacts that effect these target areas:

- Hydrological – floods and inundation (coastal, riverine, floodplain, glacial, etc.)
- Geological – earthquakes and tsunamis, landslides, volcanoes, etc.
- Atmospheric – tropical cyclones, severe weather, volcanic aerosols, etc.
- Ecological - wildfires, algal blooms, etc.
- Technological - oil spill, chemical release, marine debris, etc.

The Applied Sciences Program Disasters area has a dual mandate to conduct both Disaster Applications Research and Response activities.[14] Projects above ARL 4 are expected to be available to respond to real-world events by participating in NASA Disaster Response efforts where the project can add value. The Program is primarily seeking projects that have a realistic plan and commitment to achieve at least ARL 5 within the 12-18 months and ARL 6-9 within the remaining three-year timeframe of the project. The program will assist the PI to assess and advance project ARL via deployment and testing of the applications in a relevant environment, i.e., during activations of the program's disaster response component. This will also provide the opportunity for the project to test its ARL levels for incorporation into the program's Disaster Response Plan's Playbooks for various types of disasters. Principal Investigators and their end-user partners are required to be evaluated together for application readiness level (ARL) advancement quarterly and may also be asked to provide a status report for bimonthly and annual project reviews or during site meetings with the Program Manager and Associates.

[13] The Disasters applications area website is available at https://appliedsciences.nasa.gov/programs/disasters-program.

[14] https://disasters.nasa.gov/

3. Points of Contact

NASA points of contact concerning this program. General questions about the Program should be directed to this point of contact, while questions about specific application areas should be directed to the Associates below.	David S. Green Earth Science Division Science Mission Directorate National Aeronautics and Space Administration Washington, DC 20546-0001 Telephone: (202) 358-0032 Email: david.s.green@nasa.gov
Atmospheric and Hydro-meteorological Disasters Associate	John Murray NASA Langley Research Center MS-401B 21 Langley Blvd., Hampton, VA 23681 Telephone: (757) 864-5883 Email: John.J.Murray@nasa.gov
Geophysical Disasters Associate	Tim Stough NASA Jet Propulsion Laboratory 4800 Oak Grove Dr. Pasadena, CA 91109 Telephone: (818) 393-5347 Email: Timothy.M.Stough@nasa.gov

A.44 Health And Air Quality Applied Sciences Team

NOTICE: NASA will not solicit proposals for the Health and Air Quality Applied Sciences Team (HAQAST) program in ROSES-2019. It is anticipated that this program will be solicited next in ROSES-2020.

1. Overview

The NASA Earth Science Division (ESD) Applied Sciences Program formed a Health and Air Quality Applied Sciences Team (HAQAST) through awards under ROSES-2015. This team applies Earth observations to improve and develop decision-making activities and enable transition and adoption by public- and/or private-sector organization(s) for sustained use in decision making and services to end users in the areas of public health and air quality.

This team focuses on specific applications and demonstrations required to advance the health and air quality management communities' uses of Earth science observations and models in decision making. An emphasis of the team is on responsiveness to managerial and end user needs, as well as pursuit of multiple applications of varied durations. A significant portion of team members' time is allocated to short-term, high-impact "tiger team" projects during the course of the HAQAST.

The period of performance for HAQAST has been extended by one year. Therefore, the NASA Applied Sciences Program plans to issue a new solicitation for HAQAST proposals in ROSES-2020.

NASA point of contact concerning this program	John Haynes Applied Sciences Program Earth Science Division Science Mission Directorate NASA Headquarters Washington, DC 20546-0001 Telephone: (202) 358-4665 Email: jhaynes@nasa.gov

A.45 ECOLOGICAL FORECASTING

NOTICE: The Ecological Forecasting program element will not solicit proposals in ROSES-2019.

1. Scope of Ecological Forecasting Applications Area

The Ecological Forecasting Applications area promotes the use of Earth observations and models to analyze and forecast changes that affect ecosystems and to develop effective resource management strategies. Primary user communities are natural resource managers (both land and marine) and those involved in conservation and ecosystem management. The Applications area operates through the development, improvement, and application of predictive tools, with associated uncertainties, for assessing alternative approaches and designing effective decision support strategies for managers. It applies current scientific understanding and modeling capabilities to determine how ecosystems and their components (e.g., species, genes) are changing and likely to change over time. More information is at: http://appliedsciences.nasa.gov/programs/ecological-forecasting-program.

2. NASA point of contact concerning this program

Woody Turner
Applied Sciences Program
Earth Science Division
Science Mission Directorate
NASA Headquarters
Washington, DC 20546-0001
Telephone: (202) 358-1662
Email: Woody.Turner@nasa.gov

A.46 ADVANCING COLLABORATIVE CONNECTIONS FOR EARTH SYSTEM SCIENCE

NOTICE: Amended November 4, 2019. This Amendment releases final text and sets the due date for this program element. Notices of Intent are requested by December 12, 2019 and the due date for proposals is January 30, 2020.

1. Scope of the Program

The primary goal of the Advancing Collaborative Connections for Earth System Science (ACCESS) Program is to adopt and implement technologies to effectively manage, discover and use NASA's archive of Earth observations for scientific research and applications. This program complements NASA's Earth Observing System Data and Information System (EOSDIS) by engaging researchers and software developers external to EOSDIS in NASA's mission to "drive advances in science, technology, aeronautics, space exploration, economic vitality, and stewardship of the Earth" and furthers the Earth Science Strategic objective from the NASA 2014 Science Plan to "advance knowledge of Earth as a system to meet the challenges of environmental change and to improve life on our planet" (http://science.nasa.gov/about-us/science-strategy/). ACCESS aims to improve and expand the use of NASA's Earth science data by leveraging modern techniques for discovering, managing and analyzing large and complex Earth science data sets.

Over the past 20 years NASA's EOSDIS has significantly evolved capabilities to process, archive and distribute data from satellites, airborne missions and field campaigns. Since its inception, data from EOSDIS has been fully and openly available to anyone. In 2018, over 4.1 million users downloaded science data from the EOSDIS Distributed Active Archive Centers (DAACs). Today, EOSDIS archives contain over 31 petabytes (PBs) of Earth observations. Within 3 years, as new missions are launched and instruments commissioned, the archive is projected to be over 150 PB with an annual growth rate of nearly 50 PB per year. This long-term, continuously updated global environmental record presents unique opportunities for science and significant challenges for data management and access. For more on EOSDIS and its components, please see https://earthdata.nasa.gov/about.

The primary focus of this program element is to help address data management, discoverability, and utilization challenges faced by users and curators of NASA's Earth science data. Although focused on information technology implementation and deployment, the ACCESS program is targeted at addressing existing and anticipated future needs of the research and applied science communities. One of those needs is in the area of machine learning (ML). However, adoption of ML techniques relies heavily on availability of high-quality large training datasets. Thus, in addition to technology implementation, this program element seeks ways to create new training datasets for ML. Proposal teams must include both information technology and Earth science expertise and must be tied directly to and demonstrate specific issues facing Earth science and applied science users interacting with NASA's Earth science data.

The secondary thread of the ACCESS program aims at providing support to existing widely used open source tools and libraries. Open source tools and libraries have become a critical component to research activities and need to be continuously updated to support new data sets, efficient processing, maintenance and security. Proposals for this thread must include teams that have demonstrated experience in developing, maintaining and supporting open source tools that are widely used by Earth science research and applications communities. Additionally, these proposals must demonstrate the ability to work with the targeted open source software organizations.

2. Types of Proposals Solicited

NASA is seeking proposals that significantly advance discovery, management, use and analysis of large and complex Earth science data sets or support existing open source tools and libraries. Proposals must clearly identify user communities that will benefit from the technology and demonstrate linkages to pressing Earth science data management problems or the need for open source library and tool maintenance. In furtherance of ACCESS Program goals, proposers should focus technology developments on one or a combination of the following areas:

2.1.1 Machine Learning for Earth Science Data Systems (ESDS)
2.1.2 Enabling Science in the Cloud
2.1.3 Improvement, Maintenance, and Support of High-value Open Source Earth Science Tools and Libraries

2.1. ACCESS Technology Focus Areas

2.1.1. *Machine Learning for Earth Science Data Systems*

NASA ESDS is interested in how Earth science data systems can implement machine learning (ML) and artificial intelligence (AI) to improve data discovery, support science, and drive operational efficiencies. The program element invites the following categories of AI/ML proposals:

2.1.1.1 Broad application:

- Operational improvements: Application of ML techniques and methodologies to support automation of processes within EOSDIS enterprise services.
- Innovative applications: Collaborative proposals engaged in translational activities that employ new AI/ML techniques to improve data search/discovery, management and create new ways of utilizing data and metadata.

2.1.1.2 Creation of training data:

- Earth science ML training data are expensive, error-prone, and usually require some expert interpretation. Many ML systems, especially those with large numbers of parameters, require large amounts of training data to generalize well. Proposals in this category are encouraged to augment existing EOSDIS tools and frameworks wherever possible in creation of training datasets. Proposers shall:
  - Develop training datasets that are clean, quality-controlled, and labeled.
  - Adapt, develop, and integrate solutions that make full use of novel ways to create high-quality training datasets and improve accuracy of labeling.
  - Generate synthetic training datasets through simulations with perfectly known labels. This kind of data has many benefits such as speed (fast to

generate), accuracy (using physically-based models), tailored for specific needs, and scalable.
- Share the training datasets under existing NASA Open Data and Information policy.

2.1.1.3 Enable open sharing of ML models:

- In most cases, the ML models are developed for applications that are targeted for specific use cases, leading to duplicated effort, and making reuse impossible. Proposals in this category are encouraged to develop an open platform capable of packaging ML models into portable containerized microservices that can be easily shared via the platform's catalog, and can be integrated into various applications. Proposals should describe the process for transitioning the model from research for use in operations.

2.1.2. *Enabling Science in the Cloud*

NASA ESDS seeks proposals for development of tools using commercial cloud computing services supporting a range of applications that are important to the Earth science communities. These proposals must leverage cloud native technologies and capabilities to significantly accelerate scientific discoveries otherwise not possible. Proposals that support working with data across multiple agencies within commercial clouds are encouraged. The program element invites the following categories of proposals:

2.1.2.1 Science middleware for acceleration of science: The goal is to achieve the best time-to-solution for data-driven scientific applications and workflows using cloud computing.

- Processing at scale: The goal is to achieve processing in the cloud without download of data. Proposals should address how development of processing pipelines enable data-driven science using an API-based middleware.
- Analytics at scale: The goal is to achieve a seamless large-scale science analysis in the cloud. Proposals shall be focused toward Analytics Optimized Data Stores (AODS) and Analysis Ready Data (ARD) for data to serve as building blocks for analytic tools and services, with an emphasis on building and exposing APIs. Construction of AODS and ARD must be transparent with well-documented (provenance) to foster trust by the user community. The API-based middleware services must extract and transform data into a ready-to-consume state for analysis.

2.1.2.2 *Innovative use of cloud services and platforms:* Proposals in this category shall consider making novel use of heterogeneous hardware resources, platforms, and services to support and extend scientific applications and workflows.

2.1.3. *Improvement, Maintenance, and Support of High-value Earth Science Tools and Libraries*

Open source software libraries and tools have played an increasingly prominent role in Earth science research and applications over the past decade. As the adoption of open software accelerates scientific findings, there is a growing need among the Earth science community to provide sustained support and maintenance of the software.

ESDS seeks proposals for improvement and sustainment of high-value open source tools and libraries that have made significant impacts in the Earth science community. The proposals must clearly state the process of adding extensions, documentation, and maintenance of software code to support the user community.

3. Policies and Requirements

3.1. Earth Science Data Information Policy and Rights in Data

All proposers should review the Earth Science Data and Information Policy at http://science.nasa.gov/earth-science/earth-science-data/data-information-policy/.

3.2. Earth Science Data System Open Source Software Policy

All software developed or updated with funding from this program element must be made available to the public as Open Source Software (OSS). This includes all software developed with ESDS funding used in the production of data products, as well as software developed to discover, access, analyze, visualize and transform NASA data. Please see https://earthdata.nasa.gov/earth-science-data-systems-program/policies/esds-open-source-policy for details on the ESDS OSS policy.

3.3. Participation in Earth Science Data Systems Working Groups

Proposals selected by the ACCESS program are required to have representation on at least one of the Earth Science Data Systems Working Groups (ESDSWG). Proposals should include a brief statement outlining with which of the working groups the team would be participating and detailing what expertise the member(s) will bring. Participation in an ESDSWG is an ACCESS program requirement and is not subject to project waivers or negotiation (https://earthdata.nasa.gov/esdswg). Selected projects will be expected to submit reports on ESDSWG activities. Proposers must allocate a quarter-time (.25 FTE) for one or more members of the proposed team to participate in and travel to the annual ESDSWG meetings.

3.4. Use of Third Party Software

NASA recognizes that the use of COTS (Commercial-off-the-shelf) and GOTS (Government-off-the-shelf) software, software developed through open source licensing, and other "freeware", are of equal consideration for use in ACCESS projects. While it is not always possible to plan with certainty the life cycle of these technologies, proposers must understand and address the risks and benefits associated with their selection.

3.5. Leveraging of Past Development Efforts

ACCESS encourages the leveraging of previously-developed technologies, but proposals that choose to leverage or enhance past projects must show how the tool or capability will result in new and substantive benefits for the targeted user community. ACCESS discourages small or incremental improvements to existing technologies that are generally regarded as sustaining engineering and do not meet the objectives of this call unless the proposal is targeting section 2.1.3 - Improvement, Maintenance, and Support of High-value Earth Science Tools and Libraries.

3.6. Deploying Technologies to EOSDIS

For deployments intended for NASA's EOSDIS (https://earthdata.nasa.gov), Earthdata Cloud (https://earthdata.nasa.gov/cloud) proposers should note that NASA has processes involving DAAC managers, DAAC User Working Groups, and Headquarters to evaluate the long-term merit of technologies in terms of support, costs, and usefulness for the community. Proposals should not assume that long-term maintenance and operations costs will be covered post ACCESS funding.

3.7. Utilizing Cloud Computing Resources

ACCESS encourages proposals that use commercial cloud-native environments. NASA, along with other government agencies, have increasingly been looking to commercial cloud vendors for secure, maintainable, cost-effective, and versatile computing infrastructure. The Earthdata Cloud leverages commercial cloud resources for activities including data storage, processing, and data analysis. Proposers should research ongoing activities in this space (https://earthdata.nasa.gov/cloud) and consider how to best to leverage or build off of these efforts in the cloud to ensure their submission will be well-positioned for future integration and adoption by the ESDS program. Proposals using private cloud infrastructures are discouraged.

3.8. Demonstrating a clear path of infusion to EOSDIS

Projects selected from this program element with a software implementation focus should plan on developing the following information during project initiation:

- Deployment script
- Containerization of legacy code and licensing information
- Documentation that demonstrates workflows with cloud computing allocations and resources for development and code migration
- Operational Concept
- Architecture documentation
- Software Dependencies
- Services (Cloud) used
- Continuous Integration/Continuous Deployment documentation
- Data model and specification

3.9. Proposal Submission

Notices of Intent are requested but not required for this program element. A "Program specific Questionnaire" will accompany the cover page where the proposer must specify the type of proposal being submitted, scientific focus area(s) described in section 2.1, and the relevant issues facing the use of NASA Earth science data from EOSDIS.

4. Compliance and Proposal Evaluation

4.1 Compliance

The general information provided in The *ROSES Summary of Solicitation* (e.g., Table 1) and Section 3 (Proposal Preparation and Organization) of the *NASA Guidebook for Proposers* applies to this program element. Proposals that are not compliant (e.g., see Section IV(b)ii of the *ROSES Summary of Solicitation*) may be returned without review.

Proposals must address all phases of the project, and shall:

- Develop an open source software development plan in compliance with the ESDS Open Source Policy: https://wiki.earthdata.nasa.gov/download/attachments/118138197/ESDIS05120_HQ_ESDS_OSS_Development_Plan_Guidelines_-_V1_20190219.pdf?api=v2 https://earthdata.nasa.gov/earth-science-data-systems-program/policies/esds-open-source-policy. This open source software development plan must be placed in a separate and appropriately labeled section of no more than 3 pages directly following the 15-page S/T/M section.
- Provide a data management plan by filling in the DMP section of the cover page https://science.nasa.gov/researchers/sara/faqs/dmp-faq-roses.

4.2 Evaluation

All proposals with be evaluated for Intrinsic Merit, Cost, and Relevance, as defined in Appendix D of the *NASA Guidebook for Proposers* and consistent with Section VI(a) of the ROSES *Summary of Solicitation*. In addition, the evaluation of merit will include an assessment of whether the proposal:

- Clearly identifies user communities that will benefit from technology and demonstrates linkages to pressing Earth science or data management problems.
- Clearly identifies team members with relevant Earth and computer science expertise.
- Clearly explains how technology developed under an ACCESS award will address identified challenge(s).
- Clearly describes the software development approach and lifecycle.
- Includes a work plan and schedule for technology development, testing, and deployment.
- For proposals including deployments to EOSDIS, the evaluation of merit will include assement by NASA on the maintainability and utilitiy of developed software to support increased use of Earth science data.

Data, results, and other information created for this proposal are subject to NASA's Earth Science Data policy (see https://earthdata.nasa.gov/nasa-data-policy). All data will be released, along with the source code for algorithm software, coefficients, and ancillary data used to generate products.

5. Award Type and Funding

It is anticipated that the funding vehicle for any award under this program element will be a Cooperative Agreement (CA). Proposers should make themselves aware of the differences between a CA and a grant. For additional information review the NASA Grant and Cooperative Agreement Manual). Proposers are encouraged to discuss this form of agreement with their institutions prior to submission of an ACCESS proposal.

6. Summary of Key Information

Expected total program budget for new awards	~$5M per year

Number of new awards pending adequate proposals of merit	~9-15
Maximum duration of awards	3 years
Due date for Notice of Intent to propose	See Tables 2 and 3 of this ROSES NRA
Due date for Proposals	See Tables 2 and 3 of this ROSES NRA
Planning date for start of investigation	3 months after proposal due date
Page limit for the central Science-Technical-Management section of proposal	15 pp; see also Table 1 of ROSES *Summary of Solicitation* and Chapter 3 of the 2018 *NASA Guidebook for Proposers.*
Relevance to NASA	This program is relevant to the Earth Science questions and goals in the NASA Science Plan. Proposals that are relevant to this program are, by definition, relevant to NASA.
General information and overview of this solicitation	See the ROSES *Summary of Solicitation*
General requirements for content of proposals	See Section 3 of the *NASA Guidebook for Proposers* and Section IV and Table 1 of *the ROSES Summary of Solicitation*.
Detailed instructions for the submission of proposals	See https://nspires.nasaprs.com/tutorials/ Sections 3.22-4.4 of the *NASA Guidebook for Proposers* and Section IV(b) of *the ROSES Summary of Solicitation*.
Submission medium	Electronic proposal submission is required; no hard copy is permitted.
Web site for submission of proposal via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Website for submission of proposals via Grants.gov	http://grants.gov (help desk available at support@grants.gov or (800) 518-4726)
Funding opportunity number for downloading an application	NNH19ZDA001N-ACCESS

Points of contact concerning this program, both of whom share the following address: Earth Science Data Systems Earth Science Division Science Mission Directorate, NASA Headquarters Washington, DC 20546	Kevin Murphy Program Executive Telephone: (202) 358-3042 email: kevin.j.murphy@nasa.gov -and- Manil Maskey Program Officer email: manil.maskey@nasa.gov

A.47 CITIZEN SCIENCE FOR EARTH SYSTEMS PROGRAM

NOTICE: This program element will not be solicited in ROSES-2019. It is anticipated that this program element will next solicit proposals in ROSES-2020.

1. Scope of the Program

The primary goal of the Citizen Science for Earth Systems Program is to develop and implement capabilities to harness voluntary contributions from members of the general public to advance understanding of the Earth as a system. The program complements NASA's capability of observing the Earth globally from space, air, land, and water by engaging the public in NASA's mission to "drive advances in science, technology, aeronautics, space exploration, economic vitality, and stewardship of the Earth" and Strategic Goal 2.2 to "advance knowledge of Earth as a system to meet the challenges of environmental change and to improve life on our planet" (http://science.nasa.gov/about-us/science-strategy/). The program aims to advance the use of citizen science in scientific research about the Earth by directly supporting citizen science activities, as well as by deploying technology to further citizen science research.

Point of contact concerning this program	Kevin Murphy Program Executive for Earth Science Data Systems Earth Science Division Science Mission Directorate, NASA Headquarters Washington, DC 20546 Telephone: (202) 358-3042 Email: HQ-EOSDIS-MMOGrants@lists.hq.nasa.gov

A.48 <u>Advanced Information Systems Technology</u>

NOTICE: The Advanced Information Systems Technology (AIST) program will not be competed in ROSES-2019. NASA expects to next solicited this program again under ROSES-2020.

1. Objectives

The objectives of the Advanced Information Systems Technology (AIST) program are to identify, develop, and (where appropriate) demonstrate advanced information system technologies that:

- Reduce the risk, cost, size, and development time of Earth Science Division (ESD) space- based and ground-based information systems;
- Increase the accessibility and utility of science data; and
- Enable new observation measurements and information products.

2. Program Description

Advanced information systems play a critical role in the collection, handling, and management of the vast amounts of Earth science data, both in space and on the ground. Advanced computational systems and technology concepts that enable the capture, transmission, and dissemination of terabytes of data are essential to NASA's vision of a distributed observational network. ESTO's Advanced Information Systems Technology (AIST) program employs an end-to-end approach to develop these critical technologies - from the space segment, where the information pipeline begins, to the end user, where knowledge is advanced. Two major AIST thrusts are in progress: (1) support to a new observing strategy involving the integration of observations from orbital, airborne and *in situ* instruments along with models into a sensor web to advance the state of the art understanding of physical processes and natural phenomena, and (2) Analytic Centers focusing on a scientific investigation, where data from many sources, computational resources and tools are harmonized to improve the ability of the investigator to discover new knowledge.

3. Point of contact concerning this program

Michael M. Little
Earth Science Technology Office
Telephone: (301) 286-7404
Email: Michael.M.Little@nasa.gov

A.49 Instrument Incubator

Amended April 12, 2019. This Amendment releases the final text for this program element. A preproposal bidder's conference will be held on May 15, 2019 at 1:00 PM Eastern Daylight Time (EDT). Access information for the bidder's conference is provided in Section 8. Notices of Intent to Propose (NOIs) are requested by May 31, 2019, and proposals are due July 12, 2019. Proposers to this program element do not need to submit a data management plan.

1. Scope of Program

1.1 Introduction

The Instrument Incubator Program (IIP) supports the development of innovative technologies for new Earth observing instruments, sensors, and systems in support of Earth science. The technologies and measurement concepts developed under the IIP may extend through to field demonstrations, with a longer-term aim for infusion into future ESD research, applications, and flight programs.

Emerging technologies and exciting new instrument architectures and platforms show great promise for measuring natural Earth phenomena and physical processes that have not previously been characterized by conventional satellite instruments alone. In particular, transient, transitional, and dynamical phenomena have been difficult to study using traditional low Earth orbit (LEO) orbiting instruments due to insufficient temporal sampling of such phenomena. Inexpensive, high quality intelligent sensors and platforms operated in higher orbits, or in constellation and/or in a coordinated fashion, coupled with new pointing, real time data processing, and commanding capabilities, could now give scientists the ability to conduct observations focused on dynamic processes and/or events of interest. Selection of observation opportunities requires interconnectivity and the on-platform computational capacity to coordinate among platforms, instruments, and models of the phenomenon or process. Emerging new instrument technologies potentially coupled with new platform capabilities and rapidly evolving information technologies could become the early backbone of new observing systems that can react to changing environmental conditions.

1.2 Goals of the Instrument Incubator Program

The goal of the IIP is to promote innovation in the research, development, and demonstration of new measurement technologies that:

- Enable new or greatly enhanced Earth observation measurements, and
- Reduce the risk, cost, size, mass, and development time of Earth observing instruments.

Rapid advances in Earth system science and applications, and in other fields that the Earth science community draws from, promise new capabilities that will allow progress more rapidly than in the past:

- Advances in space system technology (such as small spacecraft, combined active/passive sensing, and emerging sensor technologies, such as photonic integrated circuits, system on a chip solution, free-form optics, metasurface/metamaterial applications, room temperature detectors, and other compact electronics and optical architectures) can address critical Earth science questions in new ways, thus providing the tools to observe new parameters.

- Innovative observational methodologies, such as advanced satellite constellations of low-cost instruments with combination of active and passive sensing can advance science and applications compared to single satellite observations.
- New smart sensing methods, coupled to emerging information processing technologies, such as machine learning, may extend the reach of science within limited resources.

In the past, the IIP focused on the scientific impact of technology development and sought to advance the community's ability to make a "science-quality" measurement, and this will not change. In this program element, successful proposals will demonstrate understanding of the system level for making measurements, incorporating new platforms or existing platforms in new ways, emerging technologies or repurposing technologies from other fields directed toward Earth science applications, combining various measurement techniques to generate an enhanced product or a new/relevant product, and utilizing the rapidly emerging algorithm and architecture advances of data and IT communities.

Proposals will need to address not just instrument design but an overall measurement system. Proposals must justify the chosen platform (CubeSat, SmallSat, joint or integrated instrument, coordinated observations, formation flying systems, etc.) clearly explaining the advantages of the chosen architecture and how it enables a new data product, or produces a significantly enhanced data product, or duplicates a current data product at a substantially lower cost, ease of use, and/or lower risk deployment posture.

To be successful, proposals must demonstrate that the proposing team is capable of producing the end-to-end measurement "system architecture," and has the demonstrated expertise in the emerging technology areas utilized, including the data centric components and tasks. The same focus on traceability to the science and applications is required.

As detailed in Section 2, this program element requests proposals for technology development activities aimed specifically at: (1) development and demonstration of new innovative Earth science remote sensing instruments; and (2) demonstration of new instrument concepts and/or measurements. No funding is available under this announcement for:

- Research and development of new instruments for *Designated Observables recommended by the 2017 Earth Science* Decadal Survey (https://www.nap.edu/catalog/24938) unless these provide significant improvement over existing techniques; however, these can be targeted for the next decade.
- Instruments that make *in situ* observations from airborne or ground, unless these involve direct communications with spaceborne systems or signals.
- Airborne instruments with no clearly defined path to space.

- Incremental improvements to existing instruments.

2. Proposal Research Topics

This IIP solicits new instrument and measurement technologies that shall support the objective of one or more of the Earth Science Focus Areas. Earth Science Focus Areas are: Carbon Cycle and Ecosystems, Climate Variability and Change, Water and Energy Cycle, Atmospheric Composition, Weather, and Earth Surface and Interior (see Appendix A.1 for descriptions of the focus areas). Relevance to these focus areas is indicated by the degree to which these new types of observations improve: (i) quality (such as temporal, spatial, and temporal resolution, sensitivity) and/or (ii) cost-effectiveness of Earth science measurements.

This program element supports the development of instruments that offer new approaches to remote sensing of Earth. Proposals should offer significant improvement to traditional instrumentation and measurement techniques that: (i) enable increased flexibility and adaptability to measurement objectives; and/or (ii) provide small and cost-effective instruments enabling innovative measurement techniques, including those that could employ multiple sensors in formation or use alternative platforms or, potentially, satellites in higher orbits. These alternative platforms could be small satellites or co-manifested opportunities, including hosted payloads and ride-share programs appropriate for observations of the Earth system. This program element also seeks instruments that demonstrate innovative ways to combine both passive and active measurement capabilities to generate multiple science measurements, or combine signals of interest across the electromagnetic spectrum to advance the accuracy of Earth science measurements.

Proposals are sought that advance the goals and objectives of IIP through technology developments in two distinct subelement topic areas:

1) Instrument development and demonstration, and
2) Instrument concept demonstration (seeking shorter duration, lower cost, earlier stage measurement or instrument demonstrations designed as proof of principle for future remote sensing measurements).

Proposers may find information about previously funded technologies at the Earth Science Technology Office (ESTO) Website.

The following documents identify the relevant missions and programs for this program:

- *Thriving on Our Changing Planet: A Decadal Strategy for Earth Observation from Space (2017)* may be accessed on the web at https://www.nap.edu/read/24938/chapter/1. This report is hereinafter referred to as the "*Decadal Survey*."
- The NASA 2014 Science Plan.

2.1 Instrument Development and Demonstration (IIP-IDD)

This subelement covers the entire instrument development process, which includes instrument design; breadboard, prototype, and engineering model construction; and laboratory and/or airborne demonstrations for innovative measurement techniques that have the highest potential to meet the objectives of the IIP and substantially improve the state-of-the-art Earth science measurements.

The proposed IIP-IDD activity is expected to have an entry Technology Readiness Level (TRL) between 2 and 3, with an exit TRL between 4 and 5. The value of each award will be approximately $1.5M per year.

2.2 Instrument/Measurement Concept Demonstration (IIP-ICD)

This subelement seeks demonstration of innovative concepts that have high potential to meet the objectives of the IIP and substantially improve the state-of-the-art of Earth science measurements.

The proposed IIP-ICD activity is expected to have an entry TRL between 1 and 2, with an exit TRL between 2 and 3. The value of each award will be approximately $500-750K per year.

The IIP-ICD is intended to advance development and maturity level of these concepts, which are typically at an early stage of formulation, through detailed analytical studies, model simulation, and/or breadboarding of critical functions or instrument subsystems. Proposals can also include innovative ways in which the instrument can be controlled or the output processed to improve the quality of the measurement, extend the life of the instrument, or to create new uses of the measurements relevant to Earth science.

Proposers are encouraged to explore utilization of emerging technologies from diverse fields to tackle the exacting measurement requirements of the Earth science community. Also, proposers may explore instruments working in coordination to provide new or significantly enhanced data products, instruments to support new measurement architectures, reconfigurable instruments, or concepts to significantly expand the capabilities of current instrumentation.

3. Programmatic Information

This document provides requirements and details tailored to this specific program element that supplement or may supplant the general guidelines of the ROSES-2019 Summary of Solicitation or *Guidebook for Proposers*. See Section I (g) of the ROSES-2019 Summary of Solicitation regarding the order of precedence.

3.1 Proposal Content and Submission

3.1.1 *Notice of Intent to Propose*

Notices of Intent (NOI), as described in the *NASA Guidebook*, are strongly encouraged, but not required.

3.1.2 *Questions and Answers*

Prospective proposers are requested to submit any questions in writing to p.ghuman@nasa.gov no later than 30 days before the proposal due date. Questions and answers may be posted in a Frequently Asked Question (FAQ) on the NSPIRES page for this program element under "other documents." It is the proposer's responsibility to check the NSPIRES page for this program element for possible updates to any FAQ document or clarifications to the solicitation. Proposers who subscribe to the

SMD email distribution list in NSPIRES will receive an email if this solicitation is amended.

4. Proposal Content

4.1 Proposal Summary (abstract)

The NSPIRES web page requires proposers fill in a text box with a proposal summary of no more than 4000 characters. The proposal summary includes: (a) objectives and benefits, (b) an outline of the proposed work and methodology, (c) the period of performance, and (d) entry and planned exit Technology Readiness Level (TRL).

4.2 Scientific/Technical/Management Section (Project Description)

This section must include the following content information in subsections that use the same titles. Failure to provide any of this material may be cause for the proposal being judged as noncompliant and returned without further review. The Project Description is limited to 15 nonreduced, single-spaced typewritten pages unless otherwise noted. Standard proposal style formats shall be in accordance with Section IV(b)ii of the *ROSES Summary of Solicitation.* Proposals that exceed the 15-page limit may be returned without review. The Project Description section includes:

1. Applicability to Earth Science Measurements – Describe the benefits to future Earth science missions that utilize the proposed technology. Include a clear description of the observing system, measurement approach, and relevancy scenario showing how the proposed technology contributes to one or more Earth science measurements. Detail the impacts of the system architecture, the choice of platform, observation strategy, and the impact of any incorporated IT advances in relation to current measurement capability.
2. Description of Proposed Technology – Provide a description of the proposed new technology for an instrument system or subsystem. Describe the technical approach and include a concept of operations for the proposed technology that shows how it addresses Earth science needs. Explain and justify how the proposed choice of measurement platform and observational strategy enables Earth Science. Discuss any possible benefits to other NASA Earth or Space Science activities or commercial benefits.
3. Comparative Technology Assessment – Describe the anticipated advantages (e.g., reduction of size, mass, power, volume or cost, improved performance, or enabling of a new capability not previously possible) of this technology compared to those currently in use in a quantitative manner. Reference the current state-of-the-art and relate it to the proposed work.
4. TRL Assessment – Proposers must define the starting point for the instrument technology or measurement technique and the exit or success criteria for the proposed activity. The TRL shall advance by at least one level during the period of performance of the activity. If proposed activity duration is for multiple years, advancement of one TRL per year is desirable. Also, proposers must discuss the readiness of the measurement technique/approach by indicating the level of maturity not only for the technology building blocks of the system but of the

certainty that the system, once fully functional, will produce the science quality data required.

TRL definitions can be found here: https://nodis3.gsfc.nasa.gov/displayDir.cfm?Internal_ID=N_PR_7123_001B_&page_name=AppendixE. Identify the entry TRL, the planned exit TRL, and success criteria in the proposal and substantiate the entry TRL in the proposal.

5. Research Management Plan – Proposer must provide a statement of work that concisely describes each task and milestone to be accomplished in the course of the research and development. Define the success criteria associated with each task or milestone. Also include a schedule chart that identifies critical milestones. At least two milestones per twelve-month period must be defined.

   Subcontracting portions of the research project is acceptable, but overall management and reporting are the responsibility of the proposing organization.

6. Personnel – Provide a list of Key Personnel and identify their experience related to the proposed activity. Proposers should include team members' science, technology development, and instrument development skills; in particular, the experience and expertise of individuals representing emerging new technology areas and their level of incorporation into and support of the instrument design process. The Key Personnel list is included in the overall page count and must include, at a minimum, the Principal Investigator (PI). Optionally, one-page resumes for Key Personnel may also be supplied; these resumes are not included in the 15-page limit for the Project Description section.
7. Facilities and Equipment – Describe significant facilities and equipment required to complete the work. Before requesting funding to purchase a major item of capital equipment, the proposer should determine if sharing or loan of equipment already available within the proposing organization is a feasible alternative. This information is not included in 15-page limit for the Project Description section.
8. Special Matters – Proposers should include a brief description of the organization, its facilities, and previous work experience relevant to the proposal. This information is not included in 15-page limit for the Project Description section.
9. Quad Chart – Provide a summary chart (quad chart) that contains the following information:
   - Upper Left Quadrant: "Objective"
   - Lower Left Quadrant: "Approach" and "Co-Is/Partners"
   - Upper Right Quadrant: A visual, graphic, or other pertinent information
   - Lower Right Quadrant: "Key Milestones" and "Entry TRL"

A template and example of the quad chart can be downloaded from http://esto.nasa.gov/files/EntryQuad_instructions_template.ppt. Note: This quad chart is not included in 15-page limit for the Project Description section.

5. Award Information

5.1 Funding

The Government's obligation to make award(s) is contingent upon both the availability of appropriated funds from which payment can be made and the receipt of proposals that NASA determines are acceptable for award under this program element. No additional funds beyond the negotiated award value will be available. NASA does not allow for payment of profit to commercial firms under grant awards, and few fees are permitted (see http://science.nasa.gov/researchers/sara/faqs#16 for example).

Proposers are encouraged to offer cost sharing. If a cost sharing arrangement is proposed, appropriate data rights that recognize the proposer's contributions, as well as the Government's rights to access, will be negotiated prior to award.

5.1.1 *Instrument Development and Demonstration Funding*

The total funding available for the Instrument Development and Demonstration subelement of the program element will limit the number and magnitude of the proposals awarded. It is anticipated that a total of 12-16 proposals will be selected and the value of each will be approximately $1.5M per year.

5.1.2 *Instrument/Measurement Concept Demonstration Funding*

The total funding available for the Instrument/Measurement Concept Demonstration subelement of the program element will limit the number and magnitude of the proposals awarded. It is anticipated that a total of 3-5 proposals will be selected and the value of each will be approximately $500K per year.

5.2 Period of Performance

5.2.1 *Instrument Development and Demonstration Period of Performance*

The expected period of performance is 12-36 months. To warrant continuation in the second and third years, proposals must define clear, measurable milestones to be achieved for each year of performance that will be evaluated during project implementation.

5.2.2 *Instrument/Measurement Concept Demonstration Period of Performance*

The expected period of performance is 12-18 months. Proposal must define clear, measurable milestones to be achieved for the first 12 months of performance in order to warrant continuation of an additional six months.

5.3 Type of Award

All selected proposals will result in the award of grants, cooperative agreements, or intra- or inter-Government transfers, as appropriate. Grants and cooperative agreements will be subject to the provisions of the *Grants and Cooperative Agreement Manual (GCAM)* and Appendix A of the *NASA Guidebook for Proposers*. In the case of any conflict, the *GCAM* takes precedence. If a commercial organization wants to receive a grant or cooperative agreement, cost sharing is required, unless the commercial organization can demonstrate that it does not expect to receive substantial compensating benefits for performance of the work. If this demonstration is made, cost sharing is not required, but may be offered voluntarily (see references in Section III(d) of the *ROSES-2019 Summary of Solicitation*).

6. <u>Evaluation Criteria</u>

The three evaluation criteria – relevance, merit, and cost – described the *NASA Guidebook for Proposers* are modified for this ROSES element as follows:

Relevance generally includes the applicability of the proposed investigation to Earth Science Focus Area(s) and other Earth science measurements and technology needs, and specifically includes:

- The degree to which the proposed investigation specifically supports the objective of at least one of the Earth Science Focus Areas (see Appendix A.1 of *ROSES-2019* for a description of Earth Science Focus Areas);
- The potential for the sensor or instrument technology development to reduce the risk, cost, size, and development time of Earth science instruments or to enable new Earth science measurements. Potential cost reductions should be clearly stated and substantiated to the extent possible with supporting analysis that indicates scalability;
- The potential of the sensor or instrument technology to be integrated, once matured, into future Earth science NASA missions; and
- The potential for the sensor or instrument technology development to have commercial benefits.

Intrinsic merit specifically includes:

- Compelling nature of observation for Earth and applied science;
- Feasibility and merit of the proposed technical approach to achieve the technology development objectives;
- Degree of innovation of the proposed technology development concept and approach;
- Past performance and related experience in the proposed area of technology development;
- Qualifications of key personnel and adequacy of facilities, staff, and equipment to support the proposed activity to ensure that the team has strong technology development and instrument development skills, as well as any leveraging/teaming, such as recent SBIR awards/awardees;
- Substantiated justification and appropriateness of the entry and exit TRL; and
- The feasibility of making a demonstrable TRL increase of at least one level during the performance period of the project.

In addition to the evaluation of cost reasonableness described in the *ROSES-2019 Summary of Solicitation*, IIP evaluation is further refined to include the following proposal characteristics:

- Adequacy and achievability of proposed milestones and associated success criteria;
- Reasonableness of the level of effort (person-time) estimated to successfully achieve the proposed task;

- Adherence to sound and consistent management practices appropriate to the TRL of the proposed task;
- Commitment of the organization's management to the proposed technology development (evidenced by prior teaming arrangements, etc.). Proposers should identify any previous investment by the organization/program and provide supporting documentation; and
- The cost of goods and services needed to conduct the proposed work.

Cost sharing is not part of the cost criteria, but cost sharing may become a factor at the time of selection when deciding between proposals of otherwise equal scientific and technical merit.

7. Technical Reporting Requirements

In addition to the agency reports for grants, a number of ESTO-specific reporting requirements are detailed on the ESTO reporting requirements website. These requirements, including semi-annual, annual, and final review presentations and the ESTO Quad Chart, must be included in the proposal and included in IIP proposal work plans.

8. Bidders' Conference

Wednesday, May 15, 2019 | 1 pm Eastern Daylight Time (GMT-04:00) | 3 hours
Meeting
Link: https://nasaenterprise.webex.com/nasaenterprise/j.php?MTID=mccf5b984c689c4a7de69ee03ef448908
Meeting number: 906 397 660
Meeting password: W@lc0m31
Audio connection:
USA Toll Free #: 1-844-467-4685
USA Local/Toll #: 1-720-259-7012
Participant Passcode: #: 7294728170
*On the day of the meeting, copy and paste the link to your browser if clicking on it does not work.
Please use the link below to test your connection prior to the meeting.
https://www.webex.com/test-meeting.html

9. Summary of Key Information

Expected program budget for first year of new awards	IIP-IDD: Up to $22M IIP-ICD: Up to $5M
Number of new awards pending adequate proposals of merit	IIP-IDD: ~12-16 IIP-ICD: ~3-5
Maximum duration of awards	IIP-IDD: Minimum 1-year / Maximum 3-year awards IIP-ICD: Minimum 1-year / Maximum 18-month awards
Due Date for Notice of Intent to Propose (NOI)	See Tables 2 and 3 in the *ROSES Summary of Solicitation*.

Due date for proposals	See Tables 2 and 3 in the *ROSES Summary of Solicitation*.
Page length for the central Science-Technical-Management section of proposal	15 pp; see also Section 3 of the *NASA Guidebook for Proposers*. See Section 4.2 of this appendix.
Relevance to NASA	This program is relevant to the Earth science strategic objectives and goals in the *NASA 2014 Science Plan*. Proposals relevant to this program are, by definition, relevant to NASA.
General information and overview of this solicitation	See the *ROSES Summary of Solicitation*.
Detailed instructions for the preparation and submission of proposals	See the *NASA Guidebook for Proposers* at http://www.hq.nasa.gov/office/procurement/nraguidebook/.
Submission medium	Electronic proposal submission is required; no hard copy is required or permitted.
Web site for submission of proposal via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Web site for submission of proposals via Grants.gov	http://grants.gov (help desk available at support@grants.gov or (800) 518-4726)
Funding opportunity number for downloading an application package from Grants.gov	NNH19ZDA001N-IIP
Point of contact concerning this program	Parminder Ghuman Science Mission Directorate Earth Science Technology Office Telephone: (301) 286-800 Email: p.ghuman@nasa.gov

A.50 ADVANCED COMPONENT TECHNOLOGY

NOTICE: The Advanced Component Technology (ACT) program will not be competed in ROSES-2019. NASA expects to solicit Earth science instrument technologies in ROSES-2020.

1. Objectives

The ACT program seeks proposals for technology development activities leading to new component- and subsystem-level space-based and airborne measurement techniques to be developed in support of the Science Mission Directorate's Earth Science Division. The objectives of the ACT program are to research, develop, and demonstrate component- and subsystem-level technology development that:

- Enable new Earth observation measurements, and
- Reduce the risk, cost, size, volume, mass, and development time of Earth observing instruments.

2. Programmatic Information

For further information about the ACT program, please contact:

Parminder Ghuman
Earth Science Technology Office
Telephone: (301) 286-8001
Email: p.ghuman@nasa.gov

A.51 IN-SPACE VALIDATION OF EARTH SCIENCE TECHNOLOGIES

NOTICE: The In-Space Validation of Earth Science Technologies (InVEST) Program will not be competed in ROSES-2019. InVEST was last competed in ROSES-2017. NASA expects to solicit Earth Science technology flight validation projects through future solicitations. The next opportunity is currently anticipated to be included in ROSES-2020.

1. Objectives

There has been and continues to be a need for some new technologies to be validated in space prior to use in a science mission. This is necessary because the space environment imposes stringent conditions on components and systems, some of which cannot be fully tested on the ground or in airborne systems. The In-space Validation of Earth Science Technologies (InVEST) program element is intended to fill that gap. Validation of Earth science technologies in space will help reduce the risk of new technologies in future Earth science missions. This program seeks to advance the readiness of existing Earth Science-related technology and reduce risks to future missions through space flight validation.

2. Point of Contact

Sachidananda Babu
Earth Science Technology Office
National Aeronautics and Space Administration
Washington, DC 20546
Telephone: (301) 286-7304
Email: Sachidananda.r.babu@nasa.gov

A.52 SUSTAINABLE LAND IMAGING-TECHNOLOGY

NOTICE: Amended March 20, 2020. Proposals for this program element are now due April 14, 2020.

This amendment presents a new opportunity in Program Element A.52. Two subelements are being solicited: 1) Advanced Technology Demonstrations (ATD) and 2) Technology Investment (TI) activities. Proposers must clearly state if they are proposing to the ATD or TI subelement area. Notices of Intent to propose are requested by February 5, 2020, and ~~proposals are due April 7, 2020~~. Questions regarding this program element may be emailed to the point of contact and responses will be posted online, see Section 2.2. Proposers to this program do not need to submit a data management plan via the NSPIRES cover pages.

1. Scope of Program

1.1 Introduction

For the past 47 years, Landsat satellites and associated U.S. Government ground processing, distribution, and archiving systems have acquired and made available global, moderate-resolution (5-120m), multispectral measurements of land and coastal regions, providing humankind's longest record of our planet from space. NASA and the U.S. Geological Survey (USGS) of the Department of the Interior (DOI) fully recognize that this information is a national asset, providing an important and unique capability that benefits a broad community, including Federal, state, and local governments; global change science, academia, and the private sector. Landsat data provide a consistent and reliable foundation for research on land use change, forest health, and carbon inventories, and changes to our environment, climate, and natural resources. Additionally, the free and open availability of the Landsat data enables the measurements to be used routinely by decision makers both inside and outside the Government, for a wide range of natural resource issues, including water resource management, wildfire response, agricultural productivity, rangeland management and urban growth.

The Administration has committed to continue the Landsat program and its invaluable data stream. To continue data collection beyond Landsat-9, the Administration proposes to design and implement a spaceborne system to provide global, continuous Landsat-quality multispectral and thermal infrared measurements for at least the next 25 years.

The aim of the Sustainable Land Imaging-Technology (SLI-T) program is to develop next-generation technology for a long-term programmatically sustainable system that as a minimum continues the historical measurement capability, and potentially improves this capability. Technology developed under this program will be considered for infusion over the lifetime of the program as a potential contributing element of the long-term sustainable program.

In FY 2019, NASA initiated a Sustainable Land Imaging Architecture Study. The team that performed this study generated a Reference Mission Architecture document (see below), which could form the basis of a Sustainable Land Imaging mission after Landsat-10. It is expected that NASA's role will continue as lead for the overall system design, flight system implementation, and launch of future missions, while USGS will lead ground system development, post-launch operations, and data processing, archiving, and distribution.

The basic guidance for the Sustainable Land Imaging program is summarized by the following three basic tenets:

Sustainability

- The SLI program should provide the land imaging data products for the long haul, without extraordinary infusions of funds, within the budget guidance provided.
- It should also ensure that the technology required for the program is available and appropriate for the long haul.

Continuity

- The SLI program should continue the long-term Landsat data record. This does not necessarily mean the imagery per se, but the usable products that define the utility of the data record.
- Understanding how the data are used is essential when considering potential architectures.

Reliability

- The SLI program should exhibit a form of functional redundancy. The data sets should be able to draw on equivalent or near equivalent deliverables from different sources to provide the data for the highest priority land imaging data products.
- With these "near equivalent" data sources identified in advance, the loss of a single satellite or instrument on orbit should not cripple the program or significantly impact users, and the program will exhibit graceful degradation.

1.2 Goals of the Sustainable Land Imaging – Technology (SLI-T) Program

The goals of the SLI-T program are to research, develop, and demonstrate new measurement technologies that improve upon the Nation's current land imaging capabilities while at the same time reduce the overall program cost for future SLI measurements. The SLI-T program seeks to:

- Reduce the risk, cost, size, volume, mass, and development time for the next generation SLI instruments, while still meeting or exceeding the current land imaging program capabilities;
- Improve the temporal, spatial, and spectral resolution of SLI measurements; and
- Enable new SLI measurements that can improve the program's operational efficiency and reduce the overall costs of the Nation's land imaging capabilities.

As discussed in more detail in Section 1.4 below, this program element requests proposals for technology development activities aimed specifically at: (1) demonstrating improved, innovative, full-instrument concepts for potential infusion into the architecture and design of missions beyond Landsat-10; and (2) development and technical maturation at the component and/or breadboard-level of technologies that have long-term potential to significantly improve future land imaging instruments and systems through substantial architecture changes.

1.3 SLI-T Reference Mission Architecture (RMA)

A baseline SLI-T Reference Mission Architecture has been defined principally to guide the nearer-term innovative instrument technology developments that represent a major (but not exclusive) part of this program element. The Reference Mission Architecture (RMA) Document is available for downloading at SLIT19_RMA.pdf. The mission orbit is based upon the current Landsat-8 orbit that will be repetitive, circular, Sun-synchronous, and near polar orbit at a nominal altitude of 705 km (438 miles) when crossing the Equator. While the current Landsat system relies on a single spacecraft acquiring 185km x 180km Worldwide Reference System-2 (WRS-2) scenes every 16 days, the SLI program is also interested in alternative acquisition approaches, including satellite constellations, that might improve observation frequency.

Key performance drivers for the SLI-T RMA include continuation of Landsat data heritage in terms of image quality and compatibility, radiometric accuracies of the data, the spectral and spatial stability of the measurements over time, and the reproducibility of data. In addition, the RMA includes additional bands prioritized in discussions with the science and applications communities. The reference mission bands are defined below in Table 1.

Table 1: Baseline SLI-T Reference Mission Architecture Bands

Band #	Band name	Center wavelength (nm)	Band width (nm)
1a	Violet	410	20
1	Coastal Aerosol	443	20
2	Blue	490	65
3	Green	560	35
4a	Orange	620	20
4	Red	665	30
5	Red Edge 1	705	15
6	Red Edge 2	740	15
7	Red Edge 3	783	20
8	NIR_Broad	842	115
8a	NIR1	865	20
9	Water vapor	945	20
8b	NIR2	1035	20
10	Cirrus	1375	30
11	SWIR 1	1610	90
12a	SWIR 2a	2040	30
12b	SWIR 2b	2100	40
12c	SWIR 2c	2210	40
13	N/A*	N/A	N/A
14a	TIR 1a	8300	350

Band #	Band name	Center wavelength (nm)	Band width (nm)
14	TIR 1	8650	350
14b	TIR 1b	9100	350
15	TIR 2	10800	1000
16	TIR 3	12000	1000

*Not applicable to this solicitation

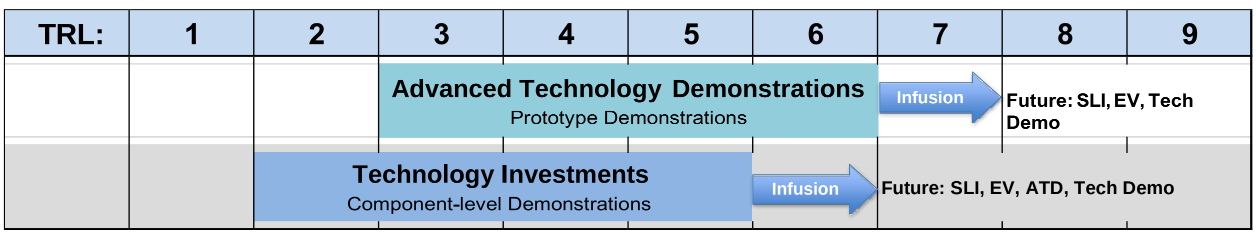
1.4 Proposal Research Topics

Proposals are sought that advance the goals and objectives of Sustainable Land Imaging through technology developments in two sub-elements:

1) Nearer-term Advanced Technology Demonstrations (ATD)
2) Longer-term Technology Investments (TI) activities

Proposers should identify what part of the RMA their proposed technology development addresses.

Table 2: ATD and TI Technology Readiness Level (TRL) Range



1.4.1 *Advanced Technology Demonstrations (ATD)*

The ATD sub-element area seeks prototypes or engineering model demonstrations of innovative instrument concepts that meet the objectives of the SLI-T program. Technology focused toward reduced SWAP is desired.

The proposed ATD activities should have an entry Technology Readiness Level (TRL) of 3-5 (link to TRL definitions) and result in the development of a prototype and/or engineering model that adequately addresses all critical scaling issues and should be demonstrated in a relevant environment. Aircraft or hosted payload demonstration is highly encouraged to verify operational performance characteristics as described in the RMA.

1.4.2 *Technology Investments (TI)*

The TI sub-element seeks components and/or breadboard demonstrations of instrument technologies that can be infused into future SLI measurement techniques.

Rapid advances in Earth science instrument technology are enabling considerably smaller instruments that may be able to meet many land imaging needs in the future. Rapid evolution of smaller satellites, when combined with increased launch opportunities, opens the possibility for many new approaches to land imaging mission implementation.

The proposed TI activities should have an entry TRL of 2 or higher and result in the validation of a component and/or breadboard in a relevant environment (exit TRL of 5).

2. Programmatic Information

This section provides requirements and details tailored to this specific program element that supplement or may supplant the general guidelines of the *ROSES-2019 Summary of Solicitation* or *Guidebook for Proposers*. See Section I (g) of the *ROSES-2019 Summary of Solicitation* regarding the order of precedence.

2.1 Notice of Intent to Propose

A Notice of Intent (NOI) to propose is encouraged, but not required, prior to the submission of proposals to this program element. The information contained in the NOI is used to help expedite the proposal review activities. NOIs shall be submitted electronically via NASA Solicitation and Proposal Integrated Review and Evaluation System (NSPIRES) by February 5, 2020. Late NOIs, as well as indications of intent NOT to propose on an earlier NOI submission, may be submitted by email to the point of contact for this program element, given in Section 8.

2.2 Questions and Answers

Prospective proposers are requested to submit any questions in writing to sachidananda.r.babu@nasa.gov no later than 30 days before the proposal due date. Questions and answers will be posted in a Frequently Asked Question (FAQ) on the NSPIRES webpage for this program element under "other documents." It is the proposer's responsibility to check the NSPIRES page for this program element for possible updates in the FAQ document or clarifications to the solicitation. Proposers who subscribe to the SMD email distribution list in NSPIRES will receive an email if this solicitation is amended.

3. Proposal Content

This section provides additional details that govern the proposed activities. The requirements have been tailored to the specific call and supplement the general guidelines announced in the NASA *Guidebook for Proposers Responding to a NASA research Announcement (NRA) or Cooperative Agreement (CAN)* and are incorporated by reference into the ROSES solicitation. This document is hereafter referred to as the *Guidebook for Proposers*.

The required proposal content follows the format prescribed in the *Guidebook for Proposers*, Section 3, except in the case where additional information is needed to supplement this solicitation. Supplemental requirements are noted below (applicable to both ATD and TI proposals).

3.1 Proposal Summary (abstract)

NSPIRES requires a proposal summary and enforces a 4000-character limit on the length. The proposal summary includes: (a) objectives and benefits; (b) an outline of the proposed work and methodology; (c) the period of performance; and (d) entry and planned exit TRL.

3.2 Scientific/Technical/Management Section (Project Description)

This section must include the following content information in subsections that use the titles given below. Failure to provide any of this material may be cause for the proposal being judged as noncompliant and returned without further review. The Project Description is limited to 20 non-reduced, single-spaced typewritten pages. Standard proposal style formats shall be in accordance with Section IV(b)ii of the *ROSES Summary of Solicitation.* Proposals that exceed the 20-page limit or in any way add extra text by violating formatting rules may be rejected without review.

Please note that the instructions below regarding the length and content of the Scientific/Technical/Management section supersede those given in the *Guidebook for Proposers* and the *ROSES Summary of Solicitation*.

The Scientific/Technical/Management Section includes

1. Proposal Summary including Description of Proposed Technology – Provide a description of the proposed new technology. Describe the technical approach and include an operational concept for the proposed technology that shows how it addresses future SLI needs. Discuss any deviations or exceptions to the SLI-T reference mission architecture and mission performance.
2. Applicability to SLI Measurements – Describe the benefits to future SLI missions that utilize the proposed technology and include a one-page relevancy scenario showing how the proposed technology contributes to one or more SLI measurements.
3. Comparative Technology Assessment – Describe the anticipated advantages of this technology compared to those currently in use - e.g., reduction of size, mass, power, volume or cost, improved performance, or enabling of a new capability not previously possible. Reference the current state of the art and relate it to the proposed work.
4. TRL Assessment – Define the starting point for the instrument technology or measurement technique and the exit or success criteria for the proposed activity. If proposed activity duration is for multiple years, advancement of one TRL per year is desirable (link to TRL definitions). The proposer must substantiate the entry TRL and identify the planned exit TRL in their proposal. Please refer to Table 2 to see the TRL ranges of the ATD and TI sub-elements. Also, proposers must discuss the readiness of the measurement technique/approach by indicating the level of maturity not only for the technology building blocks of the system but also the certainty that the system, once fully functional, will produce the science quality data required.
5. Project Management Plan – Proposers must provide a statement of work that concisely describes each task and milestone to be accomplished in the course of the research and development. Define the success criteria associated with each task or milestone. Also include a schedule chart that identifies critical milestones. At least two milestones per twelve-month period must be defined. Subcontracting portions of the research project is acceptable, but overall management and reporting are the responsibility of the proposing organization.

6. Personnel – Provide a list of Key Personnel and identify their experience related to the proposed activity. Proposers should include team members' science, technology development, and instrument development skills; in particular, the experience and expertise of individuals representing emerging new technology areas and their level of incorporation into and support of the instrument design process. The Key Personnel list is included in the overall page count and must include, at a minimum, the Principal Investigator (PI). Optionally, one-page resumes for Key Personnel may also be supplied; these resumes are not included in the 20-page limit for the Project Description section.
7. Facilities and Equipment – Describe significant facilities and equipment relevant to complete the work. Before requesting funding to purchase a major item of capital equipment, the proposer should determine if sharing or loan of equipment already available within the proposing organization is a feasible alternative. This information is not included in 20-page limit for the Project Description section.
8. Special Matters – Proposers should include a brief description of the organization, and previous work experience relevant to the proposal. This information is not included in 20-page limit for the Project Description section.
9. Quad Chart – Provide a summary chart (quad chart) that contains the following information:
    - Upper Left Quadrant: "Objective"
    - Lower Left Quadrant: "Approach" and "Co-Is/Partners"
    - Upper Right Quadrant: A visual or graphic that represents the project
    - Lower Right Quadrant: "Key Milestones" and "Entry TRL"

    A template and example of the quad chart can be downloaded from http://esto.nasa.gov/files/EntryQuad_instructions_template.ppt. Note: The quad chart is not included in the 20-page limit for the Project Description section.

4. Evaluation Criteria

The three basic evaluation criteria are given in the *ROSES Summary of Solicitation* Section VI(a) and the 2018 *NASA Guidebook for Proposers* and they are Relevance, Merit, and Cost. Additional requirements specific and clarifications to SLI-T are listed below.

4.1 Relevance

The definition of relevance is the degree to which the proposed investigation specifically supports the objectives of SLI-T program. This includes:

- The potential for the sensor or instrument technology development to reduce cost, size, and development time of future SLI instruments, or to enable new SLI measurements. Potential cost reductions should be clearly stated and substantiated to the extent possible, with supporting analysis that indicates scalability.
- The potential of the sensor or instrument technology to be integrated, once matured, into future SLI missions
- Proposals that convincingly demonstrate the potential for the commercial benefits may receive a strength, however it is not a requirement.

4.2 Intrinsic Merit

In addition to the definition given in the *Guidebook* the evaluation of Merit includes:

- Compelling nature of observation for Earth and applied science focused toward Sustainable Land Imaging;
- Feasibility of the proposed technical approach to achieve the technology development objectives;
- Degree of innovation of the proposed technology development concept and approach;
- Past performance and related experience in the proposed area of technology development;
- Qualifications of key personnel and adequacy of facilities, staff, and equipment to support the proposed activity to ensure that the team has strong technology development and instrument development skills,
- Leveraging/teaming, such as recent SBIR awards/awardees;
- Substantiated justification and appropriateness of the entry and exit TRL; and the feasibility of making a demonstrable TRL increase of at least one level during the performance period of the project.

4.3 Cost

In addition to the evaluation of cost reasonableness described in the *ROSES-2019 Summary of Solicitation*, SLI-T evaluation is further refined to include the following proposal characteristics:

- Adequacy and achievability of proposed milestones and associated success criteria;
- Reasonableness of the level of effort (person-time) estimated to successfully achieve the proposed task;
- Adherence to sound and consistent management practices appropriate to the TRL of the proposed task;
- Commitment of the organization's management to the proposed technology development (evidenced by prior teaming arrangements, etc.). Proposers should identify any previous investment by the organization/program and provide supporting documentation (see section 3.2, #8 Special Matters)
- The cost of goods needed to conduct the proposed work and
- The cost of services and/or subcontract information redacted from the peer review process will be assessed separately by NASA personnel.

Cost sharing is not part of the cost criteria, but cost sharing may become a factor at the time of selection when deciding between proposals of otherwise equal scientific and technical merit.

5. Award Information

5.1 Funding

The Government's obligation to make award(s) is contingent upon both the availability of appropriated funds from which payment can be made and the receipt of proposals that NASA determines are acceptable for award under this solicitation. All awards to non-government entities will be grants. No additional funds beyond the negotiated award value will be available. NASA does not allow for payment of profit to commercial firms under grant awards, and few fees are permitted, see http://science.nasa.gov/researchers/sara/faqs/ for more information.

If a cost sharing arrangement is proposed, appropriate data rights that recognize the proposer's contributions, as well as the Government's rights to access, will be negotiated prior to award.

5.1.1 Advanced Technology Demonstration Funding

The total funding available for the Advanced Technology Demonstration subelement of the solicitation will limit the number and magnitude of the proposals awarded. It is anticipated that a total of three to four proposals will be selected with the value of each to be approximately $1.2-$1.6 million per year.

5.1.2 Technology Investment Funding

The total funding available for the Technology Investment subelement of the solicitation will limit the number and magnitude of the proposals awarded. It is expected that a total of three to four proposals will be selected with the value of each to be approximately $300,000 per year.

5.2 Period of Performance

5.2.1 Advanced Technology Demonstration Period of Performance

The duration for ATD awards may be up to five years, but grants are funded annually, and progress must be demonstrated in order to warrant continuation into subsequent years. Proposals must provide clear, measurable milestones for each year of performance against which progress will be measured. Very detailed annual reviews with subject matter expert present at the grantee's facility are used to assess progress.

5.2.2 Technology Investment Period of Performance

The duration for TI awards may be up to three years, but grants are funded annually, and progress must be demonstrated in order to warrant continuation into subsequent years. Proposals must provide clear, measurable milestones for each year of performance against which progress will be measured. Very detailed annual reviews with subject matter expert present at the grantee's facility are used to assess progress.

6. Technical Reporting Requirement

In addition to the agency reports for grants, a number of ESTO-specific reporting requirements are detailed on the ESTO reporting requirements website. These requirements, including semi-annual, annual, and final review presentations and a Quad Chart, must be included in the proposal and included in SLI-T proposal work plans.

7. Earth Science Technology Forum and Workshops

The awardee is encouraged to participate in the Earth Science Technology Forum (ESTF) if held. The ESTF is an opportunity for NASA planners, managers, technologists and scientists to review the research funded by ESTO. It is also an opportunity for researchers from NASA, academia and industry to meet with their peers and to better understand NASA Earth science requirements.

8. Summary of Key Information

Expected program budget for first year of new awards	ATD: Up to ~$7M TI: Up to ~$1.2M
Number of new awards pending adequate proposals of merit	ATD: 3-4 awards TI: 3-4 awards
Duration of awards	ATD: Minimum 1-year / Maximum 5-years TI: Minimum 1-year / Maximum 3-year
Due Date for Notice of Intent to Propose (NOI)	See Tables 2 and 3 of this ROSES NRA
Due date for delivery of proposals	See Tables 2 and 3 of this ROSES NRA
Page length for the central Science-Technical-Management section of	20 pp. See Section 3.2.
Relevance	This program is relevant to the Earth science questions and goals in the NASA Science Plan. Proposals relevant to this program are, by definition, relevant to NASA.
General information and overview of this solicitation	See the *ROSES Summary of Solicitation*.
General requirements for content of proposals	See Section IV and Table 1 of *the ROSES Summary of Solicitation* and Section 3 of the *NASA Guidebook for Proposers*.
Detailed instructions for the submission of proposals	See https://nspires.nasaprs.com/tutorials/ Sections 3.22-4.4 of the *NASA Guidebook for Proposers* and Section IV(b) of *the ROSES Summary of Solicitation*.
Submission medium	Electronic proposal submission is required; no hard copy is permitted.
Web site for submission of proposal via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Web site for submission of proposal via Grants.gov	http://grants.gov/ (help desk available at support@grants.gov or (800) 518-4726)
Funding opportunity number for downloading an application package from Grants.gov	NNH19ZDA001N-SLIT

Point of contact concerning this program	Sachidananda Babu Science Mission Directorate Earth Science Technology Office Telephone: (301) 286-7304 Email: Sachidananda.r.babu@nasa.gov

A.53 UTILIZATION OF L- AND S- BAND SYNTHETIC APERTURE RADAR IMAGERY OVER NORTH AMERICA – JOINT NASA AND ISRO AIRBORNE CAMPAIGN

NOTICE: Released April 18, 2019. Fewer than the standard 90 days are given between release and proposal due date as a result of circumstances beyond NASA's control, including and not limited to the partial U.S. Government 35-day shutdown. Mandatory Notices of Intent are required by May 20, 2019, and 8-page proposals are due June 19, 2019.

This solicitation may be subject to modifications or cancellation at any time. Any costs incurred in preparing submissions are incurred completely at the proposer's own risk.

1. Scope of Program

NASA and the Indian Space Research Organisation (ISRO) have a mutual interest in collecting and analyzing L- and S- band (L+S) synthetic aperture radar (SAR) for improved detection, characterization, and understanding of Earth processes. As part of a broader cooperative effort in Earth science research and applications, NASA will collect L+S band SAR data from ISRO's Airborne Synthetic Aperture Radar (ASAR) instrument mounted on NASA's C-20A (Gulfstream III) utilizing the antenna pod and navigation package for the NASA UAVSAR radar system (shortened to ASAR–L+S). ISRO's ASAR is a duel frequency L+S band SAR science instrument that measures Earth's polarized reflectivity at 24 cm and 9 cm wavelength simultaneously at meter scale spatial resolution. The ASAR campaign is anticipated to take place between August and December 2019, and it will collect the first of a kind data in the United States. The primary goal of the campaign and this solicitation is to advance new and innovative L+S band research opportunities and will facilitate the development of new algorithms in advance of the NASA-ISRO Synthetic Aperture Radar (NISAR) satellite mission, which is currently in development and scheduled for launch in 2022.

This airborne campaign will collect radar data/imagery products relevant to Earth science research and applications activities in a number of topic areas by capturing duel frequency radar data for the cryosphere, ecosystems, natural hazards/solid Earth, ocean science and terrestrial hydrology research along with data supporting a wide range of applications including agriculture, oil spills and infrastructure. The overarching objective of the site selection process is to enable research spanning a wide range of scientific processes and applications that will benefit from the dual frequency ASAR–L+S campaign. The selected sites are expected to support diverse research interests into many of, but not limited to, the following topics:

- Cryosphere
    - Glacier dynamics
    - Sea ice (Beaufort Sea)
    - Snow on glaciers
    - Permafrost
- Ecosystems – Natural and anthropogenic
    - Arctic/Boreal – in particular, sites also being addressed through the Arctic

    - Boreal Vulnerability Exepeirment (ABoVE) field campaign – see https://above.nasa.gov
    - Forest
    - Wetlands
    - Agriculture
- Natural Hazards – Solid Earth
    - Landslides
    - Sinkholes
    - Volcanoes
- Ocean Science
    - Ocean currents
    - Internal waves
    - Oil spills
- Terrestrial hydrology
    - Snow – in particular, sites also being addressed through the SnowEX campaign – see https://snow.nasa.gov/campaigns/snowex/about
    - Inundation/surface water extent
    - Soil moisture

The ASAR–L+S data/imagery is anticipated to be collected in three phases to maximize the scientific breadth of data collected and to allow sufficient time for the land surface to change between acquisitions. The timing of each phase will be optimized to leverage planned activities:

1) The first phase, based out of Armstrong Fight Research Center (AFRC) in Southern California, is anticipated to collect snow (Sierra and Cascades), solid Earth (landslides, volcanoes), and oceanic imagery over targets in California, Oregon, and Washington, en route to supporting cryosphere (glacier, permafrost), and AboVE science targets in Alaska and possibly Canada. A selected number of scientific targets could be re-imaged with a shorter time between acquisitions when the plane returns to AFRC.
2) The second phase will be based out of Johnson Space Center (JSC), Houston, and will co-collect imagery in the Central United States along a predetermined UAVSAR flight plan designed to match NISAR's 12-day collection frequency over a diverse set of ecosystem, wetland, and agriculture research targets. It is anticipated that there will be one flight to the Northeast United States to collect data over ecological research sites, such as the Harvard Forest. Additional flights based out of JSC are expected to collect data over a persistent oil spill in the Gulf region and to image a region with active sinkholes in West Texas. The second phase is scheduled to occur during the fall crop harvest.
3) The third phase will begin in California, recollecting selected targets along the flight path to Alaska with the key objective of capturing dynamic processes and sea ice in the Beaufort Sea, north of Alaska. This phase will likely collect ASAR–L+S data in conjunction with planned SnowEx activities in the Western United States during November.

UAVSAR may co-collect data during flight segments in each of the collection phases to better calibrate the imagery collected by each system and to explore potential synergies between the radar systems such as bistatic and interferometric collection strategies. Interferometry is only possible in a repeat-pass mode if the wind conditions are favorable, which renders the system unusable for topographic mapping, and of limited utility for deformation mapping if repeat pass measurements are made. The primary scientific goals emphasize those that require multi-band, polarimetric measurements. The short duration of the campaign would likely only produce useful interferometric measurements over mountain glaciers, which move quickly, or forest volumes if flown with repeat long baselines.

2. Description of Solicited Research

This solicitation seeks proposals for a one-time funding opportunity that will analyze multi-frequency L+S radar for the improved detection, characterization, and understanding of Earth processes and surface interactions relevant to NASA's Earth Science Research and Analysis (R&A) Focus Areas (http://science.nasa.gov/earth-science/focus-areas/) or relevant to the Applied Sciences Program (http://appliedsciences.nasa.gov). Proposals need to include the following elements:

- Describe the scientific/application question(s) and how the simultaneously collected dual frequency ASAR–L+S campaign will uniquely advance our understanding of the process(es) and the methodology used to address the question(s);
- Geographic location(s) of the primary science/application targets that are consistent with the three collection phases described above;
- Preferred timing of the flights: approximate month(s), the number of flights over the target(s), and the collection frequency;
- Anticipated use of complementary and openly available data from ground networks, field data, and/or satellite imagery;
- Description of any potential leveraging of data from existing campaigns, such as ABoVE, SNOWEx, etc.;
- Description of unique capabilities from the Principal Investigator (PI) Team that advance our understanding about the processes/radar-surface interactions or advance our signal analsyis capabilities.

Only proposals making primary use of data/products from the ASAR–L+S airborne campaign will be responsive to this solicitation. Proposals may not include costs for acquisition of any additional or complementary airborne or ground-based data.

The use and coannalysis of data/imagery from surface-based networks and from other satellites with the the ASAR–L+S airborne data products is strongly encouraged. Proposals are also encouraged to leverage existing activities, including but not limited to ABoVE (August, Alaska), SNOWEx (November, Western US), and SMAPEx (October, Northeastern US) field campaigns.

Projects that include both NASA and ISRO PIs are strongly encouraged, but are not required. As described in the *NASA Guidebook for Proposers*, NASA can only fund reseach at U.S. institutions. Proposals that propose research to be performed by a non-U.S. organization or with a non-U.S. organization as part of a proposal submitted by a U.S. organization are normally supported through a non-exchange of funds agreement.

The PIs of successful proposals will become part of the ASAR–L+S Science Team. There will be one Science Team meeting near the end of the performance period that will discuss the findings of each project. PIs are required to attend the Science Team meeting and the proposal needs to include an appropriate budget for one or two members of the PI team to travel to the science team meeting, most likely located in Pasadena, California.

Peer reviewed publication of the results from this campaign is expected from each of the PI teams selected in response to this ROSES element.

Updates on the NASA-ISRO ASAR–L+S campaign can be found:

https://nisar.jpl.nasa.gov/files/nisar/NASA_ISRO_ASAR_LandSband_Campaign_2019.pdf

3. Programmatic Information

Proposals should request one-time funding for use over an 18-month period to cover the costs of personnel, computing, publication, and travel to attend the Science Team meeting in Pasadena. This is a one-time activity with no planned follow-on to this program element, therefore proposers should not expect opportunities for continuation awards as part of this program element. Future ROSES program element as part of ongoing R&A and/or Applications programs may support additional analysis of the ASAR–L+S campaign data.

Given that the first phase of flights will commence in the summer of 2019, leaving less time than usual to conduct an evaluation, 8-page proposals will be due 60 days after the release of this program element. This is necessary both to accelerate the formation of the peer review panel and also for proposers to provide input to the site selection process.

A mandatory Notice of Intent (NOI) is required 30 days after the release of the solicitation. Any changes to the PI team after the NOI deadline has passed must be approved by the solicitation Point of Contact.

4. Summary of Key Information

Expected annual program budget for new awards	~$1.0M
Number of new awards pending adequate proposals of merit	~9-11
Maximum duration of awards	18 months
Due date for Mandatory Notice of Intent to propose (NOI)	See Tables 2 and 3 in the *ROSES Summary of Solicitation*.
Due date for proposals	See Tables 2 and 3 in the *ROSES Summary of Solicitation*.
Planning date for start of investigation	August 1, 2019
Page limit for the central Science-Technical-Management section of proposal	8 pp; see also Section 3 of the *NASA Guidebook for Proposers*.

Relevance	This program is relevant to the Earth science questions and goals in the NASA Science Plan. Proposals that are relevant to this program are, by definition, relevant to NASA.
General information and overview of this solicitation	See the *ROSES Summary of Solicitation*.
Detailed instructions for the preparation and submission of proposals	Please see the *ROSES Summary of Solicitation* Section 1(g) Order of Precedence and the NASA Guidebook for Proposers.
Submission medium	Electronic proposal submission is required; no hard copy is required or permitted.
Web site for submission of proposal via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Web site for submission of proposal via Grants.gov	http://grants.gov (help desk available at support@grants.gov or (800) 518-4726)
Funding opportunity number for downloading an application package from Grants.gov	NNH19ZDA001N-ISROASAR
Point of contact concerning this program	Gerald Bawden Earth Science Division Science Mission Directorate National Aeronautics and Space Administration Washington, DC 20546-0001 Telephone: (202) 358-3922 Email: Gerald.Bawden@nasa.gov

A.54 DECADAL SURVEY INCUBATION STUDY TEAMS: PLANETARY BOUNDARY LAYER AND SURFACE TOPOGRAPHY AND VEGETATION

Amended April 30, 2019. This amendment releases the final text for this program element. A preproposal bidder's conference will be held on June 4, 2019, at 1:00 p.m. Eastern Time. Notices of intent to propose are requested by June 17, 2019, and the due date for five-page proposals is August 1, 2019.

1. Scope of Program

The purpose of this program element is to assemble two study teams (one each) for advancing (1) Planetary Boundary Layer (PBL) and (2) Surface Topography and Vegetation (STV) Incubation Targeted Observables (TO) Program Goals as outlined in the National Academies of Sciences, Engineering and Medicine (NASEM) 2018 decadal survey, *Thriving on Our Changing Planet: A Decadal Strategy for Earth Observation from Space* (https://www.nap.edu/catalog/24938).

The decadal survey recommended the implementation of an incubation program intended to accelerate the readiness of high-priority observables not yet feasible for cost-effective flight implementation. PBL and STV science goals[1] call for exploring next-generation measurement approaches that could be ready for spaceborne implementation in 10+ years. The decadal survey recommends focused and sustained attention to these observables to establish the associated prospective scientific and other user communities, and to make progress towards maturing both measurement capabilities and implementation concepts within this decade. The objective of the incubation study teams is to identify methods and activities for improving the understanding of and advancing the maturity of the technologies applicable to these two TOs and their associated science and applications priorities.

The main deliverable produced by each study team will be a white paper outlining potential future methods and activity areas, such as modeling and Observing System Simulations Experiments (OSSEs); field campaigns; and a range of potential observing system architectures utilizing emerging sensor and information technologies. Other deliverables include an interim report; presentations to NASA Headquarters; and a preliminary Science and Applications Traceability Matrix (SATM) that includes relevant societal or science questions, Earth science/application objectives, geophysical observables, and draft concepts of associated measurement approaches. The deliverables are expected to be used by NASA Headquarters as a basis for planning subsequent relevant activities for each TO. See section 4 for a detailed list of all deliverables.

Team membership will be determined through this program element via a competitive selection process that includes a peer review (see section 2.1). Team membership proposals should address the information requested in section 2.1 and be relevant to advancing the scientific understanding and/or technology capabilities related to PBL and STV incubation (see section 1.1 and 1.2, respectively). Individuals can also self-nominate for the positions of Study Team Science Lead or Technology Co-Lead (see section 2.2). The period of performance of each team is up to 12 months.

It is expected that each team will solicit input from the broader scientific community including academia, government agencies, and private industry. At least one in-person community meeting in an open forum should be held by each study team during the first six months of the period of performance, and allowance for virtual participation in this meeting is strongly encouraged. This community meeting could be satisfied by a meeting of opportunity, such as a Town Hall in association with the 2019 American Geophysical Union Fall Meeting or another open community workshop. The meeting's objective shall be to collect community input for the study team about topics such as relevant scientific opportunities, the current and future state of technology, and the role that modeling will play in answering scientific questions regarding the relevant TO. A summary of the community meeting shall be part of the Interim Report due to NASA eight months after the award (see section 4). NASA will provide funding for the meeting venue and team member travel (but not community participation) separate from this program element (see Section 2.3).

1.1 Planetary Boundary Layer

The PBL comprises approximately the lowest kilometer of the atmosphere closest to Earth's surface. The PBL and its height vary considerably due to the nature of the underlying surface, diurnal cycle, thermal stratification, entrainment, and advective processes. Conditions within the PBL can influence a variety of phenomena, including how much rain will fall during a storm, where and how far pollutants can spread, and the amount of damage that occurs on localized scales from hurricanes and tornadoes.

An increased understanding of the PBL and the ability to make significant advances in many application areas (air quality and human health, improved forecasting of severe storms, etc.) are currently constrained by the lack of PBL observations at sufficient spatial and temporal resolution. Global satellite observations from techniques such as radio occultation, microwave sounding and imaging, and infrared sounding are key for sampling boundary conditions over remote regions, such as oceans and high latitudes. However, satellite capabilities to penetrate and resolve the vertical structure of the PBL are still limited. Improved observations of the PBL and its interactions with the ocean, land, and ice surfaces have the potential to advance science on a number of fronts, including improvements to both short-term weather and air quality forecasts, climate modeling, and estimates of trace gas emissions and transport. New observing technologies and approaches, including in situ as well as ground-based, airborne, and satellite remote sensing, have the potential to significantly increase the amount and types of observations collected within the PBL. Emerging technologies for PBL observations include optics, photonics, sensors, in situ measurements (including those enabled by unmanned Aerial Vehicles [UAVs]), and other existing networks, such as mesonets (e.g., http://www.mesonet.org/index.php).

To better understand the PBL, a combination of techniques—including improved observations that allow for different kinds of modeling (such as large eddy simulation [LES] and mesoscale modeling)—will need to be utilized. Currently, metrics such as PBL height are still too imprecise to be useful for direct comparisons of models with observations. High-resolution models and LES are critical to PBL observations, although additional, routine PBL vertical profile observations and model evaluation metrics are also needed. Observations could also be directed to address specific quantifiable model weaknesses such as clouds, stable boundary layers, and complex land surfaces. OSSEs are one way to guide the design of new or enhanced observing systems or to evaluate the usefulness of existing observations.

In concert with the goals and expectations of the PBL Earth Science and Application Objectives described in the decadal survey, this sub-element seeks a PBL study team to identify all of the technology options now available or in development to observe the PBL, technology gaps that need to be filled, and associated activities for advancing this TO. The team's analyses should identify the particular benefits, challenges, and opportunities associated with each proposed activity.

1.2 Surface Topography and Vegetation

STV research areas include bare-surface land topography, ice topography, vegetation structure, and shallow water bathymetry. High-resolution characterization of surface topography would allow for improved understanding of geologic structure, tectonic and volcanic activity, geomorphic processes, sea-level rise and storm surge in coastal areas, ice mass balance and flow characteristics, and other dynamic processes, which, in turn, could provide new insights into forecasting of natural hazards. In a similar manner, high-resolution characterization of vegetation structure could lead to significant improvement in the understanding of ecosystems, including carbon stocks and fluxes, as well as the relationships between biodiversity and habitat. Improved measurements of inland and coastal shallow water bathymetry could further inform studies of sea-level change, ice discharge near the grounding line, nautical navigation, and other science and applications objectives at the land-water interface.

While advancements have been made in STV characterization through improved lidar, radar, and optical techniques, there is still a need for repeat global topography and vegetation structure data products at desired resolutions to meet scientific and application goals. Space-based digital elevation models (DEMs) derived from spaceborne radar offer global coverage, but have spatial resolution limitations. Optical methods can offer increased resolution, but cannot track the bare surface in vegetated environments. Lidar offers the possibility of simultaneously measuring vegetation structure and underlying bare-Earth topography at high spatial and vertical resolution. However, despite developments in airborne and spaceborne lidar over the past decade, attaining global, high-resolution, repeat lidar coverage still presents a number of challenges. For instance, global lidar, radar, and optical products at higher spatial resolution will require new algorithms optimized for changing environmental conditions (e.g., wet or dry ecosystems, complex versus simple topography, etc.) along with new methods for data processing, storage, and utilization.

STV incubation seeks observing system architectures utilizing emerging sensor and information technologies that allow for the development of contiguous, high-resolution, bare-surface land topography, ice topography, vegetation structure, and bathymetry data products with global coverage and seasonal interannual repeat cycles. The STV study team is tasked with identifying activities and approaches towards satisfying these needs. This effort includes, but is not limited to, identifying all of the technology options now available or in development to observe STV, technology gaps that need to be filled, modeling and OSSE needs, potential data acquisition or integration strategies, and associated activities for advancing this TO. The team's analyses should identify the particular benefits, challenges, and opportunities associated with each proposed activity.

STV study team expertise should span relevant Earth science and applications elements (bare-surface land topography, ice topography, vegetation structure, shallow water bathymetry) and technology areas associated with the candidate measurement approaches (e.g., lidar, radar) or other relevant emerging capabilities (e.g., optical methods). To help drive integration at the project level, proposers are encouraged to include science and technology Co-Investigators.

2. Proposal Opportunity

2.1 Study Team Membership

The purpose of this program element is to assemble two study teams to gather perspectives, define the technological state-of-the-art, and define potential activities related to advancing PBL and STV TO objectives as outlined in the 2017 decadal survey. Team membership will be determined through this program element via a competitive process that includes a peer review. Individuals will propose areas of investigation relevant to advancing the scientific understanding and/or technology capabilities related to incubation.

Proposers are asked to provide the following information:

- Selection of the team to which they are applying (PBL or STV) by answering the relevant NASA Solicitation and Proposal Integrated Review and Evaluation System (NSPIRES) cover sheet question
- Relevancy of their field of study to the TOs or the potential measurement approaches
- Experience in cross-discipline, related studies outside of their current field of study
- Experience in modeling, measurement analysis, algorithms, or instrumentation
- Experience and roles in developing SATMs and mission pre-formulation activities
- A personal vision statement, described further below
- Proposed work to accomplish within the one-year study timeframe

Proposers should provide a personal vision statement describing their views of the scientific objectives and state of technology that could characterize the relevant TO at the end of the incubation period. The statement should describe the processes, modeling, and/or OSSEs needed over the next decade to mature the current state of the art to enable the objectives as described in the decadal survey. Proposers should list potential work that can be accomplished within the one-year study timeframe. Examples of the type of work that will contribute to the overall success of the study team include, but are not limited to, refining scientific objectives and data gaps through analysis of existing datasets related to the TO, preliminary computer modeling efforts, literature searches, and publishing peer reviewed papers that establish baselines for TO advancement. Proposers should also describe the steps they would employ to gather data and work towards the objectives of this program element.

2.2 Study Team Leadership

Individuals can self-nominate for the position of Study Team Science Lead or Technology Co-Lead for the study team to which they apply. The Study Team Science Lead's primary role will be to organize team meetings, foster integration of scientific needs, and lead drafting and finalization of the study white paper. The Technology Co-Lead's primary role will be to coordinate the integration of technology surveys conducted by the team and through complementary activities directed by NASA, and co-lead drafting and finalization of the study white paper. The Technology Co-lead should also have demonstrated experience in instrument design and development. Investigators interested in being considered as a Study Team Science Lead or Technology Co-Lead must indicate their candidacy by answering the relevant NSPIRES cover sheet question and including a separate section of no more than two extra pages within their proposals. Study Team Science Leads or Technology Co-Leads will receive up to an additional $80,000 or $50,000 per year, respectively, to support their leadership activities; the proposers selected for these roles will revise their budgets to incorporate these resources during final award negotiations.

Candidate team leads are asked to provide up to two additional pages describing the following:

- Experience with leading teams
- Experience in collaborations with universities, industry, and government agencies
- Plans to organize and lead the study team
- Demonstrated ability to organize, synthesize, and clearly communicate the results of group efforts and studies in written and verbal form

In addition, NASA reserves the right to select team leadership from outside of the self-nominated pool.

2.3 Travel

Study team members should anticipate up to three trips and regular telephone calls to support team activities and the development of deliverables. A kickoff meeting/telephone call with NASA Headquarters participation will be scheduled to discuss relevant expectations for each study team. Study Team Science Leads and Technology Co-Leads should plan for an additional two trips to NASA Headquarters in Washington, D.C., to coordinate with Headquarters on study activities as well as to deliver the final presentation of team findings. NASA Headquarters will manage and provide funds for necessary travel through separate contracts, so proposals should not include travel costs.

3. Submission and Evaluation

A preproposal bidder's conference will be held on June 4, 2019, from 1-2 p.m. Eastern Time using the following connection numbers: 1-844-467-4685, passcode 994062#. Minutes from the teleconference will be posted on the NSPIRES page for this program element.

A Notice of Intent (NOI) to propose is strongly encouraged for the submission of proposals to this program element. The information contained in the NOI is used to help expedite proposal review activities and, therefore, is of considerable value to both NASA and the proposer. NOIs should be submitted electronically via NSPIRES (http://nspires.nasaprs.com/) by the due date given in section 5. Since NOIs submitted after the deadline may still be useful to NASA, late NOIs, as well as indication of intent not to propose on an earlier NOI submission, should be submitted by email directly to the points of contact for this program element (see section 5).

The page limit for the central Scientific/Technical/Management section of submitted proposals is five pages, plus two extra pages for team lead or co-lead proposals. The five-page Scientific/Technical/Management section of the proposal should prioritize addressing the information requested in Section 2.1 of this program element over the topics listed in the associated section of the NASA Guidebook for Proposers. The extra two pages for those proposing to be Study Team Science Lead or Technology Co-Lead are requested to provide the information listed in Section 2.2 in this program element.

4. Deliverables

The following deliverables shall be produced by each study team under the leadership of the respective team leads:

- At least one community meeting held within the first six months.
- An Interim Report due to NASA no later than eight months after award; this report shall include a summary of the community meeting(s) held within the first six months.
- A final white paper due to NASA no later than 12 months after award that includes, but is not limited to:
  a. TO science and applications objectives, including forward-looking spatial, temporal, and spectral capabilities, building on the decadal survey
  b. TO measurement characteristics, including capabilities now available or in development for suborbital and space-based approaches, building on the decadal survey
  c. A preliminary SATM
  d. Example approaches and activities for advancing TO maturity such as modeling, OSSEs, field campaigns, enhanced analysis of existing data, and instrument or lab work, which could inform a range of future observing system architectures utilizing emerging sensor and information technologies.
  e. Characterized efforts critical to maturing spaceborne components towards flight on a 10-year incubation timescale
  f. Potential roles of spaceborne, airborne, and surface-based components
  g. Potential commercial approaches, including the use of commercial data
  h. Observing system components that could be ready to compete for Venture-class opportunities within a five-year timescale
  i. Potential synergies with the decadal survey Designated and/or Earth System Explorer TOs and Program of Record
  j. Determination of the potential to leverage Ice, Cloud and land Elevation Satellite-2 (ICESat-2), Global Ecosystem Dynamics Investigation (GEDI), Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO),

Aeolus, and/or other existing spaceborne lidar data to reduce gaps in existing or planned PBL/STV activities

k. Existing efforts that could contribute to advancing maturity of the Incubation TOs on a 10-year timescale.

- Presentations by appointed team members to NASA Headquarters of the interim report and final white paper following delivery of those documents by each team.

5. Summary of Key Information

Expected annual program budget for new awards	~$1.5M per team
Number of new investigator awards pending adequate proposals of merit	~15 per team
Maximum duration of awards	12 months
Due date for Notice of Intent to propose	See Tables 2 and 3 of *ROSES*.
Due date for proposals	See Tables 2 and 3 of *ROSES*.
Planning date for start of Investigation	November 1, 2019
Page limit for the central Science-Technical-Management section of proposal	5 pp plus 2 pp extra for team lead or co-lead proposals; see also Section 3 of the *NASA Guidebook for Proposers.*
Relevance	This program is relevant to the Earth Science questions and goals in the NASA Science Plan. Proposals that are relevant to this program are, by definition, relevant to NASA.
General information and overview of this solicitation	See the *ROSES Summary of Solicitation.*
Detailed instructions for the preparation and submission of proposals	See the *NASA Guidebook for Proposers* at https://www.hq.nasa.gov/office/procurement/nraguidebook/
Submission medium	Electronic proposal submission is required; no hard copy is permitted.
Website for submission of proposals vis NSPIRES	http://nspires.nasaprs.com/ (Help desk available at nspires-help@nasaprs.com or 202-479-9376.)
Website for submission of proposals via Grants.gov	http://grants.gov/ (Help desk available at support@grants.gov or 800-518-4726.)
Funding opportunity number for downloading an application package from Grants.gov	NNH19ZDA001N-DSIST

Points of contact concerning this program, both of whom share this postal address: Earth Science Division Science Mission Directorate NASA Headquarters Washington, DC 20546-0001	For PBL: Gail Skofronick-Jackson Telephone: 202-358-2045 Email: gail.s.jackson@nasa.gov For STV: Benjamin R. Phillips Telephone: 202-358-5693 Email: ben.phillips@nasa.gov

APPENDIX B. HELIOPHYSICS RESEARCH PROGRAM

B.1 HELIOPHYSICS RESEARCH PROGRAM OVERVIEW

1. Overview

NASA's heliophysics strategic objective is to understand the Sun and its interactions with the Earth and the Solar System, including space weather. In this framework, the Heliophysics Research Program is guided by the *NASA 2014 Science Plan* (available at https://science.nasa.gov/about-us/science-strategy) and by the *2013 National Research Council Decadal Strategy for Solar and Space Physics report, Solar and Space Physics: A Science for a Technological Society* (www.nap.edu/catalog.php?record_id=13060). Heliophysics research addresses these recommendations by implementing a program to achieve three overarching science goals:

- Explore the physical processes in the space environment from the Sun to the Earth and throughout the solar system
- Advance our understanding of the connections that link the Sun, the Earth, planetary space environments, and the outer reaches of our solar system
- Develop the knowledge and capability to detect and predict extreme conditions in space to protect life and society and to safeguard human and robotic explorers beyond Earth

The Heliophysics Research Program supports investigations in all subdisciplines of Heliophysics and also supports investigations that span the subdisciplines and address a systems approach – emphasizing the understanding of fundamental processes and interconnections across the traditional science disciplines. The program seeks to understand phenomena, on a broad range of spatial and temporal scales, the fundamental processes that drive them, how these processes combine to create space weather events, and to enable a capability for predicting future space weather events. In concert with the other NASA science divisions (Planetary Science, Astrophysics, and Earth Science), the program shares responsibility for learning about the Earth, our solar system, the universe, and their interrelationships.

The program supports investigations of the Sun, including processes taking place throughout the solar interior and its atmosphere, as well as the evolution and cyclic activity of the Sun. It supports investigations of the origin and behavior of the solar wind, transient structures, energetic particles, and magnetic fields in the heliosphere and their interaction with the Earth and other planets, as well as with the interstellar medium. The program supports investigations of the physics of magnetospheres, including fundamental interactions of plasma wave-particle interactions and particles with fields and waves, and coupling to the solar wind and ionospheres. It supports the physics investigations of the terrestrial mesosphere, thermosphere, and ionosphere, including the coupling of these phenomena to the lower atmosphere and magnetosphere.

The program elements are as follows:

- B.2 Heliophysics Supporting Research (H-SR)
- B.3 Heliophysics Theory, Modeling, and Simulations (H-TMS)
- B.4 Heliophysics Guest Investigators Open (H-GIO)
- B.5 GOLD-ICON Guest Investigators - not solicited this year

- B.6 Living With a Star Science (LWS)
- B.7 Space Weather Science Applications Operations 2 Research (SWO2R)
- B.8 Heliophysics Instrument Development for Science (HTIDeS)
- B.9 Heliophysics Flight Opportunities for Research and Technology (H-FORT)
- B.10 Living With a Star Strategic Capabilities (LWS-SC)
- B.11 Heliophysics Data Environment Enhancements (H-DEE)
- B.12 Heliophysics U.S. Participating Investigator (H-USPI) – not solicited this year

It is the overall purpose of each of the program elements to contribute as effectively and directly as possible to the achievement of the NASA Heliophysics strategic objective. Priority for selection is given to those proposals that most clearly demonstrate the potential for such contributions. All proposals for these elements must be submitted electronically by the due date (see Table 2 and Table 3 of ROSES).

NASA Heliophysics primarily awards grants and Inter-Agency Transfers (IATs) as these are the most appropriate to the nature of the work. These are the default for program elements in Appendix B, unless stated otherwise in the program element.

1.1 Data Management

All proposals to Appendix B must present a data management plan (DMP), or an explanation of why one is not necessary given the nature of the work proposed. By default, this is accomplished by responding to the compulsory NSPIRES cover page question about the DMP. The kinds of proposals that require a data management plan on the cover pages are described in the NASA Plan for increasing access to results of Federally funded research and in the Service and Advice for Research and Analysis (SARA) Frequently Asked Questions (FAQs) about Data Management Plans (DMPs).

For proposers to B.11 H-DEE, the minimum DMP requirement is superseded by instructions in the program element that place more detailed descriptions into the body of the Scientific/Technical/Management section of proposals. See, Section 2 of B.11 H-DEE. For B.11, the NSPIRES cover page DMP entry should be simply "see proposal".

1.2 Data Eligibility

All spacecraft mission data must be available in the Solar Data Analysis Center (SDAC), Space Physics Data Facility (SPDF), or an equivalent, publicly accessible archive, at least 30 days prior to the full proposal submission deadline, unless otherwise specified in the program call. This is applicable to ROSES Heliophysics elements B.2 (H-SR), B.3 (H-TMS), B.4 (H-GIO), B.6 (LWS), B.7 (SWO2R), B.10 (LWS-SC).

1.3 Two-Step Process

Proposal submission to elements in Heliophysics will use a two-step proposal submission process (see Section IV(b)vii of the ROSES *Summary of Solicitation*), unless otherwise specified in the program call.

In a two-step process a Step-1 proposal is required. The title, science goals, and investigators may not be changed between the Step-1 and Step-2 proposals. All Heliophysics programs will review Step-1 proposals for compliance and will require a description that is limited to the 4000-character text box on the NSPIRES cover page that includes (1) the science goals and objectives, and (2) the proposed methodology. All compliant proposals submitted to these calls will be "invited" to submit a Step-2 proposal.

1.4 Multiple Submissions and Duplication

Proposers are limited to one submission per Principal Investigator (PI or Science PI) per program element, i.e., they can submit one and only one proposal as PI to each, unless otherwise specified in the program call. Submission includes Step-1 proposals, NOIs, and full (Step-2) proposals.

Proposers may not submit Step-2 (or full) proposals for the same or essentially the same work to more than one program element concurrently. This covers all program elements in Appendix B and also all cross-divisional ROSES program elements (Appendix E) supported by the Heliophysics Division. This prohibition is active for a particular submitted proposal until the PI is notified that the proposal was declined or until the proposal is withdrawn. The prohibition on duplicate proposals applies across ROSES years as well (e.g., a duplicate of a pending ROSES-2018 proposal may not be submitted in response to ROSES-2019). If a second proposal is submitted while a duplicate proposal is still pending in another program element, only the first proposal will be evaluated; the duplicate proposal may not be evaluated or considered and may be returned without review.

1.5 Organizing Science Reviews

Heliophysics has established two questions that must be answered for all proposals submitted to Elements in Appendix B on the NSPIRES cover page. The answers define the Research Regime and Science Topic for the proposal and help to organize the evaluation and peer review. Unless otherwise specified in the program call, the values will default to what is listed here. The default values for Research Regime are Sun, Heliosphere, Magnetosphere, Ionosphere-Thermosphere-Mesosphere (ITM) and System-Interdisciplinary. The default values for Science Topic are listed below.

1. Solar Interior
2. Photosphere
3. Atmosphere / Corona
4. Solar Transient Events
5. Inner Heliosphere
6. Outer Heliosphere /Interstellar Boundary
7. Particle Acceleration, Transport, Modulation
8. Turbulence, Waves
9. Dayside Magnetosphere
10. Inner Magnetosphere
11. Magnetotail
12. Ionosphere
13. Ionosphere-Atmosphere coupling
14. Neutral Atmosphere
15. Solar-Heliosphere coupling
16. Solar Wind-Magnetosphere coupling

17. Magnetosphere-Ionosphere coupling
18. Solar-Ionosphere coupling
19. Multi-disciplinary

2. Program Elements

2.1 Introduction

A brief description of each program element offered in the Heliophysics Research Program is given below. The intent of the following summaries is to give the prospective proposer some insight into the element's purpose within the context of the overall program structure. Detailed descriptions of each element are to be found in Program Elements B.2 through B.12. Please note that the numbering and names of the program elements may have changed from ROSES-18.

2.2 Heliophysics Supporting Research (H-SR):

The Heliophysics Supporting Research program is described in Program Element B.2. In order to increase the science return from funded investigations and to avoid duplication and overlap of proposal opportunities, in particular between H-GI and H-SR, a larger scope, introduced in ROSES-2016, will be maintained. Heliophysics SR awards are research investigations that employ a variety of techniques, including theory, numerical simulation, modeling, analysis, and interpretation of spacecraft data. This increased scope of investigations must be of sufficient breadth as to require approximately one full time equivalent (FTE) per year to achieve successful completion of the project. As a result, the anticipated average award size has been increased, as well. The investigations that will be of highest priority to the H-SR program will be those that use data from current or historical NASA spacecraft, together with theory and/or numerical simulation to address one of the four Heliophysics Decadal Survey goals. Proposals focused on non-NASA data are now allowed. However, such proposals must demonstrate that the proposed work is necessary to make a significant contribution to addressing one or more Decadal Survey questions.

Please note that each PI is limited to submit one and only one proposal to this program. There is no longer an exception for multiple submissions per PI that involve Science PIs.

2.3 Heliophysics Theory, Modeling, and Simulations (H-TMS):

The H-TMS program was previously one element of the Heliophysics Grand Challenges Research (H-GCR) program (H GCR-TMS, last competed in ROSES 2016 program element B.5). Before that it was called "Heliophysics Theory Program" (HTP, last competed in ROSES 2013). For simplification, this program is now referred to as the Theory, Modeling, and Simulations (TMS) element in the Heliophysics program.

2.4 Heliophysics Guest Investigators (H-GIO):

The Heliophysics Guest Investigators open program (H-GIO) is described in Program Element B.4. The H-GI program was strongly endorsed by the 2013 Decadal Survey. This program is offered for investigations that draw extensively upon the data sets from the missions of the Heliophysics System Observatory (HSO). The focus of the solicited research continuously evolves to ensure that the most important questions identified for recently launched Heliophysics missions are addressed, and to ensure that high-value data products of currently operating missions of the HSO are created to enable significant advances in Heliophysics science.

Note that proposals that use eligible GOLD data (see section 1.2 above) are allowed and encouraged to be submitted to this ROSES-19 H-GIO.

2.5 GOLD-ICON Guest Investigators:

This program element is not solicited this year. It is anticipated that this element will have two sub-elements in ROSES 2020: the Global Observations of Limb and Disk and Ionospheric Connection Explorer Guest Investigator and the Parker Solar Probe Guest Investigator.

2.6 Heliophysics LWS Science (H-LWS):

The details of NASA's Living With a Star (LWS) Science program for ROSES-2019 are described in Program Element B.6.The goal of the LWS Science Program is to develop the scientific understanding needed to effectively address those aspects of Heliophysics science that affect life and society. To ensure this, the Heliophysics LWS Science program solicits proposals for Focus Teams to conduct coordinated large-scale investigations that cross discipline and technique boundaries, leading to an understanding of the system linking the Sun to the Solar System both directly and via the heliosphere, planetary magnetospheres, and ionospheres. The LWS Science program may also solicit proposals for development of Tools and Methods that are of broad use to the community, including new data analysis techniques or software tools.

2.7 Heliophysics Space Weather Science Applications:

The Heliophysics Space Weather Science Applications O2R Program Element is described in B.7. In response to the National Space Weather Action Plan (SWAP), NASA established the Heliophysics Space Weather Science Applications Program (SnAP). The component of SnAP that addresses the aspect of transitioning knowledge between research and operations is reflected in the SnAP Operations-to-Research (O2R) program. For the purpose of this opportunity, NASA, NOAA, and NSF working under the tri-agency Space Weather MOU, have determined that the focus of this year's call is open. Please note that the proposal, in order to demonstrate relevance to SWO2R, must address how the research will directly advance the information needed by users of space weather information in the proposed focus area.

2.8 Heliophysics Instrument Development for Science (HTIDeS)

HTIDeS with sub-elements LNAPP and ITD is described in Program Element B.8.

The HTIDeS program seeks to advance the development of technologies and their application to enable investigation of key heliophysics science questions. This is done through incubating innovative concepts and development of prototype technologies. It is intended that technologies developed through HTIDeS then be proposed to H-FORT (B.9) to mature by demonstration in a relevant environment. HTIDeS utilizes the following sub-elements:

- Laboratory Nuclear, Atomic, and Plasma Physics (LNAPP) Program: The LNAPP program supports studies that probe fundamental nuclear, atomic, and plasma physical processes and produce chemical and spectroscopic measurements that support spacecraft observations and atmospheric models.
- Instrument Technology Development (ITD) Program: This includes innovative technology development and instruments that may be proposed as candidate experiments for future space flight opportunities.

The HTIDeS program is not soliciting Step-1 proposals or NOIs in 2019. Only a full proposal is solicited and must be submitted electronically by the due date (see Table 2 and Table 3 of ROSES).

2.9 Heliophysics-Flight Opportunities for Research and Technology (H-FORT)

H-FORT with sub-elements LCAS and SRO is described in Program Element B.9.

H-FORT seeks to advance the development of technologies and their application to enable investigation of key heliophysics science questions. This is done through demonstration of innovative technologies and associated science investigations in a relevant environment. It is anticipated that some of the technologies developed through HTIDeS then be proposed to H-FORT to mature by demonstration in a relevant environment, however, this is not a prerequisite for submitting a proposal to H-FORT. H-FORT utilizes the following sub-elements:

- Low Cost Access to Space (LCAS). This includes technology and associated science investigations that can be carried out with instruments flown on suborbital rockets, stratospheric balloons, suborbital reusable launch vehicles, or other platforms, collectively referred to as Low Cost Access to Space.
- SmallSats and Rideshare Opportunities (SRO). This includes technology and associated science investigations that can be carried out with instruments flown on Smallsats (including CubeSats), payloads on the International Space Station (ISS), Department of Defense (DoD), or other rideshare opportunities.

The H-FORT program is not soliciting Step-1 proposals or NOIs in 2019. Only a full proposal is solicited and must be submitted electronically by the due date (see Table 2 and Table 3 of ROSES).

2.10 Living With a Star Strategic Capabilities (LWS-SC)

A primary goal of NASA's LWS Program is the development of first-principles-based models for the coupled Sun-Earth and Sun-Solar System, similar in spirit to the first-principles models for the lower terrestrial atmosphere. Such models can act as tools for science investigations, as prototypes and test beds for prediction and specification capabilities, as frameworks for linking disparate data sets at vantage points throughout the Sun-Solar System, and as strategic planning aids to enable exploration of outer space and testing new mission concepts. The development of these models is generally conducted in terms of Strategic Capabilities, and is described in Program Element B.10.

2.11 Heliophysics Data Environment Enhancements (H-DEE):

The Heliophysics Data Environment Enhancement program is described in Program Element B.11. The goal of the H-DEE program is to enable breakthrough research in

Heliophysics by providing both a state of the art data environment and necessary supporting infrastructure to maximize the scientific return of the NASA missions. It is essential that observations be properly recorded, analyzed, released to the general public, documented, and rapidly turned into scientific results.

Proposers should take into account the special needs driven by the increasing complexity of missions, the associated increasing complexity and volume of data, and the need for innovative and enabling technologies. For proposers to B.11 H-DEE the NSPIRES cover page question about a data management plan should simply state "see proposal", as details of the plan need to be included within the proposal itself.

2.12 Heliophysics U.S. Participating Investigator (H-USPI):

The purpose of the Heliophysics U.S. Participating Investigator (H-USPI) program element is to solicit potential Heliophysics investigations in which investigators participate as a Co-Investigator (Co-I) for an instrument, experiment, or technology demonstration that is being built and flown by a sponsor agency other than NASA. The Heliophysics U.S. Participating Investigator program is described in Program Element B.12. It is not solicited in ROSES-2019.

B.2 HELIOPHYSICS SUPPORTING RESEARCH

NOTICE: August 28, 2019. In order to spread out Heliophysics due dates and give proposers additional time, the proposal due date for this program element has been changed to October 18, 2019.

August 1, 2019. Section 1.2 has been clarified to indicate that data behind a paywall is not eligible. New text is in bold and deleted text is struck through. The due dates are unchanged.

July 19, 2019. The point of contact for this program element has changed to Patrick Koehn, see Section 6.

In order to avoid duplication and overlap of proposal opportunities, between Heliophysics Guest Investigators (H-GI) and Heliophysics Supporting Research (H-SR) in particular, the H-SR program continues to solicit investigations with a larger scope than H-GI.

Proposals involving currently funded investigators must include a description in a separate subsection of the scientific/technical/ management section that specifies how the new proposed effort is different and not duplicative with currently supported efforts.

Proposals to this program will continue to be taken by the two-step process in which a Step-1 proposal, submitted by an Authorized Organizational Representative (AOR) is required. See Section 3 for details.

Please note that each PI is limited to submit one and only one proposal to this program. There is no longer an exception for multiple submissions per PI that involve Science PIs.

Check for spacecraft mission data eligibility as specified in the overview B.1, Section 1.2.

1. Scope of Program

Heliophysics Supporting Research (SR) awards are research investigations of significant magnitude that employ a combination of scientific techniques. These must include an element of (a) theory, numerical simulation, or modeling, and an element of (b) data analysis and interpretation of NASA-spacecraft observations.

Proposing teams must demonstrate the expertise necessary to cover the combination of techniques required. Awards are expected to be in the range of approximately $200K per year – $250K per year. The Heliophysics Supporting Research program is a component of the Heliophysics Research Program and proposers interested in this program element are encouraged to see the overview of the Heliophysics Research Program in Appendix B.1 of this ROSES NASA Research Announcement.

1.1 Overview

The Heliophysics Supporting Research program replaces the former supporting research elements of the Geospace Science program and the Solar and Heliospheric Science program entirely.

Science investigations are solicited with this Heliophysics SR program. These must include an element of a) theory, numerical simulation, or modeling, and an element of b) data analysis and interpretation of current or historical NASA-spacecraft observations, and should address one of the four Heliophysics Decadal Survey goals (listed below). Theory/modeling/simulation proposals must be substantiated with and guided by data. It is expected that proposing teams will be composed of investigators that cover the necessary expertise that the combination of techniques requires. Innovative ideas and techniques are welcome.

The four high level science goals from the Heliophysics Decadal survey (*Solar and Space Physics: A Science for a Technological Society* www.nap.edu/catalog.php?record_id=13060) are:

1. Determine the origins of the Sun's activity and predict the variations in the space environment;
2. Determine the dynamics and coupling of Earth's magnetosphere, ionosphere, and atmosphere and their response to solar and terrestrial inputs;
3. Determine the interaction of the Sun with the Solar System and the interstellar medium;
4. Discover and characterize fundamental processes that occur both within the heliosphere and throughout the Universe.

1.2 Data Usage **[Clarified August 1, 2019]**

Proposals with a major focus on analyzing non-NASA data, but that still include a required substantial NASA data analysis and/or interpretation aspect, must demonstrate that the proposed work is necessary to make a significant contribution to addressing one or more Decadal Survey questions.

All data, whether of NASA or non-NASA origin, must be available ~~in~~ **at no cost from** a public archive 30 days prior to the Step-2 (full-proposal) deadline. Proposals that do not contain a substantial NASA data analysis and/or interpretation aspect or that use data that is not archived 30 days prior to the full-proposal deadline will be declared noncompliant and may be returned without review. Proposals for projects that aim to produce (e.g., combined non-NASA and NASA-) data products should explain how those products would be made publicly available through a data management plan.

1.3 Organizing Science Review (see B.1)

The Heliophysics Supporting Research program is using only four values for Research Regime and 19 values for Science Topic (see B.1 for full list of default values). The four values for Research Regime mirror the four subdisciplines of Heliophysics: Sun, Heliosphere, Magnetosphere, and Ionosphere-Thermosphere-Mesosphere (ITM). The 19 values for Science Topic are listed below; some of these science topics fit within more than one Research Regime. Each proposal must choose one value for Research Regime and one of the 19 Science Topics.

1. Solar Interior
2. Photosphere
3. Atmosphere / Corona
4. Solar Transient Events
5. Inner Heliosphere
6. Outer Heliosphere /Interstellar Boundary
7. Particle Acceleration, Transport, Modulation
8. Turbulence, Waves
9. Dayside Magnetosphere
10. Inner Magnetosphere
11. Magnetotail
12. Ionosphere
13. Ionosphere-Atmosphere coupling
14. Neutral Atmosphere
15. Solar-Heliosphere coupling
16. Solar Wind-Magnetosphere coupling
17. Magnetosphere-Ionosphere coupling
18. Solar-Ionosphere coupling
19. Multi-disciplinary

System science proposals that touch on more than one of these science topics are encouraged; for the purpose of organizing the review, investigators should choose the one that is most relevant. Proposals addressing the magnetospheres or the ionospheres of other planets are permitted, but must not duplicate proposals sent to other programs.

Note: Do not choose Heliosphere meaning Heliophysics; they are not synonymous. This wastes time and resources to redirect; such misdirected proposals may be returned without review.

2. Submission and Evaluation Guidelines

2.1 General Considerations

Each Principal Investigator (PI) may submit one and only one Step-1 proposal to this program element. The expectation is that the Principal Investigator (or Science PI) will invest a substantial portion of their time, of the order of 30%, to the investigation. The scope and necessary tasks of the investigation must be of sufficient breadth that, in order to achieve successful completion of the project, on the order of an entire full-time equivalent (FTE) per year would be required. Within the proposing team, the PI and Co-Investigators (Co-Is) must each have specific and defined tasks in the project, and the tasks must be essential to the completion of the project. Use of Collaborators is discouraged. Proposals may be declared noncompliant based on either the Step-1 or Step-2 proposal if they are outside the scope of the H-SR program (see Section 2.2 below) or if they fail to meet submission guidelines specified below (Section 3).

2.2 Limitations and Scope

Proposals outside the scope of Heliophysics Supporting Research include the following:

- Proposals for the same or essentially the same work submitted concurrently to other program elements in Appendix B or E, as specified in B.1 Section 1;
- Work for which the proposing organization (or investigators) are already funded by NASA. Proposals involving currently funded investigators must include a description in a separate subsection of the scientific/technical/management section that specifies how the new proposed effort is different and not duplicative with currently supported efforts;
- Model or tool development and/or new data analysis techniques, where this effort constitutes more than 50% of a three-year effort;

3. Two-Step Submission Guidelines

To streamline the proposal process (submission, evaluation, and administration), this program uses a two-step proposal submission process. The overall description of a two-step process can be found in Section IV(b)vii of the ROSES *Summary of Solicitation*.

A Step-1 proposal is required and must be submitted electronically by the Step-1 due date (see below and Table 2 and Table 3 of ROSES). The Step-1 proposal must be submitted by the organization's Authorized Organizational Representative (AOR). No budget or other elements are required. Only proposers who submit a Step-1 proposal are eligible to submit a full proposal. Step-1 proposals will be checked for compliance, but they will not be evaluated.

The Step-1 proposal title and science goals, cannot be changed between the Step-1 and Step-2 proposals. No addition of investigators (Principal Investigator, Co-Investigators, Collaborators, Consultants, and Other Professionals) is allowed between Step-1 and Step-2 proposals. The expected format and evaluation criteria are described below. Submission of the Step-1 proposal does not obligate the offerors to submit a Step-2 (full) proposal later.

3.1 Step-1 Proposal Content

Proposers should refer to the "Instructions for Submitting a Step-1 Proposal" under "Other Documents" on the NSPIRES page for this program. The Step-1 proposal is restricted to the 4000-character Proposal Summary text box on the NSPIRES web interface cover pages.

The Step-1 proposals must include the following:

- The science goals and objectives to be addressed by the proposal;
- The relevance of the problem to one or more of the four Decadal Survey goals.
- A brief statement of the methodology to be used, including what data, models, and analysis will be used for completing the investigation.

The NSPIRES system for proposal submission requires that Step-1 proposals include a summary (i.e., abstract) describing the proposed work as outlined above. The proposal summary is entered directly into a text field in NSPIRES. No PDF attachment is required or permitted for Step-1 proposal submission. All information will be entered within the 4000-character Proposal Summary text box on the NSPIRES web interface cover pages. Proposers will be invited by NSPIRES when they are able to submit their Step-2 proposals.

Step-1 proposals may be declared noncompliant if they fail to meet submission guidelines or if they are outside the scope of the H-SR program, as discussed in Section 1. PIs of noncompliant proposals will not be eligible to submit the associated Step-2 proposal and will receive a letter to this effect.

Proposers are strongly encouraged to provide names and contact information of five experts qualified to review their proposal. These experts must not be from the institutions of the PI or Co-Is. This information can be supplied in response to NSPIRES cover page questions at the time of submission of the Step-1 proposal.

3.2 Step-2 Proposals

A Step-2 (full) proposal must be submitted electronically by the Step-2 due date (see below and Tables 2 and 3 in the *ROSES Summary of Solicitation*). The Step-2 proposal must be submitted via NSPIRES or Grants.gov by the organization's Authorized Organizational Representative (AOR). A budget and other specified information is required. The Step-2 proposal title and science goals, must be the same as those in the Step-1 proposal. No additional investigators (Principal Investigator, Co-Investigators, Collaborators, Consultants, and Other Professionals) are allowed in Step 2.

Proposers must have submitted a Step-1 proposal to be eligible to submit a Step-2 proposal. Proposers that received a noncompliant letter are not eligible to submit a Step-2 proposal.

3.3 Step-2 Proposal Content

The process for preparation and submission of the Step-2 (full) proposals is the same as that for any other ROSES proposal. Guidelines for content and formatting Step-2 full proposals are specified in the *NASA Guidebook for Proposers* and the *ROSES Summary of Solicitation*.

Proposals are restricted to fifteen (15) pages for the Scientific/Technical/Management section and must include the following sections with the preferred order:

- The science objectives, including (a) clear science question(s) to be addressed, and perceived impact of the proposed work to the state of knowledge in the field; references to existing work in the field should be limited to that which is needed to justify the value of the science proposed;
- The data and methodology to be employed in conducting the proposed research; the proposal must demonstrate (1) that the data are appropriate to address the science objectives, and (2) that the methodology is both appropriate and feasible to make substantial progress on the science objectives;
- The relevance of the proposed work to one or more of the four high-level science goals from the most recent Heliophysics Decadal survey listed in Section 1.1 must be demonstrated;
- A general plan of work, the management structure for the proposal personnel, and a description of the expected contribution to the proposed effort by the PI and each person as identified in the proposal, whether or not they derive support from the proposed budget. Postdoctoral fellows and students need not be named.

Historically, proposals that address a single well-focused compelling science objective with a limited set of specific science questions have been more successful at constructing methodologies that are demonstrably feasible and appropriate, as compared with those that propose to address a large number of science questions or that are directed at an overly-broad science topic.

3.4 Step-2 Compliance and Evaluation Criteria

All Heliophysics programs will continue reviewing Step-2 proposals for compliance. Step-2 proposals that are not compliant with formatting requirements (e.g., margins, font sizes, line spacing) may be rejected without review. See Section IV(b)ii of the *ROSES Summary of Solicitation* and the *NASA Guidebook for Proposers* for details. In particular users of LateX formatting must specify the appropriate paper size (US letter) and font size.

Proposals that have changed the scientific scope from that of their Step-1 proposal may be declared noncompliant.

Compliant proposals will be evaluated according to the criteria specified the *NASA Guidebook for Proposers*. These criteria are intrinsic scientific and technical merit, relevance to NASA's objectives, and cost realism/reasonableness.

The evaluation of scientific and technical merit will include the following:

- Compelling nature and scientific priority of the proposed investigation's science goals and objectives, including the importance of the problem within the broad field of Heliophysics; the unique value of the investigation to make scientific progress in the context of current understanding in the field, and the importance of carrying out the investigation now.
- Appropriateness and feasibility of the methodology, including the appropriateness of the selected data, models, and analysis for completing the investigation and the feasibility of the methodology for ensuring scientific success.

Based on these two factors, the evaluation will consider the overall potential science impact and probable success of the investigation.

Relevance to and priority within the H-SR program will be assessed based on criteria discussed in Section 1. Each proposal must demonstrate that the investigation is relevant and of high priority.

As indicated in the *NASA Guidebook for Proposers*, the evaluation of cost reasonableness includes the amount of work to be accomplished versus the amount of time proposed. Open-ended proposals or those with a large number of science questions to be addressed typically do not fare well in this evaluation. Only necessary Co-Investigators and Collaborators should be included, and their specific tasks and roles in the investigation must be clearly laid out.

4. Available Funds

It is expected that there will be approximately ~$6.5M available in Fiscal Year (FY) 2020 to support new Heliophysics SR investigations selected through this program element. Due to the increase in the proposed scope and complexity, annual funding is expected to fall into the ~$200-$250K range per investigation.

5. Award Types

The Heliophysics SR program will award funds through three vehicles: (1) grants, (2) interagency transfers, and (3) awards to NASA Centers. The Heliophysics SR program will not award contracts.

6. Summary of Key Information

Expected program budget for first year of new awards	~$6.5M
Number of new awards pending adequate proposals of merit	~27-30
Maximum duration of awards	3 years
Due date for Step-1 proposal	See Tables 2 and 3 of this ROSES NRA
Due date for full proposals	**October 18, 2019 [Due Date Delayed August 28, 2019]**
Planning date for start of investigation	6 months after full proposal due date.
Page limit for the central Science-Technical-Management section of full proposal	15 pp; see also Table 1 of ROSES and Section 3.7 of the *NASA Guidebook for Proposers*
Relevance	This program is relevant to the Heliophysics questions and goals in the NASA Science Plan. Proposals that are relevant to this program are, by definition, relevant to NASA.
General information and overview of this solicitation	See the *ROSES Summary of Solicitation*.
General requirements for content of proposals	See Section 3 of the *NASA Guidebook for Proposers* and Section IV and Table 1 of *the ROSES Summary of Solicitation*.
Detailed instructions for the submission of proposals	See https://nspires.nasaprs.com/tutorials/ Sections 3.22-4.4 of the *NASA Guidebook for Proposers* and Section IV(b) of *the ROSES Summary of Solicitation*.
Submission medium	Electronic proposal submission is required; no hard copy is permitted.
Web site for submission of Step 1 and Step 2 proposal via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Web site for submission of Step 1 and Step-2 proposal via Grants.gov	http://grants.gov (help desk available at support@grants.gov or (800) 518-4726)
Funding opportunity number for downloading an application package from Grants.gov	NNH19ZDA001N-HSR

Point of contact concerning this program.	**Patrick Koehn [Changed July 19, 2019]** Heliophysics Division Science Mission Directorate NASA Headquarters Washington, DC 20546-0001 Telephone: (202) 358-**3636** Email: **patrick.koehn@nasa.gov**

B.3 HELIOPHYSICS THEORY, MODELING, SIMULATIONS

NOTICE: Amended November 26, 2019. Due to disruptions caused by past fires and power outages and expected power outages from high winds in northern California next week, the Step-2 due date for this program element has been delayed to December 10, 2019.

Amended June 4, 2019. This Amendment releases the final text for this program element. Step-1 proposals are due October 3, 2019 and 20-page Step-2 proposals are due by December 3, 2019.

1. Scope of Program

The Heliophysics Theory, Modeling, Simulations (H-TMS) program is a component of the Heliophysics Research Program. Proposers interested in this program element are encouraged to see the overview of the Heliophysics Research Program in Appendix B.1 of this ROSES NRA.

The H-TMS program was previously one element of the Heliophysics Grand Challenges Research (H-GCR) program (H-GCR-TMS, last competed in ROSES-2016 as program element B.5). Before that it was called "Heliophysics Theory Program" (HTP, last competed in ROSES-2013). For simplification, this program is now referred to as the Theory, Modeling, and Simulations (TMS) element in the Heliophysics program.

The former Heliophysics Theory Program provides the foundation of the TMS element. Increasingly, as computing power becomes more affordable and more available, numerical simulations and modeling become tools that can and have been used synergistically with data analyses and rigorous theory development to solve the fundamental problems of Heliophysics. Artificial intelligence (AI) and its subset, machine learning (ML), techniques have become potentially effective means for achieving scientific goals, collecting and analyzing large data sets. Scientists have begun to use "theory-aided" or "knowledge-aided" AI to achieve breakthroughs. All of these tools and techniques can lead the way to new understanding and drive science concepts for future strategic missions.

TMS investigations may use any of these methodologies, separately or together to address a specific science problem. Theory investigations alone are encouraged. Investigations using the concepts of AI are encouraged. More traditional modeling and simulation are also acceptable for this TMS solicitation. All investigations must compare against observations for ground truth. The ultimate goal of TMS investigations is to provide a complete chain of reasoning extending from the basic laws of nature to comparison with observation to the identification of future quantitative tests of the behavior of the environment. NASA acknowledges this and renames the element "Theory, Modeling, and Simulations".

TMS investigations must address one of the four high level science goals from the Heliophysics Decadal survey (Solar and Space Physics: A Science for a Technological Society www.nap.edu/catalog.php?record_id=13060) that are:

1. Determine the origins of the Sun's activity and predict the variations in the space environment;

2. Determine the dynamics and coupling of Earth's magnetosphere, ionosphere, and atmosphere and their response to solar and terrestrial inputs;
3. Determine the interaction of the Sun with the solar system and the interstellar medium;
4. Discover and characterize fundamental processes that occur both within the heliosphere and throughout the universe.

2. Submission and Evaluation Guidelines

2.1 General Considerations

Each Principal Investigator (PI) is allowed to submit one and only one Step-1 proposal to this program element. In that proposal, the Principal Investigator is expected to invest a substantial portion of his/her time, at least 30%, to the investigation. Co-Investigators (Co-Is) must each have a specific and defined task in the project, and the task must be essential to the completion of the project. Use of Collaborators is discouraged. Proposals may be declared noncompliant based on either the Step-1 or Step-2 proposal if they are outside the scope of the TMS program (see Section 2.2 below) or if they fail to meet submission guidelines specified below (Section 3).

2.2 Limitations and Scope

Proposals outside the scope of Heliophysics TMS include the following:

- Proposals for the same or essentially the same work submitted concurrently to other program elements in Appendix B or E, as specified in B.1 Section 1;
- Work for which the proposing organization (or investigators) are already funded by NASA. Where projects might appear to overlap, proposals must show that the proposed effort does not duplicate other awards;
- Efforts of sufficient scope and breadth and focused on those aspects of Heliophysics that directly affect life and society.

Proposals that serve only as an umbrella for a variety of separate research tasks, even though they each may be related by a common theme and may each be of high scientific merit, are not appropriate for the TMS element.

3. Two-Step Submission Guidelines

To streamline the proposal process (submission, evaluation, and administration), this program uses a two-step proposal submission process. The overall description of a two-step process can be found in Section IV(b)vii of the ROSES *Summary of Solicitation*.

3.1 Step-1 proposals

A Step-1 proposal is required and must be submitted electronically by the Step-1 due date (see Tables 2 and 3 of ROSES) by an organization Authorized Organizational Representative (AOR). No budget or other elements are required. Step-1 proposals will be checked for compliance, but they will not be evaluated. Only proposers who submit a Step-1 proposal and who are "invited" can submit a Step-2 proposal submit a full (Step-2) proposal.

The Step-2 proposal title and science goals, must be the same as those in the Step-1 proposal. No additional investigators (Principal Investigator, Co-Investigators, Collaborators, Consultants, and Other Professionals) are allowed in the Step-2 proposal. The expected format and evaluation criteria are described below. Submission of the Step-1 proposal does not obligate the offerors to submit a Step-2 proposal later.

3.1.1 *Step-1 Proposal Content and Format*

Proposers should refer to the "Instructions for Submitting a Step-1 Proposal" under "Other Documents" on the NSPIRES page for this program element. The Step-1 proposal is restricted to the 4000-character Proposal Summary text box on the NSPIRES web interface cover pages.

The Step-1 proposals must include the following information:

- A description of the science goals and objectives to be addressed by the proposal;
- A brief description of the methodology to be used to address the science goals and objectives.
- The relevance to one or more of the four Decadal Survey goals.

No PDF attachment is required or permitted for Step-1 proposal submission. All information will be entered within the 4000-character Proposal Summary text box on the NSPIRES web interface cover pages. Proposers will be notified by NSPIRES whether they are invited to submit their Step-2 proposals.

3.1.2 *Step-1 Compliance*

Step-1 proposals may be declared noncompliant if outside the scope of the TMS program as described in Section 1. PIs of noncompliant proposals will not be invited through NSPIRES to submit the associated Step-2 proposal and will receive a letter to this effect.

3.1.3 *Suggested Reviewers*

Proposers are strongly encouraged to provide names and contact information of five experts qualified to review their proposal. These experts must not be from the institutions of the PI or Co-Is. This information can be supplied in response to the cover page questions associated with the Step-1 proposal.

3.2 Step-2 Proposals

Owing to the larger scope of the TMS proposals, the page limit for the Science/Technical/ Management section is revised from the default standard of 15 pages to 20 pages. A Step-2 (full) proposal must be submitted electronically by the Step-2 due date (see Tables 2 and 3 of ROSES). The Step-2 proposal must be submitted via NSPIRES by the organization Authorized Organizational Representative (AOR). A budget and other specified information is required. The Step-2 proposal title and science goals, must be the same as those in the Step-1 proposal. No additional investigators (Principal Investigator, Co-Investigators, Collaborators, Consultants, and Other Professionals) are allowed in the Step-2 proposal. Proposers must have submitted a Step-1 proposal and have been invited to submit a Step-2 proposal. Proposers that received a noncompliant letter are not eligible to submit a Step-2 proposal.

The process for preparation and submission of the Step-2 (full) proposals is the same for any other ROSES proposal. Instructions for the formatting and content of ROSES proposals are given in the *ROSES Summary of Solicitation* and, for topics not addressed there, refer to the *NASA Guidebook for Proposers*. Proposers must follow these instructions, except where they are overridden by the instructions given in the Heliophysics Research Program Overview or in this program element (e.g., the 20-page length for the Science-Technical-Management section of Step-2 proposal.

3.3 Step-2 Proposal Content

Proposals must include the following sections with the preferred order:

- The science objectives and perceived impact of the proposed work to the state of knowledge in the field; references to existing work in the field should be limited to that which is needed to justify the value of the science proposed;
- The methodology to be employed in conducting the proposed research; the proposal must demonstrate that the methodology is both appropriate and feasible to make substantial progress on the science objectives; TMS studies must be substantiated using appropriate data, primarily from NASA missions.
- The relevance of the proposed work to one or more of the four high-level science goals from the most recent Heliophysics Decadal survey listed in Section 1.1 must be demonstrated;
- A general plan of work, the management structure for the proposal personnel, and a description of the expected contribution to the proposed effort by the PI and each person as identified in the proposal whether or not they derive support from the proposed budget. PhD researches and students do not need to be named.

Historically, proposals that are focused on a specific compelling science question have been more successful at constructing methodologies that clearly address a single target question than those that propose to address a large number of science questions or that are directed at a broad science topic, rather than a specific question.

3.4 Step-2 Compliance and Evaluation Criteria

Non-compliant, Step-2 proposals will be returned without review. Step-2 proposals may be declared noncompliant if:

- The title has changed from that of their Step-1 proposal,
- Investigators have been added since the Step-1 proposal,
- The science scope/goals have changed from that of their Step-1 proposal.

Step-2 proposals that are not compliant with formatting requirements (e.g., margins, font sizes, line spacing) may be rejected without review. See Section IV(b)ii of the *ROSES Summary of Solicitation* and the *NASA Guidebook for Proposers* for details.

Compliant proposals will be evaluated according to the criteria specified Section VI (a) of the ROSES Summary of Solicitation and the *NASA Guidebook for Proposers*. These criteria are intrinsic (scientific and technical) merit, relevance, and cost reasonableness.

The evaluation of scientific and technical merit will include the following:

- Compelling nature and scientific priority of the proposed investigation's science goals and objectives, including the importance of the problem within the broad field of Heliophysics; the unique value of the investigation to make scientific progress in the context of current understanding in the field, and the importance of carrying out the investigation now.
- Appropriateness and feasibility of the methodology, including the appropriateness of the selected data, models, and analysis for completing the investigation and the feasibility of the methodology for ensuring scientific success.

Based on these two factors, the evaluation will consider the overall potential science impact and probable success of the investigation.

Relevance to and priority within the TMS program will be assessed vs. the topics discussed in Section 1. Each proposal must demonstrate that the investigation is relevant and of high priority.

Cost reasonableness will, in part, include the amount of work to be accomplished versus the amount of time proposed (See Section VI (a) of the ROSES Summary of Solicitation regarding the evaluation of cost).

Open-ended proposals or those with a large number of science questions to be addressed typically do not fare well in this evaluation. Only necessary Co-investigators and Collaborators should be included, and their specific roles in the investigation must be clearly laid out. Use of Collaborators whose only role is advisory is discouraged.

4. Available Funds

Selections for TMS from this program element are for three-year periods of performance with annual funding contingent on submission of satisfactory progress reports and available funding. The total annual budget for this program element is about $4M, and the expected annual funding per award is approximately $400-450K.

5. Award Types

The OH-GI program will primarily award funds through three vehicles: (1) grants, (2) interagency transfers, and (3) awards to NASA Centers. The OH-GI program will not award contracts, because it is not appropriate given the nature of the work solicited. An institution that has received a contract previously can receive funds as a grant by not charging a fee.

6. Summary of Key Information

Expected program budget for first year of new awards	~$4M
Number of new awards pending adequate proposals of merit	8-10
Maximum duration of awards	3 years
Due date for Step-1 proposal	See Tables 2 and 3 of this ROSES NRA
Due date for full (Step-2) proposals	See Tables 2 and 3 of this ROSES NRA
Planning date for start of investigation	6 months after full proposal due date.

Page limit for the central Science-Technical-Management section of full proposal	20 pp; see also Table 1 of ROSES and Section 3.7 of the *NASA Guidebook for Proposers*
Relevance	Proposals that are relevant to this program are, by definition, relevant to NASA. See Section VI(a) of the *ROSES Summary of Solicitation*
General information and overview of this solicitation	See the *ROSES Summary of Solicitation*.
General requirements for content of proposals	See Section 3 of the *NASA Guidebook for Proposers* and Section IV and Table 1 of *the ROSES Summary of Solicitation*.
Detailed instructions for the submission of proposals	See https://nspires.nasaprs.com/tutorials/ Sections 3.22-4.4 of the *NASA Guidebook for Proposers* and Section IV(b) of *the ROSES Summary of Solicitation*.
Submission medium	Electronic proposal submission is required; no hard copy is permitted.
Web site for submission of Step-1 and Step-2 proposals via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Web site for submission of Step-1 and Step-2 proposals via Grants.gov	http://grants.gov (help desk available at support@grants.gov or (800) 518-4726)
Funding opportunity number for downloading an application package from Grants.gov	NNH19ZDA001N-TMS
Point of contact concerning this program.	Katya Verner Heliophysics Division Science Mission Directorate NASA Headquarters Washington, DC 20546-0001 Telephone: (202) 358-1213 Email: ekaterina.m.verner@nasa.gov

B.4 HELIOPHYSICS GUEST INVESTIGATORS - OPEN

NOTICE: April 1, 2019 All Sky Imagers (ASI) and Ground Magnetometers (GMAG) associated with the THEMIS mission are considered to be part of the Heliophysics System Observatory (HSO). Investigations using these data as their primary data source are permitted.

NOTICE: Step-2 proposals are limited to ten (10) pages. Investigations focused on Global Observations of Limb and Disk (GOLD) data are permitted as long as the investigation is outside the scope of the mission science. Check for NASA spacecraft mission data compliance as specified in the overview B.1.

1. Scope of Program

The Heliophysics Guest Investigator Open (H-GIO) program is intended to maximize the scientific return from operating missions by providing support for research that is beyond the scope of work of the mission science teams. It also allows scientists who are not associated with a mission team to participate in the mission science

1.1 Overview

The H-GI Open (HGIO) program is for investigations whose primary emphasis is the analysis of data from currently operating missions. It provides support for analysis of observations from both extended missions and from missions in their prime phase (Phase E). Proposals should either (1) address the goals of the mission(s) that generated the data on which the investigation is focused, or (2) for investigations that go beyond the mission goals, proposals must address one or more of the four high-level science goals from the most recent Heliophysics Decadal Survey *Solar and Space Physics: A Science for a Technological Society* https://www.nap.edu/read/13060/chapter/1:

1. Determine the origins of the Sun's activity and predict the variations in the space environment;
2. Determine the dynamics and coupling of Earth's magnetosphere, ionosphere, and atmosphere and their response to solar and terrestrial inputs;
3. Determine the interaction of the Sun with the Solar System and the interstellar medium;
4. Discover and characterize fundamental processes that occur both within the heliosphere and throughout the Universe.

In support of any H-GIO proposal, investigations may employ theory, models, and data from other sources, as needed, to interpret and analyze data from NASA's Heliophysics System Observatory (HSO), but only as a secondary emphasis. In any such instance, the proposal must clearly demonstrate that the theory, models, and/or data in question are necessary support for interpretation of the HSO data and are not, themselves the primary object of the investigation. Development of new models and theories is not solicited in this call.

The list of operating HSO missions is found at: https://science.nasa.gov/missions-page?field_division_tid=5&field_phase_tid=29

Proposers should be aware that for many of these missions, the mission science teams and others have already accomplished a substantial amount of research. Proposals must demonstrate that the proposed research will extend the frontier of existing knowledge in a fundamental and important manner.

Additionally, prospective investigators must demonstrate that the proposed effort can be accomplished using data that was publicly available 30 days before the Step-2 submission deadline. Most Heliophysics data may be found through the Heliophysics Data Portal (HDP) found at http://heliophysicsdata.sci.gsfc.nasa.gov/websearch/dispatcher. If an investigation is proposing to use data that cannot be found at this source, it must provide a publicly accessible web address where the data can be accessed to verify that it is publicly available.

Heliophysics has established two questions that must be answered for all proposals submitted to Elements in Appendix B on the NSPIRES cover page. The answers define the Research Regime and Science Topic for the proposal and help to organize the evaluation and peer review. See B.1 Section 1.5 for details.

2. Submission and Evaluation Guidelines

2.1 General Considerations

Each Principal Investigator (PI) is allowed to submit one and only one Step-1 proposal to this program element. In that proposal, the Principal Investigator or Science PI must invest at least one month of labor to the investigation in order to adequately oversee the investigation. Co-investigators (Co-Is) must each have a specific and defined task in the project, and the task must be essential to completion of the project. Use of collaborators is discouraged. Proposals may be declared noncompliant based on either the Step-1 or Step-2 proposal if they are outside the scope of the H-GIO program (see Section 2.2 below) or if they fail to meet submission guidelines specified below (Section 3).

2.2 Limitations and Scope

Proposals outside the scope of H-GIO may be declared noncompliant based on either the Step-1 or Step-2 proposal. These include the following:

- Proposals that do not focus on analysis of data from currently-operating HSO missions;
- Proposals for the same or essentially the same work submitted concurrently to other program elements in Appendix B or E, as specified in B.1 Section 1;
- Work for which the proposing organization (or investigators) are already funded by NASA. Where projects might appear to overlap, proposals must show that the proposed effort does not duplicate other awards, including awards as part of operating space flight missions;
- Proposals for model, tool, or theory development (see Section 1.1);
- The routine, long-term gathering of observational data;

- Investigations with the main purpose of supporting ground-based infrastructure or facilities.

A PI or a Co-I on a qualifying Heliophysics mission may also propose as a PI or Co-I to the H-GIO program. However, such Heliophysics mission personnel must include in their proposal a description of their mission duties and clearly distinguish the proposed new activity from their existing responsibilities for mission operations and data analysis.

3. Two-Step Submission Guidelines

To streamline the proposal process (submission, evaluation, and administration), this program uses a two-step proposal submission process. The overall description of a two-step process can be found in Section IV. (b) vii of the *ROSES Summary of Solicitation*.

A Step-1 proposal is required and must be submitted electronically by the Step-1 due date (see below and Tables 2 and 3 in the *ROSES Summary of Solicitation*). The Step-1 proposal must be submitted by the organization's Authorized Organizational Representative (AOR). No budget or other elements are required. Only proposers who submit a Step-1 proposal are eligible to submit a full proposal. Step-1 proposals will be checked for compliance, but they will not be evaluated. The Step-1 proposal title, science goals, and investigators (Principal Investigator, Co- Investigators, Collaborators, Consultants, and Other Professionals) cannot be changed between the Step-1 and Step-2 proposals. The expected format and evaluation criteria are described below. Submission of the Step-1 proposal does not obligate the offerors to submit a Step-2 (full) proposal later.

3.1 Step-1 Proposal Content

Proposers should refer to the "Instructions for Submitting a Step-1 Proposal" under "Other Documents" on the NSPIRES page for this program. The Step-1 proposal is restricted to the 4000-character Proposal Summary text box on the NSPIRES web interface cover pages. References and any other supporting material are not required, but, if included, must fit within the limit. The Step-1 proposal must include the following information:

- The science goals and objectives to be addressed by the proposal;
- A listing of the mission data to be used in the investigation;
- A listing of the data analysis methodology and any models or simulations to be used;
- A brief statement of the relevance of the problem to the goals of the mission(s) on whose data the investigation is focused, or for investigations that go beyond the mission goals, the relevance to one or more of the four Decadal Survey goals.

The NSPIRES system for proposal submission requires that Step-1 proposals include a summary (i.e., abstract) describing the proposed work as outlined above. The proposal summary is entered directly into a text field in NSPIRES. No PDF attachment is permitted for Step-1 proposal submission. All information will be entered within the 4000-character Proposal Summary text box on the NSPIRES web interface cover pages. Proposers will be notified by email when they are able to submit their Step-2 proposals.

Proposers are strongly encouraged to provide names and contact information of five experts qualified to review their proposal. These experts must not be from the institutions of the PI or Co-Is. This information can be supplied in response to NSPIRES cover page questions at the time of submission of the Step-1 proposal.

3.2 Step-2 Proposals

A Step-2 (full) proposal (with a Scientific/Technical/Management section of no more than 10 pages) must be submitted electronically by the Step-2 due date (see below and Tables 2 and 3 in the *ROSES Summary of Solicitation*). The Step-2 proposal must be submitted via NSPIRES or Grants.gov by the organization’s Authorized Organizational Representative (AOR). A budget and other specified information is required. The Step-2 proposal title, science goals, and investigators (Principal Investigator, Co-Investigators, Collaborators, Consultants, and Other Professionals) must be the same as those in the Step-1 proposal.

Proposers must have submitted a Step-1 proposal to be eligible to submit a Step-2 proposal. Proposers that received a noncompliant letter are not eligible to submit a Step-2 proposal.

3.3 Step-2 Proposal Format

The process for preparation and submission of the Step-2 (full) proposals is the same as for any other ROSES proposal. Guidelines for content and formatting full proposals are specified in Table 1 of ROSES and the *NASA Guidebook for Proposers* and the *ROSES Summary of Solicitation*.

The Scientific/Technical/Management section is restricted to ten (10) pages and must include the following sections with the preferred order:

- The science objectives and perceived impact of the proposed work to the state of knowledge in the field; references to existing work in the field should be limited to that which is needed to justify the value of the science proposed;
- The data and methodology to be employed in conducting the proposed research; the proposal must demonstrate (1) that the data are appropriate to address the science objectives and (2) that the methodology is both appropriate and feasible to make substantial progress on the science objectives;
- The relevance of the proposed work to the goals of the mission(s) on whose data the investigation is focused; or if the proposed work goes beyond the goals of the mission(s), then relevance to one or more of the four high-level science goals from the most recent Heliophysics Decadal Survey listed in Section 1.1 must be demonstrated;
- A general plan of work, the management structure for the proposal personnel, and a description of the expected contribution to the proposed effort by the PI and each person as identified in the proposal whether or not they derive support from the proposed budget. Postdoctorals and students do not need to be identified by name.

Historically, proposals that address a single well-focused science objective with a limited set of specific science questions have been more successful at constructing methodologies that are demonstrably feasible and appropriate, as compared with those that propose to address a large number of science questions or that are directed at an overly-broad science topic.

3.3.1 *Step-2 Proposal Formatting Requirements*

All proposals submitted to ROSES must strictly conform to the formatting rules. Proposals that violate the rules may be rejected without review or declined following review if violations are detected during the evaluation process.

- The Scientific/Technical/Management section must not exceed the 10-page limit specified in this Program Element.
- Margins: no less than 1 inch on all sides, with a page size of 8.5 × 11 inches.
- Font: Times New Roman, 12-point or larger. If an alternate font is used, it must meet the requirement of having, on average, no more than 15 characters per inch. Proposers may not adjust the character spacing or otherwise condense a font from its default appearance.
- Line spacing: Font and line spacing settings must produce text that contains, on average, no more than 5.5 lines per inch. Proposers may not adjust line spacing settings for a selected font below single spaced.
- Figure captions: Captions must follow the same font and spacing rules as the main text.
- Figures and tables: For text in figures and tables, font and spacing rules listed above do not apply, but all text must be judged to be legible to reviewers without magnification above 100%. Expository text necessary for the proposal may not be located solely in figures or tables, or their captions.

Guidelines for submitting Step-2 full proposals, other than those listed above, are specified in the *NASA Guidebook for Proposers*. Where they conflict, the guidelines above supersede those found in the *Guidebook*.

3.4 <u>Step-2 Evaluation Criteria</u>

Step-2 proposals that are not compliant with format requirements may be rejected without review. See Subsection 3.3.1 of this program element, Section IV (b) ii of the *ROSES Summary of Solicitation*, and the *NASA Guidebook for Proposers* for details. Proposals that have changed the scientific scope from that of their Step-1 proposal may be declared noncompliant.

Compliant proposals will be evaluated according to the criteria specified in the *ROSES Summary of Solicitation* Section VI (a) and the *NASA Guidebook for Proposers*. These criteria are Relevance, Merit, and Cost. Clarifications and additions specific to this program element are listed below.

The evaluation of scientific and technical merit will include the following:

- Compelling nature and scientific priority of the proposed investigation's science goals and objectives, including the importance of the problem within the broad field of Heliophysics, the unique value of the investigation to make scientific progress in the context of current understanding in the field, and the importance of carrying out the investigation now.

- Appropriateness and feasibility of the methodology, including the appropriateness of the selected data, models, and analysis for completing the investigation and the feasibility of the methodology for ensuring scientific success.

Based on these two science and technical factors, the evaluation will consider the overall potential science impact and probability of success of the investigation.

Relevance to and priority within this H-GIO program element will be assessed based on criteria discussed in Section 1. Each proposal must demonstrate that the investigation is relevant and of high priority.

Cost reasonableness includes assessing the amount of work to be accomplished versus the amount of time proposed. Open-ended proposals or those with a large number of science questions to be addressed typically do not fare well in this evaluation. Only necessary Co-Investigators and Collaborators should be included, and their specific tasks and roles in the investigation must be clearly laid out in the proposal work plan.

4. Available Funds

It is expected that there will be approximately $6M available in Fiscal Year (FY) 2020 to support new Heliophysics GI investigations selected through this program element. It is anticipated that there may be $5 M in 2021 and $5 M in 2022. It is expected that the combined 3-year total budget of most proposals to be approximately $525K.

5. Award Types

As begun in 2013, the H-GIO program will primarily award funds through three vehicles: (1) grants, (2) interagency transfers, and (3) awards to NASA Centers. The H-GIO program will not award contracts. An institution that has received a contract previously can receive funds as a grant by not charging a fee.

6. Summary of Key Information

Expected annual program budget for new awards.	See Section 4
Number of new awards pending adequate proposals of merit	~30
Maximum duration of awards	3 years; shorter-term proposals are allowed
Due date for Step-1 proposals	See Tables 2 and 3 of this ROSES NRA
Due date for full Step-2 proposals	See Tables 2 and 3 of this ROSES NRA
Page limit for the central Science-Technical-Management section of proposals	10 pp; see also Table 1 of ROSES and the *NASA Guidebook for Proposers*
Planning date for start of investigation	8 months after proposal due date
Relevance	This program is relevant to Heliophysics questions and goals in the NASA Science

	Plan. Proposals that are relevant to this program are, by definition, relevant to NASA.
General information and overview of this solicitation	See the *ROSES Summary of Solicitation*
Detailed instructions for the preparation and submission of proposals	Please see *ROSES Summary of Solicitation* Section I(g) Order of Precedence and the *NASA Guidebook for Proposers*.
Submission medium	Electronic proposal submission is required; no hard copy is permitted
Web site for submission of proposal via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202 479-9376)
Funding opportunity number for downloading an application package from Grants.gov	NNH19ZDA001N-HGIO
Point of contact concerning this program	Galen Fowler Heliophysics Division Science mission Directorate NASA Headquarters Washington, DC 20546-0001 Telephone: 202-358-0039 Email: galen.fowler@nasa.gov

B.5 GLOBAL OBSERVATIONS OF LIMB AND DISK / IONOSPHERIC CONNECTION EXPLORER (GOLD/ICON) GUEST INVESTIGATORS

NOTICE: The Heliophysics Division does not plan to offer Heliophysics GOLD/ICON Guest Investigators in ROSES-2019. It is anticipated that this program will be competed in ROSES-2020, contingent on the successful launch of ICON.

1. Scope of Program

The GOLD/ICON Guest Investigators program is a component of the Heliophysics Research Program. It complements its sister element: The Open Heliophysics Guest Investigator (H-GIO) program (B.4) which is offered for investigations that draw extensively upon the data sets from the missions of the Heliophysics System Observatory (HSO). GOLD/ICON Guest Investigators (B.5) is only for investigations that primarily use data from the Global Observations of Limb and Disk (GOLD) and Ionospheric Connection (ICON) Explorer Missions. This program element is not solicited in ROSES-2019.

The NASA point of contact concerning this program is:

Galen Fowler
Heliophysics Division
Science Mission Directorate
NASA Headquarters
Washington, DC 20546-0001
Telephone: (202) 358-0039
Email: galen.fowler@nasa.gov

B.6 Heliophysics Living With a Star Science

NOTICE: Amended November 26, 2019. Due to disruptions caused by past fires and power outages and expected power outages from high winds in northern California next week, the Step-1 due date for this program element has been delayed to December 12, 2019.

Amended June 19, 2019. This Amendment releases the final text for this program element. Step-1 proposals are due December 5, 2019 and Step-2 proposals are due by February 27, 2020.

1. Introduction

The Living With a Star (LWS) Program emphasizes the science necessary to understand those aspects of the Sun and Earth's space environment that affect life and society. The ultimate goal of the LWS Program is to provide a scientific understanding of the system that leads to predictive capability of the space environment conditions at Earth, other planetary systems, and in the interplanetary medium.

The LWS program objectives are as follows:

1. Understand how the Sun varies and what drives solar variability.
2. Understand how the Earth and planetary systems respond to dynamic external and internal drivers.
3. Understand how and in what ways dynamic space environments affect human and robotic exploration activities.

The LWS Program seeks to make progress in understanding the complex Heliophysics system, focusing on the fundamental science of the most critical interconnections. Further information on the LWS Program can be found at the LWS website (http://lwstrt.gsfc.nasa.gov/). The LWS Science program maintains a strategy with three components, namely, Strategic Capabilities, Targeted Investigations, and Cross-Disciplinary Infrastructure Building programs. Only the Targeted Investigations will be competed in this announcement. Proposers interested in Strategic Capabilities should see Program Element B.10 Living With a Star Strategic Capabilities. Cross-Disciplinary Infrastructure Building may be competed in ROSES-2020.

Further background material concerning relevant research objectives can be found on the LWS website, and in the following documents:

- The LWS TR&T SDT Report (https://lwstrt.gsfc.nasa.gov/images/pdf/TRT_SDT_Report.pdf)
- The LWS *10-Year Vision Beyond 2015 Report* (http://lwstrt.gsfc.nasa.gov/images/pdf/LWS_10YrVision_Oct2015_Final.pdf)

The National Research Council Decadal Survey Report *Solar and Space Physics: A Science for a Technological Society* (http://www.nap.edu/openbook.php?record_id=13060).

1.1 Data Use in the Living With a Star Program

This program element has policies on the use of data in proposals that expand upon and supersede those given in B.1 Heliophysics Research Program Overview.

For successful completion of the proposed project, proposals to this program may only use data that is in a publicly available archive at least 30 days prior to the Step-2 deadline. This applies to both space-based and ground-based observations, as well as any data products derived from them. This latter point does not exclude data products to be developed as part of a proposed study, only those existing in advance of Step-2 submission. Any questions about whether a data set or data product qualifies as publicly available must be submitted to the program element's point of contact at least 10 days before the Step-1 deadline.

After an award is made, projects may incorporate new data that becomes available in a public archive, provided that their use does not alter the goals and objectives of the selected proposal. Any planned changes in the data used must be described in the annual progress report submitted by the Principal Investigator (PI) and approved by the LWS Program Scientist.

While the inclusion of useful ground-based observations is allowed, proposals are expected to incorporate space-based observations so collaboration between space-based and ground-based observers are permitted. Further, the Step-2 evaluation process (see Section 7.2.3) will include the consideration of the presence and importance of space-based or ground-based observations in the proposals. Regardless of the type of data that would be utilized in the proposed study, space-based, ground-based, or some combination, the proposal must clearly demonstrate why the proposed data set or data sets are sufficient to address the proposed goals and objectives.

2. Scope of Program Element - Targeted Investigations

The stated goal of LWS, that of achieving an understanding of those aspects of the Sun and Earth's space environment that affect life and society, poses two great challenges for the LWS program. First, the program seeks to address large-scale problems that cross discipline and technique boundaries (e.g., data analysis, theory, modeling, etc.); and second, the program will identify how this new understanding has a direct impact on life and society. Over time, the Targeted Investigations have provided advances in scientific understanding that address these challenges.

The Targeted Investigations component this year consists of four Focused Science Topics (FSTs). Detailed descriptions of each FST are given below.

2.1 Focused Science Topics

The FSTs permitted as the objectives for proposals this year are as follows:

1) The Variable Radiation Environment in the Dynamical Solar and Heliospheric System (described in Section 3);
2) Fast Reconnection Onset (described in Section 4);
3) Magnetospheric and Ionospheric Processes Responsible for Rapid Geomagnetic Changes (described in Section 5);
4) Causes and Consequences of Hemispherical Asymmetries in the Magnetosphere – Ionosphere – Thermosphere System (described in Section 6).

NASA desires a balance of research investigation techniques for each FST, including theory, modeling, data analysis, observations, and simulations. In previous ROSES calls, proposals could be individual proposals that would form part of a team or Targeted Science Teams (TSTs) that form prior to submission under a single PI and submit a single TST proposal that attacks the entire breadth of the FST. However, such TSTs will not be permitted this year and the FST teams will be formed from the selected individual proposals based on panel evaluations and programmatic considerations.

Given the strategic nature of LWS, and the fact that strategically feasible tasks require sufficient investment, it is anticipated that FST proposals will have annual budgets in the range of $190K - $235K per year. (This includes fully encumbered Civil Servant labor, where appropriate.) It is left to individual PIs to decide whether a strategically feasible award size could be achieved by increased collaborative efforts, greater time commitment of investigators, or a mix of the two. PIs should be cognizant, however, that verification of the level of effort versus the actual work proposed will be part of the review panel process. Given the submission of proposals of adequate number, merit, and range of investigative techniques, NASA anticipates forming teams of ~5 – 7 selections for each of the four FST topics.

Past experience has shown that Focused Science Teams usually need a year to get organized since team members may not have worked together before, followed by another three years to make significant progress on the FST. Thus, the expected duration of FST awards is four years. While proposals with shorter duration are allowed, proposers are encouraged to propose up to four years to ensure maximum overlap between individual contributions to the team efforts.

2.2 Focused Science Teams

Once selected, these investigators will form a team and coordinate their research programs. In order to foster the collaborations required to coordinate these team research efforts, one of the PIs will serve as the Team Leader for the FST for which he/she proposed. The Team Leader will organize team meetings, and will be responsible for producing a yearly report to NASA Headquarters describing team activities and progress. Proposers wishing to serve as a Team Leader must state so in their proposal, and must include a separate Appendix at the end of their proposal describing their qualifications, interest, and approaches to team leadership. Up to one extra page of the proposal is allowed for this Appendix. Team Leader activities should not be included in the proposal budget. The Team Leader will receive up to an additional $25,000 per year to support his/her leader activities, and the Team Leader's budget will be revised during final award negotiations. The selection of the Team Leader will be made by the LWS Staff and the Heliophysics Selecting Official. Guidance for the team development process will be provided by NASA after selection of the Team Leader.

All proposers should include sufficient travel funds in their budgets to cover two team meetings per year to be held on the U.S. coast farthest from their home institutions. This assumes that one meeting per year will be held in conjunction with a major U.S. scientific meeting. Successful teams will participate in a Kickoff Workshop where the selected team members will meet and develop work plans for the anticipated period of performance, generally 4 years, based on the requirements of the FST and the composition of the selected team.

3. FST #1: The Variable Radiation Environment in the Dynamical Solar and Heliospheric System

3.1 Target Description

Galactic cosmic rays (GCRs) and solar energetic particles (SEPs) propagate in the heliosphere, forming the energetic particle radiation environment close to Earth and elsewhere in the interplanetary space. Because of the low plasma density of the interplanetary medium, the dynamics of energetic particles are primarily influenced by electric and magnetic fields. GCRs and SEPs constitute a major threat to satellites and astronauts in space. This threat is difficult to mitigate using current technologies.

The energetic particle radiation environment varies at different temporal and spatial scales. The high-energy component of energetic charged particles (>500 MeV) at Earth is registered by ground-based neutron monitors. The deep solar minimum in cycle 23 and relatively weak cycle 24 have led to record increases in the flux of GCRs. Based on Voyager 1's *in situ* measurement of GCRs in the interstellar medium, 75% of the cosmic rays with energies ~1 GeV are filtered out by the heliosphere. The incoming cosmic ray flux is affected by a variety of physical processes internal to our heliosphere. The changes in the solar wind associated with the recent weak solar cycle have provided important clues for the underlying physics. If solar activity were to descend into a Dalton minimum condition, the level of the GCR flux would surge and needs to be quantitatively determined. The radiation environment is variable also because of solar transient events such as solar flares and coronal mass ejections (CMEs). The most extreme SEP acceleration gives rise to ground level enhancement events with an increase of energetic particle flux at hundreds of MeV. Fast CMEs lead to decreases of the high-energy particle flux for days termed a Forbush decrease. These effects are known to be observable in the whole heliosphere. A primary goal of the upcoming Interstellar Mapping and Acceleration Probe (IMAP) mission will be connecting energetic particles measured at 1 AU with those over the whole heliosphere. It is important to monitor and understand the variability of energetic particle radiation in the dynamical solar corona and heliosphere.

This FST is timely with the availability of measurements of the dynamical heliosphere and its boundaries from the Interstellar Boundary EXplorer (IBEX) mission, and in preparation for the upcoming IMAP mission, which will offer unprecedented measurements of energetic particles throughout the heliosphere. Work done under this FST will provide additional insights on the coupling between Earth's space environment and its interstellar surroundings. Meanwhile, the Parker Solar Probe (PSP) and the future Solar Orbiter missions will provide *in situ* measurements of high-energy particles created close to the Sun.

The FST is relevant to LWS Strategic Science Areas (SSAs): SSA-0: Physics-based Understanding to Enable Forecasting of Solar Electromagnetic, Energetic Particle, and Plasma Outputs Driving the Solar System Environment and Inputs to Earth's Atmosphere; SSA-3: Physics-based Solar Energetic Particle Forecasting Capability; and SSA-6: Physics-based Radiation Environment Forecasting Capability.

3.2 Goals and Measures of Success

The primary goals of this FST are:

- Determine the influence of solar and heliospheric plasma dynamics on high-energy particle radiation environments within the heliosphere;
- Determine the influence of major solar eruption events on the high energy particle environment near Earth and in interplanetary space.

In addition, this FST has the goals of improving the numerical models of cosmic ray modulation in the heliosphere, high-energy particles from major solar eruptions, and the Forbush decrease by extreme CME events.

Measures of success include, but are not limited to:

- Improved models of the variability of the energetic particle radiation environment in the heliosphere over the solar cycle;
- Improved models of the acceleration and transport of high energy SEPs by CMEs in the solar corona and in the heliosphere;
- Understanding the relationship between observed CME properties and Forbush decreases;
- Validation of models, and quantification of intrinsic uncertainties over a range of physical conditions.

3.3 Types of Investigations

Investigations that address this FST's science goals include, but are not limited to:

- Studies of the effect of variations in solar wind dynamic pressure on the cosmic ray flux change;
- Correlation analyses between neutron monitor data and spacecraft data to understand change of high-energy charged particles such as Forbush decrease;
- Understanding the influence of major solar eruption events on the high energy radiation environment near Earth and interplanetary space;
- Studies of the temporal and spectral properties of large SEP events;
- Simulations of high-energy particle dynamics and comparison with spacecraft measurements.

Investigations within this FST may include theoretical, numerical, and observational methods. Available data sources include measurements of solar wind parameters at 1 AU and energetic particle observations from past and present missions, including ACE, GOES, IBEX, Voyager, Parker Solar Probe, AMS-02 and neutron monitors.

3.4 Predictability, Interaction with User Communities, and Uncertainty

Given the potential relevance of this FST with the Parker Solar Probe and upcoming Solar Orbiter and IMAP missions, proposers may consider potential overlap of the FST and the anticipated observations of those missions. However, proposals must not require the use of data from these missions that do not meet the data policy in Section 1.1 to address their science questions. Rather, the impact of the potential future observations from these missions may be considered as a possible source of future data.

All investigations in this FST must consider data and model uncertainty and how sources of error impact the results (see Section 7.2.3).

4. FST #2: Fast Reconnection Onset

4.1 Target Description

Magnetic reconnection is one of the most fundamentally important physical processes that impacts heliophysics and space science more broadly. Reconnection spans energy scales, from nanoflares that contribute to coronal heating to solar flares, which are the largest explosions in the solar system. It is the mechanism by which stored magnetic energy is suddenly converted into kinetic and thermal energy, radiation, and accelerated particles and is therefore a fundamental source of the most energetic space weather phenomena, including flares, coronal mass ejections, and geomagnetic storms. Although ubiquitous, reconnection is a process that requires critical conditions to be fulfilled in order to occur, making it an excellent probe of magnetic field topology and dynamics throughout the heliosphere.

One criterion for fast magnetic-field-line reconnection to occur is that a current sheet must thin to a critical width. As examples, many fast reconnection investigations in the collisionless regime require that ions and/or electrons become demagnetized to allow the magnetic field to slip through the collisionless plasma. Another commonly invoked criterion requires the excitation of the tearing instability, which in turn relies on the current sheet reaching a critical aspect ratio. In partially ionized collisional plasmas, reconnection studies have shown that fast reconnection is achievable if the ion–electron recombination rate exceeds a critical threshold, and that this can also be related to the current sheet thinning down below the ion-neutral coupling scale. Thinning of current sheets may be caused by, for example, (non-uniform) compression of the plasma, shocking of the plasma, and stressing the large-scale magnetic configuration in which the current sheet is imbedded. The critical thickness for fast reconnection onset has been related to ion gyro-radii, to ion inertial lengths, to electron gyro-radii, to ion–neutral coupling scales, and to tearing mode criteria. The criteria for the onset of fast reconnection may depend on such variables as the magnetic field topology, the amount of magnetic shear, the amount of velocity shear, ion composition, ion plasma beta, or plasma asymmetry across the current sheet.

Throughout the heliosphere, numerous observations are now available of current-sheet conditions related to the onset of reconnection: it has been observed via remote imaging in the onset and evolution of coronal mass ejections and flares and for the evolution of coronal helmet streamers; it has been observed via *in situ* measurements for the heliospheric current sheet (e.g., from ACE and Wind, and it is expected that observations from Parker Solar Probe will soon be added to this list), for solar-wind directional discontinuities, for the Earth’s magnetosheath, for solar-wind/magnetosphere coupling at the dayside magnetopause, for substorms in the Earth’s magnetotail, and even in other planetary magnetospheres. Combining these regimes is a necessary way to make cross-disciplinary progress on this critical topic.

The FST is relevant to several LWS Strategic Science Areas (SSAs): SSA-0: Physics-based Understanding to Enable Forecasting of Solar Electromagnetic, Energetic

Particle, and Plasma Outputs Driving the Solar System Environment and Inputs to Earth's Atmosphere; SSA-1: Physics-based Geomagnetic Forecasting Capability; SSA-3: Physics-based Solar Energetic Particle Forecasting Capability; and SSA-6: Physics-based Radiation Environment Forecasting Capability. However, due to the inherent cross-disciplinary nature of this Focused Science Topic and its direct correspondence with space weather as a driver of energy release, this topic is ultimately relevant to all LWS SSAs 0 – 6.

This FST, by addressing reconnection onset throughout the heliosphere, will address key aspects of the Decadal Survey questions: "What is the role of magnetic reconnection in energy release in coronal mass ejections and flares?" "What are the interactions and feedbacks that connect the magnetosphere, solar wind, and ionosphere?" and "How does the Sun's magnetic field shape the dynamic heliosphere?"

4.2 Goals and Measures of Success

The primary goals of this FST are:

- Establish an understanding of what the critical conditions are for the onset of fast reconnection at a current sheet in the various regimes relevant for heliophysics;
- Determine what the onset criterion is and how the reconnection speed depends on these various regimes;
- Understand the global- and local-scale processes that bring a current sheet to the critical state required for reconnection for the various reconnection phenomena active in the solar corona, solar wind, and the Earth's magnetosphere;
- Establish predictive parameters for the onset of reconnection that can be implemented in large-scale MHD simulation codes for the corona, solar wind, and the Earth's magnetosphere.

This FST targets the onset of fast reconnection in a variety of environments by combining the expertise from different heliophysics subfields (i.e., observations in different contexts [remote sensing and *in situ* measurements], MHD and kinetic theory and modeling, and laboratory experimentation).

Measures of success include, but are not limited to:

- Understanding when, where, and how fast reconnection commences, and what circumstances prevent or inhibit its occurrence, in a variety of physical environments within the heliosphere;
- Determining the reconnection rate, and in particular the criteria for fast reconnection to occur in various physical environments within the heliosphere and across size scales;
- Validation of models, and quantification of intrinsic uncertainties over a range of physical conditions.

4.3 Types of Investigations

Investigations that address this FST's science goals include, but are not limited to:

- Theory and simulation studies of reconnection onset criteria for plasma regimes and magnetic field configurations relevant to heliophysics, including particle-in-

cell, hybrid, multi-fluid magnetohydrodynamic, and Hall magnetohydrodynamic investigations;
- Observational studies (remote sensing and *in situ*) of current sheet evolution and reconnection onset in the outer corona, solar wind, magnetosphere, and laboratory experiments;
- Theory and modeling studies of global and local phenomena which bring current sheets into fast reconnection states in magnetic field configurations important for heliophysics phenomena, including both kinetic physics and global magnetohydrodynamic investigations;
- Statistical analysis of observed reconnection events and detailed analysis of prime reconnection events;
- Development of predictive parameters for implementation into large-scale magnetohydrodynamic simulations of heliophysics reconnection phenomena.

4.4 Predictability, Interaction with User Communities, and Uncertainty

All investigations in this FST must consider data and model uncertainty and how sources of error impact the results (see Section 7.2.3).

5. FST #3: Magnetospheric and Ionospheric Processes Responsible for Rapid Geomagnetic Changes

5.1 Target Description

Geomagnetically induced currents (GICs) are a hazardous space weather phenomenon, which can cause serious damage to critical infrastructures such as electric power transmission systems and pipeline networks. Although the observation of GICs is limited, they are closely correlated with geomagnetic disturbances, and qualified geomagnetic field data have been collected for several decades. Major GIC events take place during extremely intense storms, and it is generally known that the intensity of the GICs depends on the rate of the change of ground geomagnetic disturbances. It still remains to be understood under what conditions the rate of the change of geomagnetic disturbances becomes extraordinarily large, what magnetospheric and ionospheric processes are responsible, and if there are any preconditions for such processes to take place and grow to extreme levels. The answers are probably different at different latitudes, and they may also depend on solar wind drivers. For tackling these issues, systematic studies including both satellite and ground observations, with the aid of global modeling are highly required.

This topic can benefit from a wide range of current and past spacecraft and ground data sets. The Heliophysics community now has unprecedented coverage of spacecraft data from the solar wind to the inner magnetosphere including data from NASA missions such as ACE, THEMIS, Van Allen Probes, and MMS. NSF’s AMPERE project provides global and large-scale ionospheric field aligned electric currents using data from the Iridium satellite constellation. Considering that qualified spacecraft and ground data have been accumulated for several decades, we can also revisit historical data sets including, for example, global auroral images taken by satellites such as Polar and IMAGE.

One of the most pressing needs is specification of the geoelectric field under disturbed space weather conditions. The geoelectric field is the space weather quantity of most interest to the operational and forecasting communities because it is the primary input for calculating GICs. Estimating the geoelectric field from the geomagnetic field generated in global models requires ground conductivity models, which range from 1D models, depending only on depth, to 2D or 3D models that depend both on depth and horizontal variations. These later models are needed to represent ground conductivity structures. NSF's EarthScope project, which was supplemented by NASA space weather funding, has recently developed, and made available for use, conductivity models on the basis of their magnetotelluric measurements over large regions in the United States. Surveys like this are also being carried out by other countries around the globe. Conductivity models, which represent conductivity structures, are needed in progressing from global to local predictions of the severity of GIC effects.

The suggested topic is the central issue of SSA-1: Physics-based Geomagnetic Forecasting Capability, and is also related to SSA-0: Physics-based Understanding to Enable Forecasting of Solar Electromagnetic, Energetic Particle, and Plasma Outputs Driving the Solar System Environment and Inputs to Earth's Atmosphere.

This FST also addresses the Decadal Survey Key Science Goal to "determine the dynamics and coupling of Earth's magnetosphere, ionosphere, and atmosphere and their response to solar and terrestrial inputs", and the Decadal Survey Solar Wind – Magnetosphere Interactions (SWMI) Science Challenge 3 to "determine how coupling and feedback between the magnetosphere, ionosphere, and thermosphere govern the dynamics of the coupled system in its response to the variable solar wind".

5.2 Goals and Measures of Success

The primary goals of this FST are:

- Determine the solar wind parameters, magnetospheric conditions, and ionospheric properties that affect the rate of the change of geomagnetic field;
- Estimate the corresponding temporal evolution of ground geoelectric fields and their spatial scales, research products, which are the primary input to operational and engineering models of GICs and of most use to these communities;
- As a potential valuable output from global models and estimations of spatial scales in this FST, provide an initial estimate of the spacing and location of magnetospheric ground-based observatories that are required to provide adequate spatial coverage for situational awareness and for triggering mitigation strategies.

5.3 Types of Investigations

This is an FST that will benefit from joint investigations of global modeling and data analysis techniques. Datasets to be included span from ground-based (magnetometers, etc.) for identification of ionospheric conditions and geomagnetic field disturbances, to space-based magnetospheric data (THEMIS, Van Allen Probes, MMS, Polar, IMAGE, NSF's AMPERE project, etc.) for identification of the magnetospheric conditions, and solar wind data: ACE, DSCOVR, OMNI.

Investigations that address this FST's science goals include but are not limited to:

- Observational and numerical approaches for determining latitudinal variations of GIC sources and effects;
- Investigation of improvements in modeling geoelectric fields associated with moving from 1D to 2D to 3D ground conductivity models during different levels of geomagnetic activity;
- Numerical simulations using solar wind – magnetosphere – ionosphere coupled models with the goal of investigating the role of solar wind in driving GICs, and accompanying observational studies of correlations between GIC and various solar wind parameters;
- Exploring improvements in the lead time and accuracy of predictive GIC modeling (for example, by focusing on specific types of interplanetary drivers or linkages to particular geospace source processes, etc.);
- New and improved indicators of GIC activity (beyond Kp, dB/dt, etc.);
- Analysis of current and historic satellite and ground data sources during extreme GIC times with the goal of discovering any preconditions necessary for extreme GICs, and of any magnetosphere–ionosphere coupling processes involved;
- Modeling of associated conditions related to GICs that cover a broad range of intensity.

5.4 Predictability, Interaction with User Communities, and Uncertainty

The formulation of this FST is based on a strong interaction between Heliophysics researchers and the user communities, as well as inputs from the Heliophysics community. The open research questions that were summarized in the 2015 LWS Institute Geomagnetically Induced Currents Working Group Report are relevant to this FST. This report is available on the LWS website (http://lwstrt.gsfc.nasa.gov/). The list of open questions in this report deal specifically with research issues constructed using inputs from Heliophysics researchers, the electric power transmission industry, the National Oceanic and Atmospheric Administration (NOAA), the US Geological Survey (USGS), the Federal Emergency Management Agency (FEMA), and insurance industry representatives. Proposers are encouraged to consider this report as a resource for interactions with the user communities.

All investigations in this FST must consider data and model uncertainty and how sources of error impact the results (see Section 7.2.3).

6. FST #4: Causes and Consequences of Hemispherical Asymmetries in the Magnetosphere – Ionosphere – Thermosphere System

6.1 Target Description

While both northern and southern polar upper atmospheric regions are closely linked through the magnetosphere, the coupling is often not symmetrical. The reasons for this are not fully understood, and certainly cannot yet be predicted. Fundamentally, these asymmetries evolve from geographic and/or geomagnetic aspects of Earth, as well as possible effects that arise directly from the solar wind. Examples of this asymmetrical coupling include magnetic pulsations, ion outflows, field-aligned currents, electromagnetic energy (Poynting) flux, auroral particle precipitation, high-latitude ionospheric convection, currents and conductance, ionospheric electron densities and thermospheric winds and mass densities. One interhemispheric area that deserved more attention is the polar cleft during extreme northward interplanetary magnetic field (IMF) magnetospheric driving: anomalous large drag is experienced by low altitude satellites as they pass over the polar cusp during some IMF Bz northward periods. It is also known that asymmetric ion outflows may be related to some of the low temperature ions observed in the magnetosphere. Many of these hemispheric asymmetries can be traced back to a handful of fundamental causes including interplanetary magnetic fields, solar illumination, Earth's magnetic field (e.g., different offsets between magnetic and geographical poles, differences in field strength at conjugate regions, displacement of the magnetic equator from the geographic equator) as well as land−sea distribution. There are also hemispherical differences at the mid and low latitudes, and associated coupling processes between the hemispheres (e.g. magnetic lines of force, winds, and electrodynamics), that lead to differences in the neutral atmosphere and plasma. This FST calls for observational and modeling studies that will establish relationships between the many types of hemispheric asymmetries, their fundamental causes, and their effects on geospace structures and the coupled geospacer system responses.

Understanding the origin and evolution of asymmetry is an important aspect of this FST as is how these asymmetries are affected by the external environment (in this case, the solar wind, solar irradiance, the offset between the geomagnetic and geographic poles, asymmetric inputs from the lower atmosphere, etc.). The challenge is to understand how asymmetric structures emerge and incorporate this information into predictive models. Hemispheric asymmetries are often investigated through statistical averaging of individual variables and/or idealized simulations focused on one causal effect. Even though such investigations are valuable, the underlying physical processes are dynamic and complex, resulting from multiple asymmetric coupling mechanisms that are operating simultaneously. Consequently, it is important to avoid treating hemispheric asymmetries in isolation.

This FST addresses LWS SSAs: SSA-2: Physics Based Satellite Drag Forecasting Capability and SSA-4: Physics-based Total Electron Content (TEC) Forecasting Capability. It also addresses the Decadal Survey's Atmosphere Ionosphere Magnetosphere (AIM) Interactions Science Goal 4: Plasma-Neutral Coupling in a Magnetic Field – How do neutrals and plasma interact to produce multiscale structures in the AIM system? This FST also addresses Key Science Goal 2 of the Decadal Survey: "Determine the dynamics and coupling of Earth's magnetosphere, ionosphere, and atmosphere and their response to solar and terrestrial inputs." In this case, the FST is focused specifically on the effects of hemispheric asymmetries in solar and terrestrial inputs.

This research is timely in preparation for the upcoming ICON mission and benefits greatly from the global views of the ionosphere – thermosphere – mesosphere (ITM) system provided by the newly launched GOLD mission. In addition, this FST is complementary to the 4-year NSF Geospace Environment Modeling (GEM) focus group on "Interhemispheric Approaches to Understand M-I Coupling (IHMIC)", that began in the summer of 2018.

6.2 Goals and Measures of Success

The efforts described above show that interhemispheric differences in coupling are ubiquitous. The topics addressed, while not coordinated, span a wide range and include a number of fundamentally important concepts, ideas that are essential for the development of successful modeling efforts. These ideas also feed directly into LWS goals, including understanding thermospheric effects and better modeling of total electron content and neutral atmospheric densities.

The primary goals of this FST are:

- To unveil the fundamental causes of hemispheric asymmetries in magnetosphere – ionosphere – thermosphere coupling. In the process it is expected that new information on magnetosphere – ionosphere coupling processes and plasma-neutral coupling will be revealed that would not be apparent under symmetrical driving conditions;
- Develop an improved physics-based understanding of, for example, time-evolving structural changes in thermospheric mass density and ionospheric electron density (TEC) between the hemispheres;
- Determine which drivers, e.g. the solar wind, the offset between the geographic and geomagnetic sources, generate the observed asymmetries and how these drivers interact with each other.

6.3 Types of Investigations

Potential approaches to hemispheric asymmetry studies might depend on the region being addressed. Investigations that address this FST's science goals include, but are not limited to:

- Comparison of differences between the Arctic and Antarctic polar vortices and the associated asymmetries that develop in the ionosphere – thermosphere system due to upward propagating effects;
- Measuring hemispheric differences in the magnetic local time (MLT) location of aurora, the relationship to IMF, and consequences for thermospheric circulation and ionospheric current systems;
- Comparing differences in high latitude convection, cross polar cap potentials, and Joule heating under a variety of asymmetric driving conditions;
- Identifying drivers that caused hemispheric asymmetries using for example coupled numerical models. These studies could incorporate data from a number of recent ground-based and space- based conjugate observations (e.g., ground-based: magnetometer chains, GPS TEC, SuperDARN, and all-sky imagers; and satellite-based: Iridium/AMPERE, DMSP, TIMED/SABER, TIMED/GUVI, GOLD). These same data sets could also be used to validate the models.

Investigating the processes that drive *low, mid, and high-latitude* hemispherical differences by employing numerical modeling and analysis of observed ionospheric plasma and neutral densities. For example, both observational and modeling techniques might be used to study how general thermospheric circulation features drive hemispheric differences in winds, and composition and to investigate the processes responsible for hemispheric differences in ionospheric structures like storm-enhanced density plumes and equatorial ionosphere anomalies.

6.4 Predictability, Interaction with User Communities, and Uncertainty

All investigations in this FST must consider data and model uncertainty and how sources of error impact the results (see Section 7.2.3).

7. Proposal Submission and Evaluation Process

To streamline the proposal process (submission, evaluation, and administration), this program uses a two-step proposal submission process (see the overall description of a two-step process in the *ROSES-2019 Summary of Solicitation* Section IV(b)vii).

Each PI, or the Science PI if applicable, is allowed to submit one and only one proposal to this program element. The expectation is that the PI (or Science PI) will invest a substantial portion of their time, at least 20%, to the investigation.

In addition to the general requirements and restrictions (e.g., in Table 1 of the *ROSES-2019 Summary of Solicitation* and in B.1 Heliophysics Research Program Overview) this program element has specific compliance constraints for both format (e.g., Sections 7.1.1 and 7.2.1) and content, e.g., involving data (see Sections 1.1 and 7.2.3). These compliance rules ensure fairness and are enforced strictly by the Heliophysics Division. Proposals that are deemed noncompliant will be returned without review or declined following review if violations are found during the evaluation process.

7.1 Step-1 Proposals

A Step-1 proposal is required and must be submitted electronically by the Step-1 due date given in Tables 2 and 3 of ROSES-2019. The Step-1 proposal must be submitted by an Authorized Organizational Representative (AOR) from the PI institution. No budget or other uploaded files are required. Only proposers who submit a Step-1 proposal are eligible to submit a Step-2 proposal. Step-1 proposals will be checked for compliance, but they will not be evaluated. Only proposers who submit a Step-1 proposal and who are invited can submit a Step-2 (full) proposal.

The Step-2 proposal title, science goals and objectives, must be the same as those in the Step-1 proposal. No additional investigators (Principal Investigator, Co-Investigators, Collaborators, Consultants, and Other Professionals) are allowed in the Step-2 proposal. Submission of a Step-1 proposal does not obligate the offerors to submit a Step-2 (full) proposal.

7.1.1 *Step-1 Proposal Format*

The Step-1 proposal is restricted to the 4000-character Proposal Summary text box on the NSPIRES web interface cover pages. It must include the following information:

- A description of the science goals and objectives to be addressed by the proposal;
- A brief description of the methodology to be used to address the goals and objectives; and
- A brief description of "Proposed Contributions to the Focused Science Team Effort" (see Section 7.2.2 for the material to be summarized).

The NSPIRES system for proposal submission requires that Step-1 proposals include a summary (i.e., abstract) describing the proposed work as outlined above. The proposal summary is entered directly into a text field in NSPIRES. No PDF attachment is required or permitted for Step-1 proposal submission. All information for the proposal summary will be entered within the 4000-character Proposal Summary text box on the NSPIRES web interface cover pages. Proposers will be notified by NSPIRES whether they are invited to submit their Step-2 proposals.

7.1.2 *Step-1 Compliance Criteria*

Step-1 proposals may be declared noncompliant if they fail to meet the submission guidelines or if they are outside the scope of the LWS Science program. PIs of noncompliant proposals will not be invited through NSPIRES to submit the associated Step-2 proposal and will receive a letter to this effect.

7.2 Step-2 Proposals

A Step-2 (full) proposal must be submitted electronically by the Step-2 due date (see below and Tables 2 and 3 of ROSES-2019). The Step-2 proposal must be submitted by an Authorized Organizational Representative (AOR) from the PI institution. A budget and other specified information is required. The Step-2 proposal title, science goals and objectives, must be the same as those in the Step-1 proposal. No additional investigators (Principal Investigator, Co-Investigators, Collaborators, Consultants, and Other Professionals) are allowed in the Step-2 proposal.

Proposers must have submitted a Step-1 proposal to be eligible to submit a Step-2 proposal. Proposers that have received a noncompliance letter are not eligible to submit a Step-2 proposal.

7.2.1 *Step-2 Proposal Format*

All proposals submitted to ROSES must strictly conform to the formatting instructions specified in the *ROSES-2019 Summary of Solicitation*. Proposals that violate these instructions may be returned without review or declined following review if violations are found during the evaluation process.

General agency guidelines for proposals are specified in the *NASA Guidebook for Proposers* but the requirements in this program element supersede those found in the Guidebook (see Section I(g) of the *ROSES-2019 Summary of Solicitation*).

7.2.2 *Required Additional Section in Step-2 Proposal Front Pages: Proposed Contribution to the Focused Science Team Effort*

Proposals to this program element must address the proposed contribution to the Focused Science Team effort in a 4,000-character plain text box on the NSPIRES cover pages and this will be peer reviewed as part of the evaluation of relevance (see Section 8.2.3). Since it is no longer included in the main body of the proposal, this text does not count against the 15-page limit for the Scientific/Technical/Management section. Proposals that fail to address the proposed contribution to the Focused Science Team effort will be declared noncompliant and will typically be returned without review or declined following review if violations are found during the evaluation process.

This section must summarize the following three topics:

- The relevance of the proposed study to the scientific objectives (Goals and Measures of Success) of the Focused Science Topic outlined in Sections 3.2, 4.2, 5.2, or 6.2;
- The potential contributions of the proposed study (Type of Investigation) to the Focused Science Team's effort outlined in Sections 3.3, 4.3, 5.3, or 6.3; and
- Metrics and milestones for determining the successful progress and outcome of the proposed research.

This summary must describe the goals of the proposed project and why they are aligned with the FST goals outlined in Sections 3.2, 4.2, 5.2, or 6.2. For proposals that address a Type of Investigation that is listed in Sections 3.3, 4.3, 5.3, or 6.3, this summary must also describe briefly how the proposed investigation addresses one or several of those investigations. For proposals that address a Type of Investigation that is NOT listed in the FST description, the summary must briefly describe the proposed Type of Investigation and how the proposed investigation will meet the Focused Science Topic Goals and Measures of Success. In addition, all proposers are expected to provide a set of metrics that they will use to identify progress toward their proposed goals. Finally, a set of milestones should indicate the anticipated timing of the major achievements during the course of the proposed study. These metrics and milestones may change once the FST Team is formed so the proposed metrics and milestones should be based on the proposed study as a stand-alone effort. The review panel will only consider material in this section when the "Proposed Contribution to the Focused Science Team Effort" portion of the proposal is evaluated.

7.2.3 *Step-2 Compliance and Evaluation Criteria*

Noncompliant Step-2 proposals will be returned without review. Step-2 proposals may be declared noncompliant if:

- The title has changed from that of the Step-1 proposal;
- Investigators have been added since the Step-1 proposal;
- The science goals and objectives have changed from that of the Step-1 proposal;
- The proposal has the same (or essentially the same) team and objectives as a Step-2 (full) proposal submitted to another Heliophysics program; or
- The proposal violates the restrictions in Section 1.1 regarding use of data. If possible, proposers should include a link or links to the data set(s) to be used in the proposed study.

Compliant proposals will be evaluated according to three main criteria: (1) Intrinsic Merit, (2) Potential Contribution to the Focused Science Team Effort (Relevance), and (3) Cost Reasonableness. The data management plan, described in ROSES, will also be evaluated. The Intrinsic Merit and Cost criteria will be evaluated primarily as specified in the *ROSES-2019 Summary of Solicitation* and the *NASA Guidebook for Proposers*, but Relevance is handled differently (see below).

The evaluation of Intrinsic Merit will consider information contained within the 15-page main body of the proposal (the Scientific/Technical/Management section). Most proposals are expected to describe a complete scientific study (i.e., clearly identified science questions and a project that makes significant progress on those questions in the context of current understanding. However, this program element also accepts proposals that lack a complete scientific study but instead describe a project that would enable or enhance the FST's activities (e.g. develop a data set or implement a model for use by the FST Team). Regardless of the project, all proposals must identify science questions responsive to the FST's goals that are addressed by the proposed work.

A critical element in enhancing understanding and developing predictive capabilities is the determination of whether the model or data products being developed, and any associated simulations, are accurate and reliable. Consequently, a methodology for verification and validation of results, and quantification of uncertainty, is required as a key component of the proposed research. As mentioned above (Sections 3.4, 4.4, 5.4, or 6.4), all proposals must address data and model uncertainty. This is described in Section 3.13 of the *NASA Guidebook for Proposers* which indicates that all proposals must address "sources of error and uncertainties and what effect they may have on the robustness of potential results and conclusions." The treatment of uncertainty will be evaluated by the review panel as a methodology issue (intrinsic merit) and will be assigned a strength or weakness based on the treatment presented in the proposal. Proposers are free to choose any appropriate method of uncertainty analysis but it must be clearly addressed in the body of the proposal. Proposals that fail to address uncertainty will be assigned a Major Weakness in the evaluation and may be considered unselectable.

The evaluation of the Potential Contribution to the Focused Science Team (Section 7.2.2) will serve as the Relevance evaluation. Please note that the review panel will consider only the response to this NSPIRES cover page question (described in Section 7.2.2) in the evaluation of this criterion and will not consider information in the main body of the proposal.

Evaluation of Cost Reasonableness will include a comparison of the scope of the proposed study to the proposed resources (personnel-time allocated, necessary computer resources, etc.).

8. Award Types

The Heliophysics LWS Science program will only award funds through three vehicles: (1) grants, (2) interagency transfers, and (3) awards to NASA centers. This call will not award contracts, as it is not appropriate for the nature of the work. Please also see the *ROSES-2019 Summary of Solicitation*, Section II a.

9. Summary of Key Information

Expected annual program budget for new awards	~ $4.9M
Number of new awards pending adequate proposals of merit	~ 21 – 26
Maximum duration of awards	4 years
Due date for Step-1 proposals	See Tables 2 and 3 of this ROSES NRA
Due date for Step-2 proposals	See Tables 2 and 3 of this ROSES NRA

Planning date for start of investigation	No earlier than 6 months after the Step-2 proposal due date.
Page limit for the central Science-Technical-Management section of proposal	15 pages; one extra page permitted for proposals to be Team Leader of a Focused Science Topic; see also Table 1 of the *ROSES-2019 Summary of Solicitation* and the *NASA Guidebook for Proposers*.
Relevance	Proposals relevant to the FSTs in this program element are, by definition, relevant to NASA. See Section 7.2.3 regarding evaluation criteria.
General information and overview of this solicitation	See the *ROSES-2019 Summary of Solicitation*.
General requirements for content of proposals	See Section 3 of the *NASA Guidebook for Proposers* and Section IV and Table 1 of *the ROSES-2019 Summary of Solicitation*.
Detailed instructions for the submission of proposals	See https://nspires.nasaprs.com/tutorials/ Sections 3.22-4.4 of the *NASA Guidebook for Proposers* and Section IV(b) of *the ROSES-2019 Summary of Solicitation*.
Submission medium	Electronic proposal submission is required; no hard copy is permitted.
Web site for submission of proposals via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Web site for submission of proposals via Grants.gov	http://grants.gov (help desk available at support@grants.gov or (800) 518-4726)
Funding opportunity number for downloading an application package from Grants.gov	NNH19ZDA001N-LWS
Points of contact concerning this program	Simon Plunkett Heliophysics Division Science Mission Directorate National Aeronautics and Space Administration Washington, DC 20546-0001 Telephone: (202) 358-2034 Email: simon.p.plunkett@nasa.gov Jeff Morrill Heliophysics Division Science Mission Directorate National Aeronautics and Space Administration Washington, DC 20546-0001 Telephone: (202) 358-3744 Email: jeff.s.morrill@nasa.gov

B.7 SPACE WEATHER SCIENCE APPLICATIONS OPERATIONS-TO-RESEARCH

NOTICE: Amended on October 17, 2019. This Amendment consists of the following changes: The specific encouragement of data assimilation and/or machine-learning techniques has been removed from Section 1 because we do not want to dictate in advance any particular technique for data analysis. The proposal content for Step-1 (Section 3.1) and for Step-2 (Section 3.2) have been changed to be consistent with each other and with the opportunity description in Section 2. Likewise, the evaluation criteria in Section 3.5, second bullet, has been changed to be consistent with the required proposal content in Sections 3.1 and 3.2. The due dates for proposals remain unchanged. New text is in bold and deleted text is struck through.

Amended on April 4, 2019. This amendment presents final text for this program element. Step-1 proposals are due by December 16, 2019, and the due date for 10-page Step-2 proposals is February 13, 2020.

Proposals to this program will be taken by a two-step process, in which the Notice of Intent is replaced by a required Step-1 proposal submitted by an Authorized Organizational Representative (AOR), see Section 3.

The requirement to address relevance of the Step-2 proposal to this program element is provided in Section 3.3.1. Please note that the proposer's response to this requirement will be provided in a 4000-character text box on the NSPIRES cover page not in the 10-page main body of the proposal. Section 3.5 explains how the evaluation criteria explicitly include assessment of the proposal relevance.

Step-2 proposers should type "not required" in the NSPIRES cover page question about a data management plan.

Please note that each PI is limited to submit one and only one proposal to this program element.

Check for NASA spacecraft mission data compliance as specified in the overview B.1.

1. Introduction

In October 2015, the National Science and Technology Council (NSTC) in the Executive Office of the President released the National Space Weather Strategy and the National Space Weather Action Plan (SWAP). In March 2019, these were updated with the release of the National Space Weather Strategy and Action Plan (NSW-SAP). The objectives of the actions described in the SWAP and NSW-SAP are to improve the understanding of, forecasting of, and preparedness for space weather events, recognizing the need for close cooperation among the federal agencies.

The SWAP and NSW-SAP call for NASA, National Science Foundation (NSF), and Department of Defense (DOD) to identify and support basic research on space weather. They also direct NASA, Department of Commerce (DOC), and DOD to identify and support research opportunities that address targeted operational space-weather needs. Furthermore, they direct NASA, NSF, DOC, and DOD to facilitate the transition of space weather information and prediction capabilities to the Nation’s space weather service providers (research-to-operations and operations-to-research).

In response to the need to advance and coordinate the Nation's space weather research and operations capabilities, NASA has established the Heliophysics Space Weather Science Applications program, of which this operations-to-research (O2R) call is a part. NASA is supporting this funding opportunity in coordination with DOC/National Oceanic and Atmospheric Administration (NOAA) to promote O2R activities.

- For this call, the objective of O2R efforts is broadly defined as the joint pursuit of improvements of operational capabilities and advancements in related fundamental research.

NASA's role as codified in its Science Applications program is to implement and support a national research program to understand the Sun and its interactions with Earth and the Solar System to advance space weather modeling and prediction capabilities applicable to space weather forecasting; develop and operate space-weather-related research missions, develop instrument capabilities, and models; and support the transition of space weather models and technology from research to operations and from operations to research. Proposers interested in this program element are encouraged to see the overview of the Heliophysics Research Program in B.1 of this ROSES NRA.

NOAA's role is to provide timely and accurate operational space weather forecasts, watches, warnings, alerts, and real-time space weather monitoring for the government, civilian, and commercial sectors, exclusive of the responsibilities of the Secretary of Defense; and to ensure the continuous improvement of operational space weather services, utilizing partnerships, as appropriate, with the research community, including academia and the private sector, and relevant agencies to develop, validate, test, and transition space weather observation platforms and models from research to operations and from operations to research.

To be relevant, work proposed in response to this call must be in support of one or more NASA and/or NOAA goals and objectives described above, with attention to transitioning from science research to applications driven by the expressed need of the users.

2. <u>Space Weather Science Application Program</u>

For this opportunity, in order to enable broad input from the space weather science and user communities, there is no focused topic, unlike the previous O2R calls.

The primary goal of this funding is to support research by the grant recipient to improve numerical models and/or data utilization techniques that could advance specification and/or forecasting capabilities and that could also lead to improved scientific understanding. Effective utilization of available data is encouraged. ~~Employing data assimilation and/or machine-learning techniques is also encouraged.~~

Proposals to this opportunity must define the products that will be developed and the timetable for producing them. Proposals must also define the metrics and validation methods that will be employed to evaluate the products. The products must have clear relevance to this program element. Proposers must address relevance with a statement inserted in a mandatory text box on the NSPIRES web page provided for this purpose. See subsection 3.3.1 and the description of evaluation factors in Section 3.5.

Proposers are strongly encouraged to include industry participants on their teams.

Proposals involving software development must describe the software license for distribution of the software to be developed by the proposing institution(s). It is strongly encouraged that the software license allow the software to be made available upon request to individual users, free of charge limited to non-commercial use only. Users that are granted access to the software will be allowed to redistribute to a third party only when specifically permitted by the originator(s)/license holder(s).

Below is a partial list of possible topics, listed in no particular order. This is not a complete list. Other relevant space weather topics that meet the requirements of this call are also encouraged. To demonstrate the relevance of the research, the proposal must address how the research will directly improve the ability of the user community to utilize space weather information in the proposed topical area.

- Satellite drag
- GNSS accuracy and availability (or Position, Navigation, and Timing)
- Impacts on RF and communication
- Satellite launch and on-orbit anomalies
- Human spaceflight and aviation radiation
- Electric power grid and ground-based infrastructure

3. Submission and Evaluation Guidelines

To streamline the proposal process (submission, evaluation, and administration), this program uses a two-step proposal submission process. The overall description of a two-step process can be found in Section IV. (b) vii of the *ROSES Summary of Solicitation*.

A Step-1 proposal is required and must be submitted electronically by the Step-1 due date (see below and Tables 2 and 3 of *ROSES*). The Step-1 proposal must be submitted by the organization Authorized Organizational Representative (AOR). No budget or other elements are required. Only proposers who submit a Step-1 proposal are eligible to submit a full proposal. Step-1 proposals will be checked for compliance, but will not be evaluated further. The Step-1 proposal title, science goals, and investigators (Principal Investigator, Co- Investigators, Collaborators, Consultants, and Other Professionals) cannot be changed between the Step-1 and Step-2 proposals. The expected format and evaluation criteria are described below. Submission of the Step-1 proposal does not obligate the offerors to submit a Step-2 (full) proposal later.

3.1 Step-1 Proposal Content

Proposers should refer to the "Instructions for Submitting a Step-1 Proposal" under "Other Documents" on the NSPIRES page for this program. The Step-1 proposal is restricted to the 4000-character Proposal Summary text box on the NSPIRES web interface cover pages. References and any other supporting material are not required, but, if included, must fit within the text box. The Step-1 proposal must include the following information:

- The science goals and objectives to be addressed by the proposal;
- The expected forecast products **and/or specification capabilities** that will be developed;
- The expected metrics and validation methods that will be applied;
- A brief statement of the relevance of the problem to the focus area of this SWO2R announcement.

The NSPIRES system for proposal submission requires that Step-1 proposals include a summary (i.e., abstract) describing the proposed work as outlined above. The proposal summary is entered directly into a text field in NSPIRES. No PDF attachment is permitted for Step-1 proposal submission. All information will be entered within the 4000-character Proposal Summary text box on the NSPIRES web interface cover pages. Proposers will be notified when they are able to submit their Step-2 proposals.

Proposers are strongly encouraged to provide names and contact information of five experts qualified to review their Step-2 proposal in response to optional NSPIRES cover page questions at the time of submission of the Step-1 proposal, See Section 3.7.

3.2 Step-2 Proposals

A Step-2 (full) proposal of no more than 10 pages must be submitted electronically by the Step-2 due date (see below and Tables 2 and 3 in the *ROSES Summary of Solicitation*). The Step-2 proposal must be submitted via NSPIRES or Grants.gov by the organization Authorized Organizational Representative (AOR). A budget and other specified information is required. The Step-2 proposal title, science goals, and investigators (Principal Investigator, Co-Investigators, Collaborators, Consultants, and Other Professionals) must be the same as those in the Step-1 proposal.

Proposers must have submitted a Step-1 proposal to be eligible to submit a Step-2 proposal. Proposers that received a noncompliant letter are not eligible to submit a Step-2 proposal.

3.3 Step-2 Proposal Content

Step-2 Proposals should include a section titled Scientific/Technical/Management which includes clear descriptions of the following:

(1) The Space Weather O2R goals this proposal will enable and the appropriateness of the currently existing data sets (ground-based and/or space-based), models (CCMC hosted or other accessible resource), and/or other publicly available and utilized resource;
(2) The existing O2R need that is being addressed and its importance relative to current operational and forecasting capabilities;
(3) A full description of the ~~methodology~~ **methods and validation**, resources needed, and the technical approach to providing the proposed O2R-enabling enhancement;
(4) Plans to provide public access to the models, tools, and value-added products developed;

(5) The **forecast** products **and/or specification capability** that will be developed, the timetable for producing them, the metrics **and validation methods** that will be used to evaluate them, and a description of the industry/government decisions that would benefit from the availability of these products.

3.3.1 *Required Additional Section in Step-2 Proposal Front Pages: Proposed Relevance to the Program Element.*

Proposals to this program element must address the relevance of the proposal, as described in Section 1, in a 4000-character plain text box on the NSPIRES cover pages and this will be peer reviewed as part of the evaluation of relevance (see Section 3.5). Since it is no longer included in the main body of the proposal, this text does not count against the 10-page limit for the Scientific/Technical/Management section. Proposals that fail to address relevance will typically be declined despite any merits that may have been found by peer review.

This section must demonstrate relevance to this program element by addressing one or more NASA and/or NOAA goals and objectives described above, with attention to transitioning from science research to applications driven by the expressed need of the users.

For additional submission guidance, proposers are encouraged to reference the *NASA Guidebook for Proposers* and the *ROSES Summary of Solicitation* for further insights on preparation and submission of ROSES proposals. Otherwise, please contact the POC listed in Section 5 below.

3.4 Step-2 Proposal Formatting Requirements

Proposals that are not complaint with format requirements below may be rejected without review. See also Section IV(b)ii of the *ROSES Summary of Solicitation* and the *NASA Guidebook for Proposers* for further details.

- The Scientific/Technical/Management section must not exceed ten pages.
- Margins: no less than 1 inch on all sides, with a page size of 8.5 × 11 inches.
- Font: Times New Roman, 12-point or larger. If an alternate font is used, it must meet the requirement of having, on average, no more than 15 characters per inch.
- Proposers may not adjust the character spacing or otherwise condense a font from its default appearance.
- Line spacing: Font and line spacing settings must produce text that contains, on average, no more than 5.5 lines per inch. Proposers may not adjust line spacing settings for a selected font below single spaced.
- Figure captions: Captions must follow the same font and spacing rules as the main text.
- Figures and tables: For text in figures and tables, font and spacing rules listed above do not apply, but all text must be judged to be legible to reviewers without magnification above 100%. Expository text necessary for the proposal may not be located solely in figures or tables, or their captions.

Guidelines for submitting Step-2 full proposals, other than those listed above, are specified in the *NASA Guidebook for Proposers*. Where they conflict, the requirements above supersede those found in the Guidebook.

3.5 Evaluation Criteria

Compliant proposals will be evaluated according to the scientific and technical merit, the relevance, and the cost reasonableness. The assessment of relevance will be based on the goals and objectives of the agencies and the O2R objective, as summarized in this program element. Please note that the review panel will consider only the response to this NSPIRES cover page question (described in Section 3.3.1) in the evaluation of this criterion.

In addition to the evaluation of Merit given in Appendix D of the *NASA Guidebook for Proposers*, the evaluation of the scientific and technical merit will include:

- The potential for improving specifications and/or forecasts of space weather phenomena;
- The potential value of the proposed metrics **and validation methods** to establishing the state-of-the-art and to measuring progress in specifying/forecasting space weather, and;
- The degree to which the resulting product can be ingested into an operational environment in a timely manner.

Moreover, part of the assessment of the impact of the proposed work (which is part of Merit) will include consideration of whether and how software will be made available for non-commercial use (e.g., as described in Section 2 of this program element), as well as whether or not industry participation is included in the team. Participants of the team must be listed in the standard summary table of work effort described in Section IV(b)iii of the ROSES Summary of Solicitation. As these aspects of the proposed effort are encouraged, rather than required, their inclusion may result in strengths in the proposal evaluation, but their absence will not result in weaknesses.

Cost reasonableness will include assessing the amount of work to be accomplished versus the amount of time proposed.

3.6 Joint Agency/Community Evaluation

Given the unique nature of this opportunity to support Space Weather Science Applications program, proposal reviewers will include both scientific peers and knowledgeable representatives from the space weather operations community. Proposals must discuss the relationship of the proposed effort to the advancement of the Space Weather O2R objective.

NASA (on behalf of NASA and NOAA) will review the proposals in accordance with NASA's processes/criteria connected to the O2R objective. The final award recommendations will be made in consultation with both agencies' program officers. Final selections will be made by the NASA Selecting Official.

3.7 Request for Reviewer Names

Proposers are strongly encouraged to provide names and contact information for up to five experts qualified to review their Step-2 proposal. These experts must not be from the institutions of the PI or Co-Is nor stand to benefit financially from the selection (or otherwise) of the proposal. This information can be supplied in response to NSPIRES cover page questions at the time of submission of the Step-1 proposal.

4. Reports

An annual report and a final report will be submitted by each selected PI detailing the scientific results and an assessment of the value of the products developed based on the proposed metrics and, if possible, industry feedback. PIs are also encouraged to include recommendations for further research needed to improve product quality in the final reports.

5. Available Funds

Funding available in both Fiscal Year (FY) 2019 and FY 2020 to support this O2R opportunity are shown in Section 6. The total funding available in fiscal year (FY) 2019 for new proposals submitted in response to this solicitation is expected to be about $2.0M. This funding is expected to support at least eight awards depending upon funds available. Awards will not be more than two years in duration. It is expected that combined 2-year budgets of most proposals will not exceed $500K.

6. Summary of Key Information

Expected program budget	$4.0M
Number of new awards pending adequate proposals of merit	~8
Maximum duration of awards	2 years
Due date for Step-1 proposals	See Tables 2 and 3 of this ROSES NRA
Due date for Step-2 proposals	See Tables 2 and 3 of this ROSES NRA
Planning date for start of investigation	6 months after proposal due date
Page limit for the central Science-Technical-Management section of proposal	10 pages; see also Table 1 of the ROSES *Summary of Solicitation* and Section 3.7 of the *NASA Guidebook for Proposers*
Relevance	This program is relevant to Heliophysics Space Weather Operations-to-Research in NASA and NOAA. Proposals that are relevant to this program are, by definition, relevant to one or more of the supporting agencies.
General information and overview of this solicitation	See the *ROSES Summary of Solicitation*
Detailed instructions for the preparation and submission of proposals	Please see the *ROSES Summary of Solicitation* Section I(g) Order of Precedence and the *NASA Guidebook for Proposers*.
Submission medium	Electronic proposal submission is required; no hard copy is permitted

Web site for submission of full proposal via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Web site for submission of proposals via Grants.gov	http://grants.gov (help desk available at support@grants.gov or (800) 518-4726)
Funding opportunity number for downloading an application package from Grants.gov	NNH19ZDA001N-SWO2R
Point of contact concerning this program element	James Spann Heliophysics Division Science mission Directorate NASA Headquarters Washington, DC 20546-0001 Telephone: 202-358-0574 Email: jim.spann@nasa.gov

B.8 HELIOPHYSICS TECHNOLOGY AND INSTRUMENT DEVELOPMENT FOR SCIENCE

NOTICE: What was in past years the R&T Flight sub-element of this program element has been pulled out of this program element; research and technology proposals mature enough for flight are solicited separately in program element B.9 Heliophysics Flight Opportunities for Research and Technology (H-FORT). This program element solicits research and technology proposals not mature enough for flight.

This year, proposal submission will not use the two-step process. Step-1 proposals are not requested for this program element. See Section 4 for details.

1. Scope of Program

The Heliophysics Instrument Development for Science (H-TIDeS) program is a component of the Heliophysics Research Program and proposers interested in this program element are encouraged to see the overview of the Heliophysics Research Program in Appendix B.1 of this ROSES NASA Research Announcement.

1.1 Overview

Advancement in heliophysics science requires the development and application of innovative new technologies and capabilities. H-TIDeS seeks to enhance the ability to achieve significant progress toward the scientific and technical challenges in heliophysics in the coming years.

H-TIDeS seeks to advance the development of technologies and their application to enable investigation of key heliophysics science questions. This is done through incubating innovative concepts and development of prototype technologies. It is intended that technologies developed through H-TIDeS would then be proposed to H-FORT to mature by demonstration in a relevant environment. Promising technologies, such as instruments, sensors and detectors are sought, as described below. To advance the Technology Readiness Levels of promising technologies, H-TIDeS utilizes the following sub-elements:

- Laboratory Nuclear, Atomic, and Plasma Physics (LNAPP) Program: The LNAPP program supports studies that probe fundamental nuclear, atomic, and plasma physical processes and produce chemical and spectroscopic measurements that support spacecraft observations and atmospheric models (see Section 2 below).
- Instrument Technology Development (ITD) Program: This includes innovative technology development and instruments that may be proposed as candidate experiments for future space flight opportunities (see Section 3 below).

H-TIDeS investigations are carried out in support of the NASA Strategic Objective for Heliophysics Research, to understand the Sun and its interactions with the Earth and the Solar System, including space weather. In this framework, the Heliophysics Research Program is guided by the Heliophysics Division's overarching goals defined in the *NASA 2014 Science Plan* (available at https://science.nasa.gov/about-us/science-strategy):

1. Explore the physical processes in the space environment from the Sun to the Earth and throughout the Solar System;
2. Advance our understanding of the connections that link the Sun, the Earth, planetary space environments, and the outer reaches of our Solar System;
3. Develop the knowledge and capability to detect and predict extreme conditions in space to protect life and society and to safeguard human and robotic explorers beyond Earth.

Proposals to the H-TIDeS program shall link the proposed work to the NASA Heliophysics Science Plan as documented in the proposal traceability matrix (Table 1 of this program element) and supported by the proposal text:

A) NASA Heliophysics Science Goal(s);
B) The science questions to be answered in achieving the science goals;
C) The proposed investigation objective(s) required to address the science goals (either technological or observational or both)

Table 1. Example Science Traceability Matrix

A. Science Goal(s)	B. Science Questions	C. Investigation Objective Requirements			Future Mission, Top Level Requirements
		Measurement	Requirement	Projected Performance	
Goal # Goal # Etc.	Question # Question # Etc.	Examples: Temporal Resolution Etc.	XX Sec.	XXX Sec.	Examples: Observing strategies: requires yaw and elevation maneuvers Launch window: to meet nadir and limb overlap requirements. Window applies day to day
		Precision	YY%	YYY%	
		Accuracy	ZZ %	ZZZ%	

The three Heliophysics Science Goals have a broad scope, while a proposed objective is a more narrowly focused part of a strategy to achieve the goal(s) (e.g. identify specific science questions to be addressed and/or demonstrate a new technology is capable of obtaining future measurements that may bring closure to the science questions or goals). Proposed investigations must achieve their proposed technological objectives (letter C, above).

The ability to determine whether a proposed investigation is successful depends on a well-formulated articulation of the proposed science question(s) and investigation objectives. Each proposal shall clearly define its science question(s), shall demonstrate how the science questions are derived from the high-level science goals, and shall show how the science question(s) lead to investigation objectives that subsequently map into measurement, data and instrument requirements. Instructions for proposal submission are provided in Section 4.

H-TIDeS solicits investigations of high risk and high impact as defined below:

High Risk: The proposed investigation will test novel or significant hypotheses, for which there is scant precedent or preliminary data or which run counter to the existing scientific consensus.
High Impact: The proposed investigation, if successful, will have a large effect on current thinking, methods or practice.

2. Laboratory Nuclear, Atomic and Plasma Physics (LNAPP)

The LNAPP program supports studies that probe fundamental nuclear, atomic, and plasma physical processes and produce chemical and spectroscopic measurements that support spacecraft observations and atmospheric models. They provide benchmarks for integrating theory and modeling with observation in heliophysics. Laboratory experiments allow the use of a controlled environment to perform reproducible measurements that shed light on key processes with the heliophysics environment. These experiments are directed toward understanding basic processes. Additionally, there are also important experiments that are directly used to facilitate the interpretation of spacecraft observations, e.g., spectroscopic or cosmic ray measurements. As such, LNAPP encompasses measurements of fundamental atomic parameters, e.g., cross sections associated with various processes.

3. Instrument Technology Development (ITD) Program

The ITD program supports the development of instrument, sensor/detector concepts that show promise for use in scientific investigations on, or give rise to future heliophysics missions, including the development of laboratory instrument prototypes, sensors and detectors, etc., but not of major space flight hardware. Proposals for ITD must demonstrate relevance to the Heliophysics Program, including clearly defined scientific goals appropriate for future heliophysics missions. The goal of the program is to define and develop scientific instruments and/or components of such instruments to the point where complete instruments may be proposed in response to future Announcements of Opportunity.

Either new concepts or methods to improve the performance of existing instruments or sensors may be proposed, provided they would be candidates for use in space. Among the characteristics typically desirable in space-quality detection systems are high sensitivity to relevant signals, low mass, low vulnerability to particle radiation effects, low power consumption, compactness, ability to operate in a vacuum (such that high-voltage arcing is minimized), vibration tolerance, ease and robustness of integration with instrumentation, and ease of remote operation, including reduced transient effects and ease of calibration.

Small satellites are increasingly playing a larger role in NASA planning as a means to execute scientific missions at far lower cost and complexity than typical space science missions. As such, NASA seeks to make ITD awards across a range of mission concepts, including technologies that will enable smaller missions in deep space.

4. Proposal Submission Guidelines

This year, proposal submission will not use the two-step process. Neither Notices of Intent (NOIs) nor Step-1 proposals are requested for this program element. The guidelines for submitting proposals are provided in section 4.1.

Each Principal Investigator is allowed to submit one and only one proposal to each sub-element (LNAPP, ITD) of this solicitation. The Principal Investigator is expected to invest a substantial portion of his/her time, 10-30%, to the investigation. Co-investigators must each have a specific and defined task in the project, and the task must be essential to completion of the project. Use of multiple team members is discouraged, and team members are expected to have defined tasks in the project. Collaborators are expected to have defined tasks in the project with a separate source of funding identified for completion of the tasks. Proposals may be declared non-compliant if they are outside the scope of the H-TIDeS Program as defined in previous sections, or if they fail to meet submission guidelines specified below.

Proposers are strongly encouraged to provide names and contact information of five experts qualified to review their proposal. These experts must not be from the institutions of the PI or Co-Is. The PI can confidentially provide this information by sending an email to the Point of Contact listed in Section 6 of this Program Element by the proposal due date.

ITD and LNAPP proposals must demonstrate relevance to the Heliophysics Program, including clearly defined scientific goals appropriate for current and/or future heliophysics missions and linkage to the proposal objectives, and that the proposed work is a necessary precursor to solving specific scientific problems. The proposers are not expected to apply the results of their efforts to the science problem(s) within the time period of the proposed effort. Proposals for projects that aim to produce data products for wide use across the heliophysics community should explain how those products would be made available to the intended users in a stable fashion.

Proposals must be submitted electronically by the due date given in Tables 2 and 3 of ROSES. An Authorized Organizational Representative (AOR) from the institution of the PI must submit the proposal. A budget and other specified information is required.

Proposers are expected to respond to requests to conduct reviews for up to four proposals in the H-TIDeS or H-FORT. Much of the science expertise lies in the PIs and Co-Is, since nearly the entire heliophysics community proposes. In order to maintain a high caliber review process, it is important to request that the heliophysics experts conduct reviews.

Important Note: A science traceability matrix is required for every proposal. The matrix must show the connection between the relevant science goals, the proposal objectives and the measurements required to achieve those objectives. An example science traceability matrix is provided in Table 1 of this program element.

4.1 Proposal Content

This year, proposal submission will not use the two-step process. Neither Notices of Intent nor Step-1 proposals are requested for this program element. Guidelines for content and formatting of proposals are specified in Table 1 in the *ROSES Summary of Solicitation*.

Proposals to the H-TIDeS program must contain the following elements within the Science/Technical/Management (S/T/M) section:

I) The proposal shall describe the investigation to be performed, the types of measurements to be taken; the characteristics, precision, and accuracy required to attain the investigation objectives; and the projected instrument performance. This section shall describe the data to be returned in the course of the investigation. The quality (e.g., resolution, coverage, pointing accuracy, measurement precision, signal to noise ratio, background identification/removal, etc.) and quantity (bits, images, etc.) of data that must be returned shall be described. The relationship between the proposed data products (e.g., flight data, ancillary or calibration data, theoretical calculations, higher order analytical or data products, laboratory data, etc.) and the investigation objectives, as well as the expected results, shall be described. How the science products and data obtained will be used to fulfill the scientific requirements shall be demonstrated and supported by quantitative analysis.

II) A traceability matrix from science goals to measurement requirements to instrument requirements (functional and performance), and to top-level mission requirements shall be provided in tabular form and supported by narrative discussion. Note that the term "mission" refers to future mission(s) envisioned to address the proposed science question and utilizing the research and/or technology development being investigated. Projected instrument performance shall be compared to instrument performance requirements. This matrix provides the reference points and tools needed to track overall investigation requirements. A sample science traceability matrix is shown in Table 1 of this program element.

III) A science data management plan is required for all proposed investigations. All data obtained through H-TIDeS funded efforts shall be made public in a prompt manner. Proposals must describe the management plan of any science data obtained in the investigation described. Proposals must describe the management plan of any science data obtained in the investigation described. ITD proposals must discuss the release of data obtained in an investigation characterizing the performance of an instrument technology, although it is permissible to summarize this data. In addition to the public release of data, proposals must describe the analysis, interpretation, and dissemination in professional meetings and publications of the results of the proposed investigation. The Data Management Plan provided for the NSPIRES cover pages will suffice for this requirement.

IV) If technology development and/or maturation is a component of the proposed investigation, then a technology summary section is required, as shown in Table 2 of this program element. This section requires an assessment of the Technology Readiness Level (TRL) at the start of the proposed work, and the projected TRL at the conclusion of the proposed work. One of the goals of the H-TIDeS program is to identify promising technologies for enabling future heliophysics missions. The TRL is a metric-based assessment of the maturation of new technologies. The NASA Technology Readiness Level definitions are provided at https://www.nasa.gov/pdf/458490main_TRL_Definitions.pdf . The primary technology area refers to the technology areas defined in the NASA Space

Technology Roadmaps
(https://www.nasa.gov/offices/oct/home/roadmaps/index.html).

Table 2. An Assessment of Technology Benefits and Advancements

Primary Technology Area (TA)	Refer to NASA Space Technology Roadmaps. Provide TA number down to level 2 or 3.
Target Destination (The Sun, Earth, Moon, Mars, Others inside the Solar System, Outside the Solar System, Foundational Knowledge)	Select up to 3.
Start TRL*	
Estimated End TRL*	
Anticipated Benefits	

* Refer to https://www.nasa.gov/pdf/458490main_TRL_Definitions.pdf

5. Award Duration and Type

The maximum duration of LNAPP and ITD awards is three years. H-TIDeS will not award contracts. H-TIDeS does not make separate awards to the Principal Investigator (PI) and Co-Investigators (Co-Is) of the same investigation at different institutions, except in those cases where a Co- Investigator is affiliated with a U.S. Government Laboratory (see Section IV(d) of the *ROSES Summary of Solicitation*), in which case NASA separately funds that Co-Investigator through a direct transfer of funds. In all other cases, the PI institution is expected to fund participating Co-I(s). No separate Co-I cost proposals will be accepted.

6. Summary of Key Information

Projected program budget for first year of new awards	ITD: $4M LNAPP: $0.5M
Anticipated number of new awards pending adequate proposals of merit	ITD: 10-15 LNAPP: 4-6
Maximum duration of awards	ITD and LNAPP – 3 years.
Neither Step-1 proposals nor NOIs are requested for this program element.	
Due date for proposals	See Tables 2 and 3 of this ROSES NRA
Planning date for start of LNAPP and ITD Investigations	6 months after proposal due date.
Page limit for the central Science-Technical-Management section of proposal.	15 pages; see also Table 1 of ROSES *Summary of Solicitation* and the *NASA Guidebook for Proposers*.
General information and overview of this solicitation	See *ROSES Summary of Solicitation.*

Detailed instructions for the preparation and submission of proposals	Please see *ROSES Summary of Solicitation* Section I(g) Order of Precedence and the *NASA Guidebook for Proposers*.
Submission medium	Electronic proposal submission is required; no hard copy is permitted.
Web site for submission of proposals via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Web site for submission of proposals via Grants.gov	http://grants.gov/ (help desk available at support@grants.gov or (800) 518-4726)
Funding opportunity number for downloading an application package from Grants.gov	NNH19ZDA001N-HTIDS
Point of contact concerning this program	Roshanak Hakimzadeh Heliophysics Division Science Mission Directorate NASA Headquarters Washington, DC 20546-0001 Telephone: (202) 358-0784 Email: hakimzadeh@nasa.gov

B.9 Heliophysics Flight Opportunities for Research and Technology

NOTICE: Amended October 31, 2019. This amendment delays the due date for proposals to this program element due to the fires in California. Proposals are now due November 8, 2019.

Amended June 17, 2019. Section 2.1 "Special Interest LCAS Topic: Parker Solar Probe Collaborative Investigations" has been added and in Section 6 the "Number of new awards pending adequate proposals of merit" has been changed. Proposals are now due September 17, 2019. New text is in bold and deleted text is struck through.

Amended May 14, 2019. Cubesats and payloads on the International Space Station have been removed from Low Cost Access to Space (Section 2) but those opportunities remain in SmallSats and Rideshare Opportunities (Section 3). Deleted text has been struck through. The due date for proposals remains unchanged.

This new program element, B.9 Heliophysics Flight Opportunities for Research and Technology (H-FORT), replaces the R&T Flight sub-element of Heliophysics Instrument Development for Science (H-TIDeS). This program element solicits research and technology proposals mature enough for flight, whereas H-TIDeS solicits research and technology proposals that are not mature enough for flight.

Proposal submission will not use the two-step process. Step-1 proposals are not requested for this program element. See Section 4 for details.

1. Scope of Program

This Heliophysics Flight Opportunities for Research and Technology (H-FORT) program element is a component of the Heliophysics Research Program and potential proposers are encouraged to see the overview of the Heliophysics Research Program in Appendix B.1 of this ROSES NASA Research Announcement.

1.1 Overview

Advancement in heliophysics science requires the development and application of innovative new technologies and capabilities. H-FORT seeks to enhance the ability to achieve significant progress toward the scientific and technical challenges in heliophysics in the coming years. Proposals submitted to H-FORT shall have the following characteristics:

1. The investigation objectives address NASA Heliophysics Science Goals;
2. The investigator develops an instrument/sensor;
3. Spaceflight is required to achieve investigation objectives;
4. Data acquired is reduced, analyzed, and interpreted in terms of investigation objectives;
5. The reduced (calibrated) data is archived in a NASA on-line facility and the interpretation is published in professional journals;
6. The investigation is completed within a time interval less than or equal to four years;

7. The investigation cost is consistent with the available program funding (Section 6 of this program element);
8. The Principal Investigator (PI) manages all the program resources (including schedule and cost) and no reserve is held by NASA.

H-FORT seeks to advance the development of technologies and their application to enable investigation of key heliophysics science questions. This is done through demonstration of innovative technologies and associated science investigations in a relevant environment. It is anticipated that some of the technologies developed through H-TIDeS might then be proposed to H-FORT to mature by demonstration in a relevant environment, however, this is not a prerequisite for submitting a proposal to H-FORT. Promising technologies, such as instruments, sensors, and detectors are sought, as described below. To advance the Technology Readiness Levels of promising technologies through testing in a relevant environment, H-FORT utilizes the following sub-elements:

- Low Cost Access to Space (LCAS). This includes technology and associated science investigations that can be carried out with instruments flown on suborbital rockets, stratospheric balloons, suborbital reusable launch vehicles, or other platforms, collectively referred to as Low Cost Access to Space (see Section 2 below).
- SmallSats and Rideshare Opportunities (SRO). This includes technology and associated science investigations that can be carried out with instruments flown on SmallSats (including CubeSats) or payloads on the International Space Station (ISS), Department of Defense (DoD), or other rideshare opportunities (see Section 3 below).

H-FORT investigations are carried out in support of the NASA Strategic Objective for Heliophysics Research, to understand the Sun and its interactions with the Earth and the Solar System, including space weather. In this framework, the Heliophysics Research Program is guided by the Heliophysics Division's overarching goals defined in the *NASA 2014 Science Plan* (available at https://science.nasa.gov/about-us/science-strategy):

1. Explore the physical processes in the space environment from the Sun to the Earth and throughout the Solar System;
2. Advance our understanding of the connections that link the Sun, the Earth, planetary space environments, and the outer reaches of our Solar System;
3. Develop the knowledge and capability to detect and predict extreme conditions in space to protect life and society and to safeguard human and robotic explorers beyond Earth.

Proposals to H-FORT shall link the proposed work to the NASA Heliophysics Science Plan as documented in the proposal traceability matrix (Table 1 of this program element) and supported by the proposal text:

A) NASA Heliophysics Science Goal(s);
B) The science questions to be answered in achieving the science goals;
C) The proposed investigation objective(s) required to address the science goals (either technological or observational or both)

The three Heliophysics Science Goals have a broad scope, while a proposed objective is a more narrowly focused part of a strategy to achieve the goal(s). For example, identify specific science questions to be addressed and/or demonstrate a new technology is capable of obtaining future measurements that may bring closure to the science questions or goals. Proposed investigations must achieve their proposed technological objectives (letter C in Table 1 of this program element, below).

Table 1. Example Science Traceability Matrix

A. Science Goal(s)	B. Science Questions	C. Investigation Objective Requirements			Mission Top Level Requirements
		Measurement	Requirement	Projected Performance	
Goal # Goal # Etc.	Question # Question # Etc.	Examples: Temporal Resolution Etc.	XX Sec.	XXX Sec.	Examples: Observing strategies: requires yaw and elevation maneuvers. Launch window: to meet nadir and limb overlap requirements. Window applies day to day.
		Precision	YY%	YYY%	
		Accuracy	ZZ %	ZZZ%	

The ability to determine whether a proposed investigation is successful depends on a well-formulated articulation of the proposed science question(s) and investigation objectives. Each proposal shall clearly define its science question(s), shall demonstrate how the science questions are derived from the high-level science goals, and shall show how the science question(s) lead to investigation objectives that subsequently map into measurement, data and instrument requirements. Instructions for proposal submission are provided in Section 4.

H-FORT solicits proposals of high risk and high impact as defined below:

High Risk: The proposed investigation will test novel or significant hypotheses, for which there is scant precedent or preliminary data or which run counter to the existing scientific consensus.

High Impact: The proposed investigation, if successful, will have a large effect on current thinking, methods or practice.

Export Control: Export licenses are required for all foreign persons accessing flight programs. H-FORT Principal Investigators (PIs) should contact the program office with whom they are working (ISS, etc.) regarding PI responsibilities in this arena. Procuring the required State Department licenses can take some time, so PIs are urged to begin the process well before team members need access to the actual flight hardware. Appendix A of the *NASA Guidebook for Proposers* includes links to information regarding U.S. export regulations, export-control guidelines applicable to proposals including foreign participation, and how to handle export-controlled material in proposals.

2. Low Cost Access to Space (LCAS) **[Section corrected May 14, 2019]**

The LCAS program supports investigations addressing NASA Heliophysics Science Goals using investigator-developed instrumentation that must be completed through suborbital flights. Suborbital launch vehicle services include those provided by the

NASA Sounding Rocket Program Office (SRPO), the NASA Balloon Program Office (BPO), NASA Airborne Science Program (ASP), and commercial suborbital Technology Mission Directorate. ~~The Science Mission Directorate also provides launch opportunities for CubeSats and International Space Station payloads.~~ Detailed information, including suborbital ~~and orbital~~ specifications and points of contact, is found in the *ROSES Summary of Solicitation*, Section V(b), Suborbital-Class Investigations:

(i) NASA-provided Sounding Rocket Services;
(ii) NASA-provided Balloon Services;
(iii) Suborbital Reusable Launch Vehicles (sRLV);
~~(iv) Research Investigations utilizing the International Space Station;~~
~~(v) Use of Short Duration Orbital Platforms (CubeSats and other Flights of Opportunity)~~

~~Note: "Short Duration" in (v) above refers to the Suborbital program plan mission assurance level defined by NPR 7120.8.~~ **[Deleted May 14, 2019]**

LCAS is expected to lead the way in the development of a large fraction of the instrument concepts for future solar, heliospheric, magnetospheric, and ionosphere-thermosphere-mesosphere (ITM) missions. LCAS-investigations provide unique opportunities not only for executing intrinsically meritorious science investigations, but also for advancing the technology readiness levels of future space flight sensors and supporting technologies and for preparing future leaders of NASA space flight missions, such as junior researchers and graduate students.

2.1 Special Interest LCAS Topic: Parker Solar Probe Collaborative Investigations [This entire section was added June 17, 2019]

In 2018, NASA successfully launched the Parker Solar Probe (PSP) into an orbit that will allow for unprecedented access to the near-coronal region. PSP carries onboard four investigations that will make plasma-, field-, radio-, energetic particle- and coronal/heliospheric white-light observations. To the extent possible, all four investigations will make continuous observations during the extended perihelion encounter periods.

Recognizing that observations by LCAS investigations may provide valuable observations that in conjunction with PSP observations could lead to significant scientific advances and that may otherwise not be realized, fast turn-around low-cost access to space projects in conjunction with upcoming PSP perihelion passages are of particular interest to NASA. The following table lists the near-term perihelion passages that fall within the assumed performance period of typical ROSES19 H-FORT investigations. Highlighted in the Table of PSP Conjunctions below are perihelion passages that may be of specific interest to proposers.

Table of PSP Conjunctions

Perihelion #	Approximate Perihelion Location	Date/Time	Solar Distance (Rs)
4	Central Meridian	Jan. 29, 2020 09:34 UT	27.9
5	East Limb	June 7, 2020 08:19 UT	27.9
6	(Far Side)	Sept. 27, 2020 09:11 UT	20.4
7	Central Meridian	Jan. 17, 2021 17:34 UT	20.4
8	East Limb	Apr. 29, 2021 08:45 UT	16.0
9	(Far Side)	Aug. 9, 2021 19:08 UT	16.0
10	West Limb	Nov. 21, 2021 08:23 UT	13.3
11	Central Meridian	Feb. 25, 2022 15:38 UT	13.3
12	East Limb	June 1, 2022 22:51 UT	13.3
13	(Far Side)	Sept. 6, 2022 06:04 UT	13.3
14	West Limb	Dec. 11, 2022 13:15 UT	13.3
15	Central Meridian	March 17, 2023 20:30 UT	13.3

3. SmallSats and Rideshare Opportunities (SRO)

This new sub-element includes all SmallSats (including CubeSats), payloads on the ISS, and all other rideshare opportunities.

SRO investigations are solicited to achieve: 1) validation of scientific observables for future space missions, 2) execution of intrinsically meritorious science investigations, and 3) advancement of the technology readiness levels of future space flight sensors, detectors, instruments and supporting technologies. In addition, as in LCAS, SRO investigations provide an important opportunity for preparing future leaders of NASA space flight missions, by involving the investigation teams in all aspects of achieving science goals via space flight.

The Science Mission Directorate provides launch opportunities for either CubeSats or International Space Station (ISS) attached payloads (see Section V of the *ROSES Summary of Solicitation*):

- CubeSat missions can be flown through the NASA HEOMD CSLI Program (https://www.nasa.gov/directorates/heo/home/CubeSats_initiative). NASA Science Mission Directorate will facilitate the application to CSLI for the appropriate flight opportunity.
- Proposers may also propose to utilize the ISS to fly an attached research investigation payload. ISS attached payload proposals must provide with the proposal an ISS Letter of Technical Interface and Resource Accommodation

Feasibility Assessment. This can take several weeks, so proposers are urged to contact the ISS Research Integration Office as early as possible for such requests.

Proposals may propose to utilize alternate SmallSat and rideshare flight opportunities. If such opportunities are proposed, the specific details, including risk management, must be provided in the proposal.

4. Proposal Submission Guidelines

Proposal submission will not use the two-step process. Neither Notices of Intent (NOIs) nor Step-1 proposals are requested for this program element. The guidelines for proposal contents are provided in section 4.1.

Each Principal Investigator is allowed to submit one and only one proposal to each sub-element (LCAS, SRO). The Principal Investigator is expected to invest a substantial portion of his/her time, 10-30%, to the investigation. Co-investigators must each have a specific and defined task in the project, and the task must be essential to completion of the project. Use of multiple team members is discouraged, and team members are expected to have defined tasks in the project. Collaborators are expected to have defined tasks in the project with a separate source of funding identified for completion of the tasks. Proposals may be declared non-compliant if they are outside the scope of the H-FORT Program as defined in previous sections, or if they fail to meet submission guidelines specified below.

SRO proposals will be required to include a formulation phase in their proposal schedule for 4 months and at a cost not to exceed $40K. Following the formulation phase, a Concept Study Report (CSR) must be submitted for evaluation and only the successful proposals will be invited to proceed to the implementation phase. The CSRs are required to address the following:

- Respond to any weaknesses in the evaluation of the original proposal submitted to H-FORT
- Develop the system architecture
- Completion of the mission and preliminary system designs
- Preparation of the project plan for implementation

Successful SRO proposals will receive a CSR guidance document prior to the start of the formulation phase. All PIs will be notified of the results of the evaluation, and the successful PIs will be awarded the funding to proceed to implementation.

Note: The $40K – 4 month formulation phase should be built into the budget and schedule as part of the proposals (see Section 4.1).

Proposers are strongly encouraged to provide names and contact information of five experts qualified to review their proposal. These experts must not be from the institutions of the PI or Co-Is. The PI can confidentially provide this information by sending an email the Point of Contact listed in Section 6 of this program element by the due date of the proposal.

LCAS and SRO proposals must demonstrate relevance to the Heliophysics Program, including clearly defined scientific goals appropriate for current and/or future heliophysics missions and linkage to the proposal objectives. For the technology development objective(s) of the investigation, the proposals are not necessarily required to apply the results of their efforts to the science problem(s) within the time period of the proposed effort. Proposals for projects that aim to produce data products for wide use across the heliophysics community should explain how those products would be made available to the intended users in a stable fashion.

A proposal must be submitted electronically by the due date given in Tables 2 and 3 of ROSES. An Authorized Organizational Representative (AOR) from the institution of the PI must submit the proposal. A budget and other specified information is required.

Important Note: A science traceability matrix is required for every proposal. The matrix must show the connection between the relevant science goals, the proposal objectives and the measurements required to achieve those objectives. An example science traceability matrix is provided in Table 1 of this program element.

Budgets are expected to cover complete investigations, including payload development and construction, instrument calibration, launch activities, and data analysis. The aforementioned "launch activities" to be included in the budget do not include the standard CSLI-provided launch services described in Section V(b)v of the *ROSES Summary of Solicitation*. The cost of launch for a single, ≤3U, spacecraft to Low Earth Orbit (LEO) will be provided under the NASA/HEOMD CubeSat Launch Initiative (CSLI) at no cost to the investigation or the H-FORT program. For this standard case proposers should merely mention (e.g., in the budget justification) that only the standard CSLI-provided launch services are needed. For investigations >3U, the H-FORT program officer will work with CSLI to determine the additional cost, which will be paid for out of the available H-FORT budget (Section 6). Please note that the available budget number of investigations expected to be funded in Section 6 assumes CubeSat proposals up to 3U. Given the fixed budget, fewer CubeSats >3U can be selected. Moreover, to be competitive, proposals for >3U must deliver proportionally larger science returns.

The number of investigations that can be supported is limited and heavily dependent on the funds available to this program. Note that NASA does not carry reserves to accommodate any cost overrun incurred by a particular investigation, including the loss of the payload owing to a rocket or balloon system failure. Therefore, failure to achieve the proposed goals within the proposed time and budget could require either de-scoping the initially proposed investigation, delaying it, canceling a particular launch date opportunity, or canceling the investigation altogether.

Science support elements, such as science radars, lidars, ionosondes, optical sites, and the associated logistics, can be supported, when appropriate. The funding for these support elements must be included in science proposal budgets.

Proposers are expected to respond to requests to conduct reviews for up to four proposals in H-FORT or H-TIDeS. Much of the science expertise lies in the PIs and Co-Is, since nearly the entire heliophysics community proposes. In order to maintain a high caliber review process, it is important to request that the heliophysics experts conduct reviews.

4.1 Proposal Content

Proposals must be for a complete investigation, based on clearly defined investigation objectives that address scientific questions appropriate for the heliophysics missions linked back to Heliophysics Science Goals. The investigation objectives must be achieved through a process, including payload construction, space or near-space flight, data analysis, data archiving, and publication of results. In addition, proposals must also provide sufficient information on the flight performance characteristic and the mission requirements in order to demonstrate the feasibility of the investigation.

The Science/Technical/Management (S/T/M) section of proposals is restricted in the number of pages (see Section 6 of this program element). In addition to the content requirement provided in Table 1 of *ROSES Summary of Solicitation,* the S/T/M section must include the following information:

I) The proposal shall describe the investigation to be performed, the types of measurements to be taken; the characteristics, precision, and accuracy required to attain the investigation objectives; and the projected instrument performance. This section shall describe the data to be returned in the course of the investigation. The quality (e.g., resolution, coverage, pointing accuracy, measurement precision, signal to noise ratio, background identification/removal, etc.) and quantity (bits, images, etc.) of data that must be returned shall be described. The relationship between the proposed data products (e.g., flight data, ancillary or calibration data, theoretical calculations, higher order analytical or data products, laboratory data, etc.) and the investigation objectives, as well as the expected results, shall be described. How the science products and data obtained will be used to fulfill the scientific requirements shall be demonstrated and supported by quantitative analysis.

II) A traceability matrix from science goals to measurement requirements to instrument requirements (functional and performance), and to top-level mission requirements shall be provided in tabular form and supported by narrative discussion. Projected instrument performance shall be compared to instrument performance requirements. This matrix provides the reference points and tools needed to track overall investigation requirements. A sample science traceability matrix is shown in Table 1 of this program element. The science traceability matrix shall be included as a table within the S/T/M section. This matrix should summarize how the instrument performance requirements are a direct consequence of the proposed science questions and investigation objectives. The traceability matrix is a critical tool in both the evaluation of a proposed investigation as well as the management and implementation of a selected investigation.

III) A science data management plan is required for all proposed investigations. All data obtained through H-TIDeS-FORT funded efforts shall be made public in a prompt manner. Proposals must describe the management plan of any science data obtained in the investigation described. Proposals must describe the management plan of any science data obtained in the investigation described. Proposals must discuss the release of data obtained in an investigation characterizing the performance of an instrument technology, although it is permissible to summarize this data. In addition to the public release of data, proposals must describe the analysis, interpretation, and dissemination in professional meetings and publications of the results of the proposed investigation. The Data Management Plan provided for the NSPIRES cover pages will suffice for this requirement.

IV) If technology development and/or maturation is a component of the proposed investigation, then a technology summary section is required, as shown in Table 2 of this program element. This section requires an assessment of the Technology Readiness Level (TRL) at the start of the proposed work, and the projected TRL at the conclusion of the proposed work. One of the goals of the H-FORT program is to identify promising technologies for enabling future heliophysics missions. The TRL is a metric-based assessment of the maturation of technologies. The NASA Technology Readiness Level definitions are provided at https://www.nasa.gov/pdf/458490main_TRL_Definitions.pdf. The primary technology area refers to the technology areas defined in the NASA Space Technology Roadmaps (https://www.nasa.gov/offices/oct/home/roadmaps/index.html).

Table 2. An Assessment of Technology Benefits and Advancements

Primary Technology Area (TA)	Refer to NASA Space Technology Roadmaps. Provide TA number down to level 2 or 3.
Target Destination (The Sun, Earth, Moon, Mars, Others inside the Solar System, Outside the Solar System, Foundational Knowledge)	Select up to 3.
Start TRL*	
Estimated End TRL*	
Anticipated Benefits	

* Refer to https://www.nasa.gov/pdf/458490main_TRL_Definitions.pdf

Performance characteristics (which shall be considered as requirements on the flight system) shall include mass, power, volume, data rate(s), thermal, pointing (such as control, stability, jitter, drift, accuracy, etc.), spatial and spectral resolution, observable precision, retrieved parameter sensitivity and accuracy, and calibration requirements. This section shall demonstrate that the instrumentation can meet the measurement requirements, including factors such as retrieval results for each remote sensor, error analysis of the information in all sensors, vertical and horizontal resolution, signal-to-noise (S/N) calculations, and any other aspects of the instrumentation upon which the observations depend.

The mission requirements that the science goals and investigation objectives impose on the mission design elements, including mission design, instrument accommodation, platform design, required launch vehicle capability, ground systems, communications approach, and mission operations plan, shall be provided in tabular form in the mission requirements column of the traceability matrix, and supported by narrative discussion.

Reference for management of H-FORT investigations in NPR 7120.8. Typically, management compliance of projects conducted under the NASA Sounding Rocket and Balloon Programs is ensured by their respective Program Offices. Proposals for flight investigations using other flight opportunities (International Space Station (ISS), CubeSat, Flight of Opportunity, etc.) must provide a management plan explicitly compliant with NPR 7120.8.

Proposals must supply information that is needed in order to generate an estimate of the costs associated with the operational requirements for the proposed investigation. For example, for sounding rockets, this information is the envisioned vehicle type and quantity, payload mass, trajectory requirements, launch site, telemetry requirements, attitude control or pointing requirements, and any plans for payload recovery and reuse. Balloon projects needing unique engineering and/or technical support services and/or vehicles and/or the Wallops Arc-Second Pointing System (WASP) should contact the Balloon Program Office (BPO) directly for an estimate of the Government Furnished Equipment (GFE) cost of the desired support. It is advisable that PIs contact SRPO or BPO before submitting proposals requesting large amounts of resources (e.g., high number of rocket flights) to determine if the proposed investigation is realistic. Investigations using Flights of Opportunity spaceflight must include a statement from the organization providing the flight stating the proposed investigation is manifested on the relevant mission.

For SmallSats and rideshare opportunities, a table specifying the expected mass/size, power, and telemetry budgets, including reserves, the orbit characteristics (perigee, apogee, inclination), and access-to-space methodology must be included in the main page limited S/T/M section of the proposal. Three additional pages (up to 23 total) are permitted for SRO proposals, given the added necessity of describing the SRO investigation systems (e.g., attitude control, telemetry, power, space environment survivability, etc.). The three additional pages must be in a clearly labeled section that describes only the SRO investigation systems.

Note: Data returned from flight investigations shall be deposited in a publicly accessible NASA repository, such as the Solar Data Analysis Center (SDAC) or Space Physics Data Facility (SPDF). Quick look data shall be deposited as soon as possible after it is acquired and all reduced data shall be deposited before the end of the investigation.

All investigations with unique requirements must obtain a letter of mission feasibility from the relevant program office point of contact (listed in Section V(b) of the *ROSES Summary of Solicitation*). Unique requirements include, but are not limited to, remote launch campaigns and phenomenological constraints on the time of launch. The mission feasibility letter must be included in the proposal submission, but it does not count against the proposal page limit. Investigations using Flights of Opportunity spaceflight must include a statement from the organization providing the flight stating the proposed investigation will be manifested on the relevant mission. All ISS payload investigations must obtain a letter of mission feasibility from the ISS Research Integration Office. This does not apply to CubeSats dispensed from the ISS.

For SRO proposals, the schedule of budget must include provision for a formulation phase (4 months, and up to $40K). For planning purposes, the schedule in Section 6 should be used. While NASA will endeavor to meet the targeted dates for formulation and implementation phase selection announcements, unanticipated budget and programmatic issues may force changes in these dates and so this schedule does not represent a commitment on the part of NASA.

5. Award Duration and Type

H-FORT awards are expected to be three years, with a maximum of four years for highly meritorious investigations. H-FORT will not award contracts as it would not be appropriate given the nature of the work solicited. H-FORT does not make separate awards to the Principal Investigator (PI) and Co-Investigators (Co-Is) of the same investigations at different institutions, except in those cases where a Co-Investigator is affiliated with a U.S. Government Laboratory (see Section IV(d) of the *ROSES Summary of Solicitation*), in which case NASA separately funds that Co-Investigator through a direct transfer of funds. In all other cases, the PI institution is expected to fund participating Co-I(s). No separate Co-I cost proposal will be accepted.

6. Summary of Key Information

Projected program budget for first year of new awards	LCAS: $5-6M SRO: $9M
Anticipated number of new awards pending adequate proposals of merit	LCAS: 6-7 SRO: **2-6** ~~1-2~~ **[Updated June 17, 2019]**
Maximum duration of awards	LCAS and SRO – 4 years.
Neither Step-1 proposals nor NOIs are requested for this program element.	
Due date for proposals	See Tables 2 and 3 of this ROSES NRA
Planning date for start of LCAS Investigations	6 months after proposal due date.
Planning date for start of SRO formulation phase	3 months after proposal due date
Planning start date for SRO implementation phase:	2 months after submission of the Concept Study Report
Page limit for the central Science-Technical-Management section of the proposal	LCAS: 20 pages SRO: 23 pages
General information and overview of this solicitation	See *ROSES Summary of Solicitation.*
Detailed instructions for the preparation and submission of proposals	Please see *ROSES Summary of Solicitation* Section I(g) Order of Precedence and the *NASA Guidebook for Proposers*.
Submission medium	Electronic proposal submission is required; no hard copy is permitted.
Web site for submission of proposals via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Web site for submission of proposals via Grants.gov	http://grants.gov/ (help desk available at support@grants.gov or (800) 518-4726)

Funding opportunity number for downloading an application package from Grants.gov	NNH19ZDA001N-HFORT
Point of contact concerning this program	Dan Moses Heliophysics Division Science Mission Directorate NASA Headquarters Washington, DC 20546-0001 Telephone: (202) 358-0558 Email: dan.moses@nasa.gov

B.10 HELIOPHYSICS LIVING WITH A STAR STRATEGIC CAPABILITIES

NOTICE: Amended September 9, 2019. This LWS program element has been shifted to ROSES-2020 due to overlap with other similar programs. The deadlines will be announced in ROSES-2020, to be released in February 2020.

1. Introduction

The Living With a Star (LWS) Program emphasizes the science necessary to understand those aspects of the Sun and Earth's space environment that affect life and society. The ultimate goal of the LWS Program is to provide a scientific understanding of the system that leads to predictive capability of the space environment conditions at Earth, other planetary systems, and in the interplanetary medium.

The LWS program objectives are as follows:

1. Understand how the Sun varies and what drives solar variability.
2. Understand how the Earth and planetary systems respond to dynamic external and internal drivers.
3. Understand how and in what ways dynamic space environments affect human and robotic exploration activities.

The LWS Program seeks to make progress in understanding the complex Heliophysics system, focusing on the fundamental science of the most critical interconnections. Further information on the LWS Program can be found at the updated LWS website (http://lwstrt.gsfc.nasa.gov/). The LWS Science program maintains a strategy with three components, namely, Strategic Capabilities, Targeted Investigations, and Cross-Disciplinary Infrastructure Building programs. Only the Strategic Capabilities are solicited in this announcement. Proposers interested in Targeted Investigations should see program Element B.6.

Living With a Star Strategic Capabilities is not solicited this year. It is anticipated that it will be solicited in ROSES-2020. [September 9, 2019]

2. Points of Contact

Points of contact concerning this program all of whom share this mailing address: Heliophysics Division Science Mission Directorate National Aeronautics and Space Administration Washington, DC 20546-0001	Jeff Morrill Telephone: (202) 358-3744 Email: jeff.s.morrill@nasa.gov Simon Plunkett Telephone: 202-358-2034 Email: simon.p.plunkett@nasa.gov Janet Kozyra Telephone: (202) 875-3278 Email: janet.kozyra@nasa.gov

B.11 HELIOPHYSICS DATA ENVIRONMENT ENHANCEMENTS

NOTICE: Proposal submission to most calls in Heliophysics will be done by a two-step process in which the Notice of Intent is replaced by a required Step-1 proposal submitted by an Authorized Organizational Representative (AOR). See Section 3 for details.

Resident Archives are no longer being offered; the data from missions is now flowing directly to Final Archives, and the "ramp-down funding" when a mission ends will be expected to cover any final expenses for transitioning data to a final archive.

The Data Upgrades portion of the HDEE will not be offered this year since there has been a strongly declining interest in proposing relevant projects, and a new avenue is open for producing datasets in conjunction with science proposals.

What will be solicited are directed Value Added Enhancement projects aimed at furthering the use of Python in Heliophysics. These are to be treated similarly to the LWS Focus Topics in that all the proposers will be expected to work together in the context of the whole project.

Proposers to this program element are not required to provide a data management plan via the NSPIRES cover page question (simply answer that question with "See proposal"). Instead, that is superseded by instructions in the sections below that place more detailed descriptions into the body of the Scientific/Technical/ Management section of proposals; see Section 2.2 below.

1. Introduction

The Heliophysics Data Environment Enhancements (HDEE) program is a component of the Heliophysics Research Program and proposers interested in this program element are encouraged to see the overview of the Heliophysics Research Program in B.1 of this ROSES NRA.

The work carried out for this program should be in support of the Heliophysics strategic goals and objectives in NASA's 2018 *Strategic Plan* and Chapter 4.1 of the NASA *2014 Science Plan* (both at https://science.nasa.gov/about-us/science-strategy). The recommended priorities of the Heliophysics community are also discussed in the National Research Council Decadal Strategy for Solar and Space Physics report, *Solar and Space Physics: A Science for a Technological Society* (http://www.nap.edu/catalog/13060/solar-and-space-physics-a-science-for-a-technological-society). Note particularly the sections of the Decadal report dealing with the "DRIVE" initiative, more specifically "R" and "I," and the discussion in Appendix B. The specific context of this call is provided by the *NASA Heliophysics Science Data Management Policy* (https://hpde.gsfc.nasa.gov/Heliophysics_Data_Policy_v1.2_2016Oct04.html).

The HDEE program encompasses the data environment needs throughout Heliophysics, including Solar, Heliospheric, and Geospace Sciences (Magnetosphere and Ionosphere/Thermosphere/Mesosphere [ITM]).

As part of a mission-oriented agency, the Heliophysics Python Project (HPP) preferentially seeks to fund those efforts that directly impact NASA missions or interpretation of their data. Therefore, investigations that are judged to be more appropriate for submission to other Federal agencies (because, for example, the datasets involved do not belong to NASA), even if of considerable merit, will not be given high priority for funding through this program element, although they may be considered if they are generally relevant to NASA Heliophysics (HP) research.

2. Heliophysics Data Environment Enhancements (HDEE)

In recent years, the HDEE program has emphasized the role of datasets from missions, and the importance of preserving such data for long term use. Thus, the primary support has been for "Data Upgrades" that have assured that older datasets were recovered, preserved, and served efficiently. With time, this task has become less necessary. Additionally, the HP community has been developing a wide variety of tools for data access, production, and analysis based on the high-level, general-purpose Python programming language. (See http://heliopython.org for an overview and references.) Younger researchers, especially, tend to come from backgrounds where Python is the norm and languages such as IDL and MatLab are seldom used. Many senior researchers are also finding that Python provides a very natural way to conduct analysis and data-processing tasks. Python has the advantage over some other currently popular languages in that it is open source, and thus provides no economic barriers for use. It is widely used, with a model for namespaces that encourages the development of packages of code centered on a particular task; this has led to the rapid development in recent years of many of the tools needed in HP research.

The flip side of all the above development is that there have been a large number of HP groups writing code, often for nearly identical tasks. This is clearly inefficient, as well as contrary to the spirit of Python code development. Starting in June, 2018, the Heliophysics Data Environment (HPDE) has funded one researcher to begin to unify the HP efforts who has worked with the community to develop web pages, hold telecons, and to convene a meeting of HP Python code developers (often the scientists using the codes). Much of the writing of Python code is carried out in the spare time of students and young researchers, but there is a perceived need to have at least part of the community funded to provide cohesion, high code standards, and completeness. Thus, a continuing topic of discussion has been what the best use of modest funding would be. This call is a result of that discussion.

This call solicits proposals (Value Added Enhancements) to advance the goal of a robust, vital, and cohesive Python environment for Heliophysics. Resident Archives will no longer be supported; these are no longer needed as the data from current missions is flowing directly to Final Archives. Data Upgrades also will not be supported through this call, but anyone who finds a need for such an Upgrade is encouraged to contact Jeffrey Hayes, Aaron Roberts, or the HP archives (Space Physics Data Facility and Solar Data Analysis Center).

2.1 Programmatic Considerations

Proposals *must* discuss the relationship of the proposed effort to the present and anticipated state of knowledge in the field, to the relevant datasets and code that should be available from any related existing or planned missions, and to any related NASA community research efforts.

All proposals to this call should address two general areas:

I. Science Rationale. This includes:

a. Key objectives and their scientific importance;

b. Relationship to NASA strategic plans and the HP Data Policy; and

c. Uniqueness or scientific advantages of the proposed approach compared to alternatives.

II. Architecture and Implementation Approach. This includes:

a. Technical approach and its requirements and feasibility;

b. Plans for collaboration with other efforts under this call, including, but not limited to participation in telecons and meetings.

c. The use of standards developed by the PyHC (Python in Heliophysics Community) or the larger HPDE community.

The above issues will all be addressed naturally by following the format required in Section 2.2.

It is anticipated that approximately $500K will be made available to support new selections for Data Environment Enhancements, all for Value Added Enhancements. The typical grant is expected to be $50K or less for one year, but larger dollar amounts are possible given sufficiently strong justification. This first year of funding will be largely to establish the optimal model for funding in future years to make the most of relatively small resources. The discussion of funding requirements in the proposals should include the extent to which the particular project is currently being done in the context of missions or research grants. In general, the amount of funding available through this program is hoped to be sufficient to provide continuity and cohesion to the Python efforts in Heliophysics, rather than providing a funding source for all projects. It is still expected that both mission and scientific research proposals (SR&T) will support required code development. In the long run, the HDEE effort will likely provide a larger context and, for example, resources to improve a particular group's code to make it useful to a wider community; this issue will be part of the first year's discussions.

Submitting a proposal to this program element implies that if an award is made, code that is produced will be open source and provided to the community through mechanisms to be agreed upon by the PyHC and NASA.

Proposers to this program element are not required to provide a data management plan via the NSPIRES cover page question. Instead, that is superseded by instructions in the sections below that place more detailed descriptions into the body of the Scientific/Technical/Management section of proposals. See Sections 2.2 and 2.3, below.

2.2 Python Value Added Enhancement Proposals

The primary goal of this one-year start-up effort is to establish clear directions for the HPP, including its governance structure, expected goals for software development in support of HP science, and an associated funding plan. Useful information about the current status of work in this area can be found in the recently published overview paper by Burrell, et al. [Snakes on a Spaceship, 2018, https://doi.org/10.1029/2018JA025877], and more recent information can be found on the Python on Heliophysics web site, http://heliopython.org. The latter site is rapidly evolving, but it is the central locus of information about this project.

The philosophy of this call is that the best way to make progress is to work on real projects of scientific community interest, with the aim to make functional code and to incorporate it into the PyHC framework. In the process, the community will decide which efforts constitute “core” code that should be stable and maintained in a central repository, and which are more specialized tasks, still to be held to high standards, but the responsibility of a specific group. Future calls are likely to focus on the maintenance and upgrading of core functionality, but this is still to be determined by the first-year efforts.

Consistent with the Heliophysics Data Policy, all projects under this program must involve scientific input, and all software and processes should support scientific utility, as evidenced by the support and participation of scientists. As a complement to this, all efforts must show evidence of good IT engineering practices, for example, the use of clear, documented, tested, efficient code that fully accounts for IT security issues. Proposers to this call agree to the Python in Heliophysics Community Standards https://github.com/heliophysicsPy/standards/blob/master/standards.md that include requirements to provide documentation, version control, testing, standard packaging, and other elements intended to optimize the utility of the results. In line with the recommendations of the NAS Space Studies Board report, *Best Practices for a Future Open Code Policy for NASA Space Science* (http://sites.nationalacademies.org/SSB/CurrentProjects/SSB_178892), the results of projects under this call will be made publicly available as open source software as detailed by the PyHC in conjunction with NASA. Each subgroup (separate grant effort under this call) must work in collaboration with the whole group for the benefit of all. The group as a whole decides on its governance, protocols, and procedures. Awardees are expected to attend group meetings and abide by group decisions. Proposals to this call should indicate explicitly the understanding of, and agreement with, the above points. After selection, any areas where there are questions or concerns in terms of governance, protocols, and procedures will be adjudicated by the cognizant NASA program officer.

Proposers should show an awareness of the wide variety of datasets now available through e.g., the Space Physics Data Facility (SPDF: https://spdf.gsfc.nasa.gov; see the "CDAWeb" link); the Virtual Solar Observatory (VSO: https://www.nso.edu/data/vso/; see the SolarSoft link); the Virtual European Solar and Planetary Access site (VESPA: http://www.europlanet-vespa.eu/EPN2020.shtml); the European Space Astronomy Centre site (ESAC: https://www.cosmos.esa.int/web/esdc); the Coupling, Energetics, and Dynamics of Atmospheric Regions site (CEDAR: http://cedar.openmadrigal.org for

“Madrigal” data access); and more specialized or related repositories (e.g., the LASP Interactive Solar Irradiance Data Center http://lasp.colorado.edu/lisird/; the Planetary Data Systems Planetary Plasma Interactions node https://pds-ppi.igpp.ucla.edu; or the “SuperMAG” ground-based magnetometer site http://supermag.jhuapl.edu among many others). Most of these repositories are available through “restful” Web Services or other machine-to-machine protocols, increasingly including the general Heliophysics Application Programmer Interface (HAPI: https://github.com/hapi-server). Proposers are also encouraged to utilize and contribute to the Heliophysics Data Portal (https://heliophysicsdata.gsfc.nasa.gov) that provides metadata, documentation, and access points for an increasingly complete set of HP data and other products. Suggested types of projects to be proposed under this call include:

- Data readers/writers for standard formats (FITS, CDF, NetCDF)
- Analysis code, e.g., SPEDAS or SolarSoft components; common research methods.
- Visualization: improvements on common packages, focused on our needs including graphics from line graphs to 2D and 3D representations of data and simulations.
- Large data and large simulation use; parallel implementations; data mining.
- Specific science tasks that require either wrappers of, e.g., scipy and numpy routines or novel code.
- Innovations we haven't thought of.

Proposers should be aware of work already undertaken in both the general Python community and by specific groups, including others who could be included in this call. The PyHC website (http://heliopython.org) includes pointers to many of these efforts.

Groups that anticipate working directly on assisting others with tasks such as code optimization and clean-up can ask for (modest) funding to do this. Each group should be working on this for itself, but some may wish to offer services for others. Suggestions on how such work should be supported in future years should be part of the result of the first year.

The leadership structure of the PyHC and membership in it shall be decided by the community through collective mechanisms of its choice. It is expected that one result of this first year of funding will be specific funding recommendations for helping with future governance. During the year of this proposal effort, in the interest of stability, NASA will continue to fund the same person to help the PyHC explore relevant topics and to assist with logistics of meetings, web sites, and communication.

A proposal for a Value-Added Enhancement must include explicit subheadings as given in each of the bulleted points below, in the order below, with a discussion of each topic indicated (explicitly note if not applicable):

- *Software or enhancement to be produced*: A clear description of the code(s) to be produced or community assistance to be implemented, including the scientific or other problems solved and the basic methods used.
- *Scientific utility*: An argument for why the codes or assistance are scientifically relevant and useful. Specific research projects should be mentioned, along with an assessment of whether these will bring qualitatively new insights. This should

be supported by, e.g., refereed publications or other citations and uses by people outside the PI team. A poor justification would be: “This work supports projects involving long-term changes in the heliosphere” without specific examples. An excellent justification would be: “The following three groups are awaiting this code to be able to do these cutting-edge scientific studies …”. In the case of very generic capabilities (e.g., a CDF reader), the breadth of the utility may be more important than the support of specific projects.

- *Method of Production*: How the Enhancement will be produced, including a presentation of relevant algorithms.
- *Current Status*: The current status of the code and its current means of support.
- *Documentation Plan*: A plan for providing required metadata and information needed for independent scientific usability.
- *Archive and Dissemination Plan*: A discussion of the use of GitHub or other code repositories and the methods of code distribution consistent with PyHC standards.
- *Need for Resources*: A discussion that demonstrates that the requested resources are necessary and sufficient for success in achieving the proposed effort. A good resource discussion will include: how many hours of what specific level of support person are required, why and what level of science support is needed in terms of FTEs, and how HDEE resources complement other support.

The discussion of each of these points may be brief, but each point must be clearly addressed, and these points are the key elements of a proposal. The Scientific/Technical/Management section (including figures) of proposals shall be no more than ten pages. Proposers should take care to avoid the intensive use of technical jargon.

3. Submission and Evaluation Process

3.1 Step-1 Proposals

To streamline the proposal process (submission, evaluation, and administration), this program uses a two-step proposal submission process. The overall description of a two-step process can be found in Section IV. (b) vii of the ROSES *Summary of Solicitation*. A Step-1 proposal is required and must be submitted electronically by the Step-1 due date (see below and Tables 2 and 3 in the *ROSES Summary of Solicitation*). Proposers should refer to the "Instructions for Submitting a Step-1 Proposal" under "Other Documents" on the NSPIRES page for this program. The Step-1 proposal must be submitted by the organization’s Authorized Organizational Representative (AOR). No budget or other elements are required. Only proposers who submit a Step-1 proposal are eligible to submit a full proposal. Full (Step-2) proposals must contain the same science goals proposed in the Step-1 proposal. In addition, the Step-1 proposal title and investigators (Principal Investigator, and Co-Investigators, Collaborators, Consultants, and Other Professionals) may not be changed between the Step-1 and Step-2 proposals. The expected format and compliance evaluation criteria are described below. Submission of the Step-1 proposal does not obligate the offerors to submit a Step-2 (full) proposal later.

3.1.1 Step-1 Proposal Format and Content

The Step-1 proposal is restricted to the 4000-character Proposal Summary text box on the NSPIRES web interface cover pages. It should include the following information:

- A description of the science goals this proposal is enabling and that are appropriate for Heliophysics investigations.
- A brief description of the methodology to be used to address the science goals and objectives. This will include a description of the Python products to be improved or produced and their relationship to the larger PyHC effort.

The NSPIRES system for proposal submission requires that Step-1 proposals include a summary (i.e., abstract) describing the proposed work as outlined above. The proposal summary is entered directly into a text field in NSPIRES. No PDF attachment is required or permitted for Step-1 proposal submission. All information will be entered within the 4000-character Proposal Summary text box on the NSPIRES web interface cover pages. Proposers will be notified when they are able to submit their Step-2 proposals.

3.1.2 Step-1 Evaluation Criteria

NASA may determine Step-1 proposals to be noncompliant based on the requirements listed in Section 2 and its subsections. PIs of noncompliant proposals will not be eligible to submit the associated Step-2 proposal and will receive a letter to this effect.

3.1.3 Request for Reviewer Names

Proposers are strongly encouraged to provide names and contact information for up to five experts qualified to review their proposal. These experts must not be from the institutions of the PI or Co-Is or stand to benefit financially from the selection (or otherwise) of the proposal. This information can be supplied in response to NSPIRES cover page questions at the time of submission of the Step-1 proposal.

3.2 Step-2 Proposals

A Step-2 (full) proposal must be submitted electronically by the Step-2 due date (see below and Tables 2 and 3 in the *ROSES Summary of Solicitation*). The Step-2 proposal must be submitted by the organization Authorized Organizational Representative (AOR). A budget and other specified information is required. The Step-2 proposal title, Principal Investigator, and all Co-Investigators, Collaborators, Consultants, and Other Professionals must be the same as those in the Step-1 proposal. Step-2 proposals must contain the same scientific goals proposed in the Step-1 proposal.

Proposers must have submitted a Step-1 proposal to be eligible to submit a Step-2 proposal. Proposers that have received a letter of noncompliance are not eligible to submit a Step-2 proposal. The Step-2 review panel will independently evaluate the issue of proposal compliance.

3.2.1 Step-2 Proposal Content

Proposers should refer to the PDF entitled "How to submit a Step-2 proposal" that will appear under "Other Documents" on the NSPIRES page for this program after the Step-1 proposal due date. The process for preparation and submission of the Step-2 (full) proposals is that for any other ROSES proposal. Guidelines for content and formatting of Step-2 full proposals are specified in the *NASA Guidebook for Proposers* and the *ROSES Summary of Solicitation*, except where superseded by the above description.

Proposals should include the following within their Scientific/Technical/Management section: clear descriptions of (1) specific Heliophysics scientific problems that could be addressed with the proposed Python projects (2) the importance of the problems, and (3) the details of the technical approach to providing the promised enhancements. The answers to the above points should arise naturally in following the required format in Section 2.2.

3.2.2 Step-2 Proposal Format

Step-2 proposals that are not compliant with format requirements and page limit may be rejected without review. See Section IV (b) ii of the *ROSES Summary of Solicitation* and the *NASA Guidebook for Proposers* for further details.

- The Scientific/Technical/Management section must not exceed ten pages.
- Margins: no less than 1 inch on all sides, with a page size of 8.5 × 11 inches.
- Font: Times New Roman, 12-point or larger. If an alternate font is used, it must meet the requirement of having, on average, no more than 15 characters per inch. Proposers may not adjust the character spacing or otherwise condense a font from its default appearance.
- Line spacing: Font and line spacing settings must produce text that contains, on average, no more than 5.5 lines per inch. Proposers may not adjust line spacing settings for a selected font below single spaced.
- Figure captions*:* Captions must follow the same font and spacing rules as the main text*.*
- Figures and tables: For text in figures and tables, font and spacing rules listed above do not apply, but all text must be judged to be legible to reviewers without magnification above 100%. Expository text necessary for the proposal may not be located solely in figures or tables, or their captions.

Guidelines for submitting Step-2 full proposals, other than those listed above, are specified in the *NASA Guidebook for Proposers*. The Guidelines above supersede those found in the Guidebook.

3.2.3 Step-2 Evaluation Criteria

Compliant proposals will be evaluated according to the criteria specified in the *NASA Guidebook for Proposers*. These criteria are intrinsic scientific and technical merit, relevance, and cost reasonableness.

The evaluation of scientific and technical merit will include:

- Compelling nature and scientific priority of science goals enabled by the Value Added Enhancement, including the importance of the problem within the broad field of Heliophysics; the unique value of the investigation to enable scientific progress in the context of current understanding in the field, and the importance of carrying out the project now.
- Appropriateness and feasibility of the methodology, including the appropriateness of the selected algorithms for completing the development and the feasibility of the methodology for ensuring success.

Based primarily on these two factors within merit, the evaluation will consider the overall potential science impact and probable success of the investigation.

Relevance will be judged by whether the proposal addresses the goals and objectives of a Python Value Added Enhancement.

The evaluation of cost reasonableness will include assessing the amount of work to be accomplished versus the amount of time proposed. Only necessary Co-Investigators and Collaborators should be included, and their specific roles in the investigation must be clearly laid out. Use of Collaborators whose only role is advisory is discouraged.

4. Summary of Key Information

Expected program budget for first year of new awards	$500K
Number of new awards pending adequate proposals of merit	~5-12
Maximum duration of awards	1 year
Due date for Step-1 proposals	See Tables 2 and 3 of this ROSES NRA
Due date for full Step-2 proposals	See Tables 2 and 3 of this ROSES NRA
Planning date for start of investigation	6 months after Step-2 proposal due date.
Page limit for the central Science-Technical-Management section of proposal	10 pages
Relevance	This program is relevant to the Heliophysics questions and goals in the NASA Science Plan. Proposals that are relevant to this program are, by definition, relevant to NASA.
General information and overview of this solicitation	See the *ROSES Summary of Solicitation*.
Detailed instructions for the preparation and submission of proposals	Please see ROSES *Summary of Solicitation* Section I(g) Order of Precedence and the *NASA Guidebook for Proposers*.
Submission medium	Electronic proposal submission is required; no hard copy is permitted.
Web site for submission of Step 1 and Step 2 proposal via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Web site for submission of proposals via Grants.gov	http://grants.gov (help desk available at support@grants.gov or (800) 518-4726)
Funding opportunity number for downloading an application package from Grants.gov	NNH19ZDA001N-HDEE

Points of contact concerning this program element.	Jeffrey J. E. Hayes Heliophysics Division Science Mission Directorate NASA Headquarters Washington, DC 20546-0001 Telephone: (202) 358-0353 Email: jhayes@nasa.gov and D. Aaron Roberts Heliophysics Science Division Code 672 Goddard Space Flight Center Greenbelt MD 20771 Telephone: (301) 286-5606 Email: aaron.roberts@nasa.gov

B.12 HELIOPHYSICS U.S. PARTICIPATING INVESTIGATOR

NOTICE: August 2, 2019. This program element will not be solicited this year. It is anticipated that it will be solicited next in ROSES-2020.

~~**The Heliophysics Division may solicit Heliophysics U.S. Participating Investigator as program element B.12 of ROSES-2019. If so, final text will be released by an amendment no fewer than 90 days in advance of the Step-2 proposal due date. Until then the due dates will appear as "TBD".**~~

1. Introduction

The Heliophysics U.S. Participating Investigator (H-USPI) program element solicits potentials Heliophysics investigations in which investigators participate as a Co-Investigator (Co-I) for an instrument, experiment, or technology demonstration that is being built and flown by a sponsor agency other than NASA.

These studies are carried out in support of NASA's Heliophysics strategic objective "to understand the Sun and its interactions with Earth and the solar system, including space weather" from the *Science Mission Directorate Science Plan for 2014* (http://science.nasa.gov/about-us/science-strategy). The recommended priorities of the Heliophysics community are also discussed in the National Research Council Decadal Strategy for Solar and Space Physics report, *Solar and Space Physics: A Science for a Technological Society* (http://www.nap.edu/catalog.php?record_id=13060).

2. Scope and Relevance

A proposed investigation as a U.S. Participating Investigator on a non-NASA space mission may be as a Co-I for an instrument, experiment, or technology demonstration that is being built and flown by a sponsor agency other than NASA. The Co-I role can include, but is not limited to, instrument design, modeling and simulation of the instrument's operation and measurement performance, calibration of the instrument, scientific analysis and/or research of the data returned, and/or development of innovative data analysis techniques. A U.S. Participating Investigator may also serve as a member of a non-NASA space mission science or engineering team and participate in science team activities, such as mission planning, mission operations, data processing, data analysis, and data archiving. Regardless of the nature of the U.S. Participating Investigator role, an investigation proposed under this category must be for a science or technology investigation and must include some meaningful data analysis component, archiving of the complete data set, and the publication of science results in the peer reviewed literature. All aspects of the investigation through publication must be within the proposed cost.

Investigations requiring the provision of flight hardware are not solicited through this H-USPI solicitation.

A proposed investigation as an H-USPI on a non-NASA mission or instrument may take any form that clearly and demonstrably enhances the scientific output of the mission, benefits the U.S. scientific community, and enables the U.S. heliophysics science community access to a highly valued scientific data set.

The proposed investigations can vary in duration, to include just the prime science mission phase or to begin at the post-confirmation development phase (e.g., for calibration analysis) through the prime mission operational phase, depending on the science requirements of the investigation. All investigations shall include adequate time for data analysis and archiving following the conclusion of the prime mission phase.

This program element solicits new investigations only. Proposals whose intent or purpose is to extend or directly supplement existing investigations already funded for approved space flight missions or other NASA-supported research programs are not appropriate for this program element. Investigators who are members of the science teams of ongoing missions and who propose to use data from those missions must clearly demonstrate that the proposed research is distinct from their existing efforts.

Amended August 2, 2019. This program element will not be solicited this year. It is anticipated that it will be solicited next in ROSES-2020.

3. Point of contact

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B.13 Outer Heliosphere Guest Investigators (OH-GI)

NOTICE: Amended November 26, 2019. Due to disruptions caused by past fires and power outages and expected power outages from high winds in northern California next week, the Step-2 due date for this program element has been delayed to December 10, 2019.

Amended October 3, 2019. Section 2.2 has been corrected to indicate that eligible mission data is not limited to the list in Section 1.1, but may include any data "that would enable the study of the outer heliosphere". Step-1 proposals are now due October 24, 2019 and the ~~10-page Step-2 proposals are still due by December 3, 2019~~. New text is in bold, deleted text is struck through.

Amended May 31, 2019. This Amendment creates a new opportunity in ROSES-19 though this program element: B.13 Outer Heliosphere Guest Investigators (OH-GI).

Eligible proposers who have already submitted to Heliophysics Guest Investigators Open (H-GIO) a Step-1 proposal with the same (or essentially the same) team and objectives may either submit a full (Step-2) proposal to H-GIO or submit Step-1 and Full (10-page) Step-2 proposals to this call instead. ~~Step-1 proposals are due October 17~~, 2019 and 10-page Step-2 proposals are due by December 3, 2019.

1. Scope of Program

The Outer Heliosphere Guest Investigators (OH-GI) program, solicits proposals that focus on analysis of data from Voyager, the Interstellar Boundary Explorer (IBEX), and other space assets that generate data enabling the study of the outer heliosphere. This program is intended to maximize the scientific return from these mature missions by providing support for research beyond presently funded investigations. It may also act to inform future exploration and investigation opportunities of interstellar space. Funded investigators (PIs and Co-Is) of this solicitation will be considered Guest Investigators of Voyager and/or IBEX for the duration of the award and will be invited to attend and present progress at Voyager and IBEX team meetings.

Proposals should address a subset of the Heliophysics Decadal Survey Goal 3 (HDSG3): "Determine the interaction of the Sun with the Solar System and the interstellar medium," focusing only on the interaction of the Sun with the interstellar medium.

The OH-GI program is a component of the Heliophysics Research Program and proposers interested in this program element are encouraged to see the overview of the Heliophysics Research Program in Appendix B.1 of this ROSES NASA Research Announcement.

1.1 Overview

The most recent decadal survey (http://www.nap.edu/catalog.php?record_id=13060) endorsed a substantial increase in resources for mission specific calls under the GI program. The OH-GI program is part of the implementation of the Diversify, Realize, Integrate, Venture, Educate (DRIVE) initiative recommended in the decadal survey.

As with the open element of the H-GI program, investigations may employ theory, models, and data from other sources, as needed, to interpret and analyze NASA's OH data, but only as a secondary emphasis. That is, in any such instance, the proposal must clearly demonstrate that the theory, models, and/or data in question are necessary for interpretation of the OH data and are not themselves the primary object of the investigation. Development of new models and theories is not solicited.

The twin Voyager spacecraft launched in 1977 as a mission to explore the outer planets. After passing Neptune in 1989, the program was renamed as the Voyager Interstellar Mission (VIM). Both spacecraft have passed beyond the heliopause and continue to measure interstellar particle fluxes, waves and fields. The Interstellar Boundary Explorer (IBEX) was launched in 2008 to investigate the interaction of the solar wind with the interstellar medium. It continues to measure energetic neutral atoms from 1 AU. While the mission was ongoing, the INCA instrument aboard the Cassini spacecraft measured interstellar neutral particles beyond ENA energies that are covered by IBEX. The Cassini mission ended in 2017. Also, the New Horizons spacecraft performed a flyby of Pluto in 2017 while continuing its journey away from the Sun, and carries instruments to measure solar wind plasma, dust, and energetic particles. Additional information for these missions can be found at:

- Voyager: https://voyager.jpl.nasa.gov/
- IBEX: https://www.nasa.gov/mission_pages/ibex/index.html
- Cassini: https://www.nasa.gov/mission_pages/cassini/main/index.html
- New Horizons: https://www.nasa.gov/mission_pages/newhorizons/main/

1.2 Avoidance of Duplicate Investigations

The mission science teams are already funded to do a substantial amount of research. Proposals that would duplicate or directly supplement existing investigations already funded for approved space flight missions or other Heliophysics research programs are not appropriate for the OH-GI program. However, proposals aiming at providing independent analysis of investigations conducted by the mission team are compliant. A Principal Investigator (PI) or a Co-Investigator (Co-I) on the target missions may also propose as a PI or Co-I to this program element. However, such Heliophysics mission personnel must include in their proposal a description of their mission duties and clearly distinguish the proposed new activity from their existing responsibilities for mission operations and data analysis.

Proposers eligible for this call who have submitted a Step-1 proposal to the Open GI of the same (or essentially the same) team and objectives may either submit a full proposal to the Open GI call, or submit Step-1 and Full proposal to this OH-GI call instead, but may not do both.

1.3 Data Availability

The requirements outlined in B.1 The Heliophysics Division Overview regarding data availability apply to this program element as well. All data to be used for proposed investigations must be available in a public archive at least 30 days before the Step-2 deadline. This applies to both the mission data and ancillary data from other sources.

2. Submission and Evaluation Guidelines

2.1 General Considerations

Each Principal Investigator (PI) may submit one and only one Step-1 proposal to this program element. In that proposal, the Principal Investigator or Science PI must invest at least one month of labor to the investigation. Proposals utilizing a Science PI must mark that individual as such in NSPIRES and the individual must be named. Co-Investigators (Co-Is) must each have a specific and defined task in the project, and the task must be essential to completion of the project. Use of collaborators is discouraged.

Proposals may be declared noncompliant based on either the Step-1 or Step-2 proposal if they a) do not adhere to the requirements outlined above, b) are outside the scope of the OH-GI program (see Section 2.2 below), or c) fail to meet submission guidelines specified below (Section 3).

2.2 Limitations and Scope **[Corrected October 3, 2019]**

Proposals outside the scope of OH-GI may be declared noncompliant based on either the Step-1 or Step-2 proposal. These include the following:

- Proposals that do not focus on analysis of data ~~from the above-listed target missions~~ **that would enable the study of the outer heliosphere**;
- Proposals for the same or essentially the same work submitted concurrently to other program elements in Appendix B or E, as specified in B.1 Section 1;
- Work for which the proposing organization (or investigators) are already funded by NASA. Where projects might appear to overlap, proposals must show that the proposed effort does not duplicate other awards, including awards as part of operating space flight missions;
- Proposals for model, tool, or theory development (see Section 1.1);
- The routine, long-term gathering of observational data;
- Investigations with the main purpose of supporting ground-based infrastructure or facilities.

3. Two-Step Submission Guidelines

To streamline the proposal process (submission, evaluation, and administration), this program uses a two-step proposal submission process. The overall description of a two-step process can be found in Section IV.(b)vii of the *ROSES Summary of Solicitation*. A Step-1 proposal is required and must be submitted electronically by the organization Authorized Organizational Representative (AOR) by the Step-1 due date (see Tables 2 and 3 of ROSES). No budget or other elements are required. Only proposers who submit a Step-1 proposal and are "invited" via NSPIRES to proceed can submit a full proposal. Step-1 proposals will be checked for compliance, but they will not be evaluated.

The Step-2 proposal title and science goals, must be the same as those in the Step-1 proposal. No additional investigators (Principal Investigator, Co-Investigators, Collaborators, Consultants, and Other Professionals) are allowed in the Step-2 proposal. The expected format, content and evaluation criteria are described below. Submission of the Step-1 proposal does not obligate the offerors to submit a Step-2 (full) proposal later.

3.1 Step-1 Proposal Content

Proposers should refer to the "Instructions for Submitting a Step-1 Proposal" under "Other Documents" on the NSPIRES page for this program. The Step-1 proposal is restricted to the 4000-character Proposal Summary text box on the NSPIRES web interface cover pages. References and any other supporting material are not required, but, if included, must fit within the limit. The Step-1 proposal must include the following information:

- The science goals and objectives to be addressed by the proposal;
- A listing of the mission data to be used in the investigation;
- A listing of the data analysis methodology and any models or simulations to be used;
- A brief statement of the relevance of the problem to the program by using OH data to address the relevant Decadal survey goal.

The Step-1 proposal summary is entered directly into a text field in NSPIRES. No PDF attachment is permitted for Step-1 proposal submission. All information will be entered within the 4000-character Proposal Summary text box on the NSPIRES web interface cover pages. Proposers will be notified when they are able to submit their Step-2 proposals.

Proposers are strongly encouraged to provide names and contact information of five experts qualified to review their proposal. These experts must not be from the institutions of the PI or Co-Is. This information can be supplied in response to cover page questions associated with the Step-1 proposal.

3.2 Step-2 Proposals

A 10-page Step-2 (full) proposal must be submitted electronically by the Step-2 due date (see Tables 2 and 3 of ROSES). The Step-2 proposal must be submitted via NSPIRES or Grants.gov by the organization Authorized Organizational Representative (AOR). A budget and other specified information is required. The Step-2 proposal title and science scope/goals must be the same as those in the Step-1 proposal. No additional investigators (Principal Investigator, Co-Investigators, Collaborators, Consultants, and Other Professionals) are allowed in the Step-2 proposal. Proposers must have submitted a Step-1 proposal to be eligible to submit a Step-2 proposal. Proposers that received a noncompliant letter are not eligible to submit a Step-2 proposal.

3.3 Step-2 Proposal Format

The process for preparation and submission of the Step-2 (full) proposals is the same for any other ROSES proposal. Guidelines for content and formatting full proposals are specified in Table 1 of the *ROSES Summary of Solicitation* and the *NASA Guidebook for Proposers*.

Proposals are restricted to ten (10) pages for the Scientific/Technical/Management section and must include the following sections with the preferred order:

- The science objectives and perceived impact of the proposed work to the state of knowledge in the field; references to existing work in the field should be limited to that which is needed to justify the value of the science proposed;
- The data and methodology to be employed in conducting the proposed research; the proposal must demonstrate (1) that the data is appropriate to address the science objectives and (2) that the methodology is both appropriate and feasible to make substantial progress on the science objectives;
- The relevance of the proposed work to the goals of the program. This section must demonstrate how the proposed work uses outer heliosphere data to address the specific subset of Heliophysics Decadal survey goal #3.
- A general plan of work, the management structure for the proposal personnel, and a description of the expected contribution to the proposed effort by the PI and each person as identified in the proposal whether or not they derive support from the proposed budget. Postdoctorals and students do not need to be identified by name.

Historically, proposals that address a single well-focused science objective with a limited set of specific science questions have been more successful at constructing methodologies that are demonstrably feasible and appropriate, as compared with those that propose to address a large number of science questions or that are directed at an overly-broad science topic.

3.3.1 *Step-2 Proposal Formatting Requirements*

All proposals submitted to ROSES must strictly conform to the formatting rules. Proposals that violate the rules may be rejected without review or declined following review if violations are detected during the evaluation process. Guidelines for submitting Step-2 full proposals are specified in the *NASA Guidebook for Proposers*.

3.4 <u>Step-2 Compliance and Evaluation Criteria</u>

3.4.1 *Step-2 Compliance*

Non-compliant Step-2 proposals will be returned without review. Step-2 proposals may be declared noncompliant if:

- The title has changed from that of their Step-1 proposal,
- Investigators have been added since the Step-1 proposal,
- The science scope/goals have changed from that of their Step-1 proposal,
- Proposals with the same (or essentially the same) team and objectives as a full (Step-2) proposal submitted to Heliophysics Guest Investigators Open.

Note: Proposers eligible for this call who have submitted a Step-1 proposal to the Open GI of the same (or essentially the same) team and objectives may either submit a full proposal to the Open GI call, or submit Step-1 and Full proposal to this OH-GI call instead, but may not do both.

Step-2 proposals that are not compliant with format requirements may be rejected without review. See Section IV(b)ii of the *ROSES Summary of Solicitation* and the *NASA Guidebook for Proposer*s for details.

3.4.2 *Step-2 Evaluation Criteria*

Compliant proposals will be evaluated according to the criteria specified in the *ROSES Summary of Solicitation* Section VI(a) and the *NASA Guidebook for Proposers* and they are Relevance, Merit, and Cost. Clarifications and additions specific to this program element are listed below.

The evaluation of scientific and technical merit will include the following:

- Compelling nature and scientific priority of the proposed investigation's science goals and objectives, including the importance of the problem within the broad field of Heliophysics, the unique value of the investigation to make scientific progress in the context of current understanding in the field, and the importance of carrying out the investigation now.
- Appropriateness and feasibility of the methodology, including the appropriateness of the selected data, models, and analysis for completing the investigation and the feasibility of the methodology for ensuring scientific success.

Based on these two science and technical factors, the evaluation will consider the overall potential science impact and probability of success of the investigation.

Relevance to and priority within the OH-GI program will be assessed vs. the topics discussed in Section 1. Each proposal must demonstrate that the investigation is relevant and of high priority.

Cost reasonableness includes assessing the amount of work to be accomplished versus the amount of time proposed. Open-ended proposals or those with a large number of science questions to be addressed typically do not fare well in this evaluation. Only necessary Co-Investigators and Collaborators should be included, and their specific tasks and roles in the investigation must be clearly laid out in the proposal work plan.

4. Available Funds

It is expected that there will be approximately ~$750K available to support the first year of new Heliophysics OH-GI investigations selected through this program element. The average yearly budget of an OH-GI proposal is expected to be $125-150K.

5. Award Types

The OH-GI program will primarily award funds through three vehicles: (1) grants, (2) interagency transfers, and (3) awards to NASA Centers. The OH-GI program will not award contracts, because it is not appropriate given the nature of the work solicited. An institution that has received a contract previously can receive funds as a grant by not charging a fee.

6. Summary of Key Information

Expected annual program budget for first year of new awards	~$750K; See Section 4
Number of new awards pending adequate proposals of merit	~5-6
Maximum duration of awards	3 years; shorter-term proposals are allowed
Due date for Step-1 proposals	See Tables 2 and 3 of this ROSES NRA
Due date for full Step-2 proposals	See Tables 2 and 3 of this ROSES NRA
Page limit for the central Science-Technical-Management section of proposals	10 pp; see also Table 1 of the *ROSES Summary of Solicitation* and Section 3.7 of the *NASA Guidebook for Proposers*
Planning date for start of investigation	8 months after proposal due date.
Relevance	Proposals that are relevant to this program are, by definition, relevant to NASA. See Section VI(a) of the *ROSES Summary of Solicitation*
General information and overview of this solicitation	See the *ROSES Summary of Solicitation*.
General requirements for content of proposals	See Section 3 of the *NASA Guidebook for Proposers* and Section IV and Table 1 of *the ROSES Summary of Solicitation*.
Detailed instructions for the submission of proposals	See https://nspires.nasaprs.com/tutorials/ Sections 3.22-4.4 of the *NASA Guidebook for Proposers* and Section IV(b) of *the ROSES Summary of Solicitation*.
Submission medium	Electronic proposal submission is required; no hard copy is permitted.
Web site for submission of proposals via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Web site for submission of proposals via Grants.gov	http://grants.gov (help desk available at support@grants.gov or (800) 518-4726)
Funding opportunity number for downloading an application package from Grants.gov	NNH19ZDA001N-OHGI
Point of contact concerning this program element	Arik Posner Heliophysics Division Science Mission Directorate NASA Headquarters Washington, DC 20546-0001 Telephone: (202) 358 0727 Email: arik.posner@nasa.gov

B.14 Heliophysics System Observatory Data Support

NOTICE: July 23, 2019. In order to give proposers additional time, the proposal due date for this program element has been changed to August 15, 2019.

NOTICE: 8-page Proposals are due ~~August 1, 2019~~. As a result of this shortened timeline, no preliminary statement such as an NOI or Step-1 proposal is requested. Awards to non-governmental organizations will be as cooperative agreements. This program element only accepts proposals submitted by U.S. institutions, regardless of an observatory's location or management.

When proposers contact the Solar Data Analysis Center (SDAC) for the statement of support (see Section 2.3), the latter will discuss the archive's requirements not included in this program element. Proposers are strongly encouraged to contact SDAC as soon as possible. The SDAC point of contact may be found on the SDAC website: https://umbra.nascom.nasa.gov/index.html/.

1. Scope of Program

The Heliophysics System Observatory Data Support (HSO Data Support) program solicits proposals for ground-based solar and coronagraphic observations that would complement and provide context for the Parker Solar Probe (PSP) data set, and enable an enhanced science return from the mission. These observations are expected to cover as much as possible of the 30 days before and 30 days after the 2019 and 2020 perihelia: 1 September 2019, 29 January 2020, 07 June 2020, and 27 September 2020.

HSO Data Support requires the acquisition, processing, and archiving of data from ground-based observatories; a limited amount of funding is available to cover required tasks in excess of normal operations.

While NASA expects observatories to interact with the PSP science team and the Solar Data Analysis Center (SDAC) to optimize data acquisition and archiving, this solicitation does not support science investigations or any other task beyond those necessary for the archiving of the specified observations.

The HSO Data Support program is a component of the Heliophysics Research Program. Proposers interested in this program element are encouraged to read ROSES Appendix B.1, Heliophysics Research Program Overview.

2. Proposal Guidelines

Guidelines for the content and formatting of proposals are specified in Table 1 of the *ROSES Summary of Solicitation*, and the *NASA Guidebook for Proposers*. Those guidelines apply except where superseded by this program element.

2.1 Required Archival Products

Proposals to this program element shall commit to archiving the following products for the proposed observations:

- Level 0 data. (i.e., unprocessed data, along with any instrumental measurements needed to remove those effects – flat-fields, darks, reference spectra, etc.);
- Level 1 data. (i.e., science data with instrumental effects removed);
- Level 2 data, if put into physical units. (i.e., spectra converted into wavelength and fluxes, as opposed to pixels and DN);
- Documentation describing the observation method. (This should be an outline of the instruments used, the modes (if any) of said instruments, and the weather conditions while the data were obtained);
- Documentation describing the Level 0 and the Level 1 processing. (If a pipeline was used to obtaining Level 1 and Level 2 data, the algorithm used in the pipeline. The FITS headers will have the appropriate usual parameters so that the provenance of the data can be traced);
- All data files shall be produced in the Flexible Image Transport System (FITS) format and delivered (with metadata and other documentation) to the Solar Data Analysis Center (SDAC). All accompanying documentation shall be delivered as PDFs. Delivery of every processed set of observations shall be completed no more than 90 days after the respective perihelion. The data will be subject to verification on the NASA archive side to ensure that the data delivered meet the requirements of the points enumerated above.

2.2 <u>Proposal Participants</u>

The proposal PI shall, in addition to tasks related to the project's leadership, be responsible to NASA for 1) leading necessary interactions with the PSP science team and SDAC, 2) ensuring that the observation acquisition are optimized to complement the PSP data set, and 3) ensuring that the acquired observations are delivered to SDAC consistent with the requirements of this program element.

The proposal team shall include a cognizant representative of the observatory as Co-I/Institutional PI, if that individual is not the proposal PI. Technical individuals at the observatory do not need to be identified by name but their roles and responsibilities must be clearly described.

The proposal need not identify postdoctoral researchers and students by name, but shall clearly describe their roles and responsibilities within the Scientific/Technical/Management section.

2.3 <u>Proposal Content</u>

Proposals may only include tasks that are necessary for the acquisition, processing, and archiving of the ground-based observations. As part of those tasks, proposals may request support for necessary virtual and face-to-face meetings with the PSP science team and SDAC.

Proposals shall include a letter of resource support from their observatory's relevant management, as described by the *NASA Guidebook for Proposers* (Section 3.17). This requirement holds regardless of whether the observatory is managed by the proposing institution or the observatory’s geographic location.

Proposals shall include a statement of support from SDAC. Proposers are strongly encouraged to email the SDAC point of contact as soon as possible to ensure receipt of the statement before the proposal due date. As part of this interaction with SDAC, the archive will discuss the archive's requirements not included in this program element. Contact information for the SDAC POC may be found on the SDAC webpage: https://umbra.nascom.nasa.gov/index.html/.

Proposals shall adequately describe the observations to be acquired and address how those observations would complement and provide context for the PSP data set, and enable an enhanced science return from the mission. This includes, but is not limited to:

- A description of the observatory and observation method(s);
- A description of the observations, including measurement characteristics (e.g. field of view, physical units, accuracy, precision, sensitivity);
- A description of the plan to optimize the acquisition and the archiving of the observations;
- The expected duration of coverage (baring weather) around each perihelion; and
- The expected cadence during observing times.

Proposals shall adequately address the preparation of data products and their delivery to SDAC. This includes, but is not limited to:

- A description of the observation processing and calibration;
- A description of the files documenting the observations, and their processing and calibration for archiving with SDAC;
- The estimated organization, number, and size of the archival files;
- The estimated level of effort to acquire, process, and calibrate the data;
- The estimated level of effort to produce the accompanying documentation; and
- The estimated schedule for deliveries to SDAC.

2.4 Proposal Format

All proposals submitted to ROSES must strictly conform to the formatting rules in the *ROSES Summary of Solicitation*, except where superseded by this program element.

- Scientific/Technical/Management section: No more than 8 pages.
- Margins: No less than 1 inch on all sides, with a page size of 8.5 × 11 inches.
- Font: Times New Roman, 12-point or larger. If an alternate font is used, it must meet the requirement of having, on average, no more than 15 characters per inch.
- Line spacing: Font and line spacing settings must produce text that contains, on average, no more than 5.5 lines per inch.
- Figure captions: Captions must follow the same font and spacing rules as the main text.
- Figures and tables: For text in figures and tables, font and spacing rules listed above do not apply, but all text must be judged to be legible to reviewers without magnification above 100%. Expository text necessary for the proposal may not be located solely in figures or tables, or their captions.

3. Proposal Submission, Evaluation, and Selection

3.1 Proposal Submission

This program element does not request a Notice of Intent nor a Step-1 proposal. Full proposals are due 30 days after the release of this program element. See Tables 2 and 3 of this ROSES NRA.

This program element only accepts proposals submitted by U.S. institutions. Those institutions are responsible for the execution of the proposed work and the management of all sub-award/sub-contract activities, consistent with requirements specified in Sections III(a) and IV(d) of the *ROSES Summary of Solicitation*. That is, participation in ROSES-funded research by non-U.S. organizations in this program is welcome, but on a "no exchange of funds" basis. However, the acquisition of observations, processing, and delivery of archival products from non-U.S. sources by U.S. award recipients is permitted. See ROSES FAQ #14 on this topic and guidebook references therein.

3.2 Proposal Evaluation

Given the time-sensitive nature of the solicited observations, proposals submitted to this program element will be subject to a rapid evaluation process and proposers will received an abridged evaluation, consistent with NASA policy.

Compliant proposals will be evaluated according to the criteria specified in Section VI(a) of the *ROSES Summary of Solicitation* and the *NASA Guidebook for Proposers*. In addition, proposals to this program element will be evaluated according to the following specifics:

- Intrinsic Merit will include consideration of how the ground-based observations would complement and provide context for the PSP data set, including related to points listed in and similar to those listed in Section 2.2 of this program element.
- Intrinsic Merit will include consideration of how the ground-based observations would enable an enhanced science return from the PSP mission, including related to points listed in and similar to those listed in Section 2.2 of this program element.
- Intrinsic Merit will include consideration of the usefulness and usability of the archival data products and their accompanying documentation, including related to points listed in and similar to those listed in Section 2.2 of this program element.
- Intrinsic Merit will include consideration of the plan to optimize both the acquisition and the archiving of the observations, including communications with the PSP science team and SDAC.

3.3 Proposal Selection

Selections for this program element will weigh NASA programmatic interests more than research-focused programs. Programmatic interests include, but are not limited to, type of observation, observation temporal coverage, and observatory geographic coverage.

Proposals may be declined for non-compliance, non-responsiveness to this program element, and/or non-adherence to the program element's requirements. If warranted and appropriate, this decline may be without review.

4. Award Types

This program element will award funds through three vehicles: (1) cooperative agreements, (2) interagency transfers, and (3) awards to NASA Centers. This program element will not award contracts or grants.

Because of the required interactions between the proposer and the PSP Mission Science Team and the SDAC, awards to non-governmental organizations will be cooperative agreements.

5. Summary of Key Information

Expected annual program budget for new awards.	$600k
Number of new awards pending adequate proposals of merit	4
Maximum duration of awards	2 years; shorter-term proposals are allowed
No NOIs or Step-1 Proposals	No NOIs or Step-1 Proposals
Due date for full proposals	See Tables 2 and 3 of this ROSES NRA
Page limit for the central Science-Technical-Management section of proposals	8 pp; see also Table 1 of ROSES and the *NASA Guidebook for Proposers*
Planning date for start of investigation	3 months after proposal due date
Relevance	Proposals that are relevant to this program are, by definition, relevant to NASA.
General information and overview of this solicitation	See the *ROSES-2019 Summary of Solicitation*.
General requirements for content of proposals	See Section 3 of the *NASA Guidebook for Proposers* and Section IV and Table 1 of *the ROSES-2019 Summary of Solicitation*.
Detailed instructions for the submission of proposals	See https://nspires.nasaprs.com/tutorials/ Sections 3.22-4.4 of the *NASA Guidebook for Proposers* and Section IV(b) of *the ROSES-2019 Summary of Solicitation*.
Submission medium	Electronic proposal submission is required; no hard copy is permitted
Web site for submission of proposal via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202 479-9376)
Funding opportunity number for downloading an application package from Grants.gov	NNH19ZDA001N-HSODS

Point of contact concerning this program	Jeffrey Hayes Heliophysics Division Science mission Directorate NASA Headquarters Washington, DC 20546-0001 Telephone: (202) 358-0353 Email: jhayes@nasa.gov

B.15 Heliophysics System Observatory Connect

NOTICE: Amended October 25, 2019. This amendment adds this new program element to ROSES-2019. A Step-1 proposal is mandatory for all proposers. Step-1 proposals are due by January 15, 2020, and Step-2 proposals are due March 13, 2020.

1. Scope of Program

The goal of the Heliophysics System Observatory (HSO) Connect program is to enhance the scientific return of the HSO by supporting investigations that innovatively connect observations from one or more HSO missions with spacecraft or ground-based observations from other SMD Divisions, and/or other agencies within or outside the U.S. This instance of HSO-Connect focuses on observations from the Parker Solar Probe (PSP) mission together with other observations throughout the whole heliosphere. This includes data from currently operating space missions and ground-based observatories, and can include data from missions or observatories not yet launched or operational, but expected to be operational within the time interval of awards from this competition. In addition to PSP observations, investigations can include, but are not limited to, any HSO mission, but also Solar Orbiter, Bepi-Colombo, the Daniel K. Inouye Solar Telescope (DKIST) for example. In order to include observations not yet available, NASA Heliophysics is relaxing the requirement that all data must be in a public archive ahead of proposal submission (see Section 3.4.3 Limited Risk Waver).

Key elements for achieving this goal are advanced planning of coordinated observing campaigns, integration of data analysis activities, and modeling/simulations of the Sun, the heliosphere, geospace, planetary space environments, and the interstellar boundary. HSO-Connect (HSO-C) is intended to support science that cannot effectively be done by individual investigators but that requires a team effort, coordinating observations and using state-of-the-art tools to advance Heliophysics science. Proposals should be ambitious, should include the full range of expertise needed, but also need to be focused enough to be achievable within the lifetime of the award.

HSO-Connect is a component of the Heliophysics Research Program and proposers interested in this program element are encouraged to see the overview of the Heliophysics Research Program in Appendix B.1 of this ROSES NASA Research Announcement.

1.1 Solicited Investigations

Proposals to this solicitation must specify specific science objective(s) and show how they fit within one of the three HSO-Connect program objectives below, each of equal importance.

1. Investigate the structure and dynamics of phenomena and/or mechanisms responsible for processes, at the Sun and inner heliosphere.
2. Investigate effects of solar disturbances and/or heliospheric structures on the magnetosphere, ionosphere, and atmosphere of Earth.
3. Investigate effects of solar disturbances and/or heliospheric structures on planetary space environments and/or the space environments of small bodies in the solar system, and/or the interstellar boundary.

All proposals must utilize observations from the Parker Solar Probe (PSP) mission together with additional observations, and may interpret the observations through data analysis, theory, simulations, and/or modeling. Awards will be made on the basis of excellence, so proposal selections may not be equally divided within these three program objectives.

1.2 Proposal Team Roles and Responsibilities

The Principal Investigator of a selected proposal, and up to one other team member will be added to the Parker Solar Probe Science Team as Participating Scientists and will be given all of the rights and responsibilities of PSP Co-Is. In the case that a proposal names a Science PI, that individual (and not the named Principal Investigator) will be added to the PSP Science Team as a Participating Scientist. The PI (or Science PI) takes responsibility for ensuring that their proposal team members follow the PSP Project Data Management Plan and instrument-specific Rules of the Road documents.

Participating Scientists should plan to attend one or more PSP Science Working Team meetings per year in order to allow coordination with the PSP team. Ideas and plans for coordination and/or data usage must be discussed in the proposal. Up-to-date information on the Parker Solar Probe mission can be found on the following web site: http://parkersolarprobe.jhuapl.edu/. Additional information on PSP and its orbits can be found in the HSO-Connect Proposal Information Package (PIP), found on the NSPIRES page for this program element.

1.3 Additional Campaign Coordination Resources

PIs may utilize resources offered through the Whole Heliosphere and Planetary Interactions (WHPI) campaign (https://whpi.hao.ucar.edu). This has been set up to enhance collaboration within the science community for studies using PSP perihelion passes and other observations throughout the whole heliosphere. The website will contain information and links, such as past and future campaign interval information, data and model products, and supplemental products, such as summary plots, spacecraft magnetic connectivity maps, and augmented data sets.

The HSO-Connect Proposal Information Package (PIP), found on the NSPIRES page for this program element, has more detailed information about WHPI products and services. Participation in or collaboration with the WHPI campaign is not a criterion of proposal evaluation.

1.4. Data Usage and Availability

Observations made by Parker Solar Probe and other missions that are part of the Heliophysics System Observatory are or will be archived by the Space Physics Data Facility (SPDF) https://spdf.gsfc.nasa.gov/ or by the Solar Data Analysis Center (SDAC) https://umbra.nascom.nasa.gov/index.html/. Observations of NASA Planetary Science spacecraft are archived at the Planetary Data System (PDS), https://pds.nasa.gov/.

SDAC will also host data from ground-based solar observatories during PSP perihelion passes from the following sources:

- K-Cor ground-based coronagraph observations, operated daily at Mauna Loa Solar Observatory (MLSO) by the High Altitude Observatory

- Expanded Owens Valley Solar Array (EOVSA) observations of solar microwave emission in the 1-18 GHz range
- high spatial resolution (~ 0.1 arcsec) imaging observations made by the 1.6 m Goode Solar Telescope at Big Bear Solar Observatory
- high-spatial-resolution imaging, spectroscopic, and polarimetric observations of the photosphere and chromosphere will be provided using four instruments of the Dunn Solar Telescope at Sacramento Peak in New Mexico.

Non-NASA data may be used in a proposed investigation for HSO-Connect as long as information describing the data is publicly available and the data to be used will become available to the public within twelve months of acquisition. This can be through one of the data archives specified above or linked through WHPI (https://whpi.hao.ucar.edu). Costs associated with making data available to the public must be part of the proposed budget. Discussions in advance with the archives or with WHPI are strongly encouraged and should be included as part of the proposal. Any costs of conducting observations by non-NASA facilities cannot be charged to the HSO-Connect program.

In order to enable coordinated observations of Parker Solar Probe with other science data, pre-proposal-submission availability of data in a public archive is not required. For HSO-Connect, it is permitted to plan analysis of or coordinate with data suppliers of upcoming observations that are not yet archived or even collected. However, a contingency plan must be presented to address how the research will be carried out in the event these data sources do not materialize or are significantly delayed.

NASA policy is to make all scientific observations available to the public in a timely manner. It is required that all data, models, and simulations, will be: 1) open and accessible no later that 12 months after data are acquired; 2) will contain appropriate Space Physics Archive Search and Extract (SPASE) metadata; 3) will be documented to a level where a non-expert user can interpret and analyze the data; 4) software used to analyze the data and models should be open source, sufficiently documented, and deposited in a repository agreed to by NASA.

Models to be used or developed under HSO-Connect must be made available and archived through the Community Coordinated Modeling Center (CCMC) https://ccmc.gsfc.nasa.gov/, or WHPI (https://whpi.hao.ucar.edu), or some other archive as agreed to by NASA. Plans for archiving at the CCMC or other sites should be included in the proposal.

The HSO-Connect Proposal Information Package (PIP), found on the NSPIRES page for this program element, has more detailed information about missions and data products listed in this solicitation. Use of any of these missions and/or data with the exception of Parker Solar Probe is not a criterion of proposal evaluation.

1.5 High-End Computing (HEC) Needs

HEC computational resources are a limited resource; proposals must justify access to time on HEC machines and expertise to optimize its usage if this is a needed resource.

NASA maintains two major computing facilities – the NASA Center for Climate Simulation (NCCS) at the Goddard Space Flight Center, and the NASA Advanced Supercomputing (NAS) facility at the Ames Research Center. If the program specific data question on the use of NASA-provided HEC is answered in the affirmative, an appendix document must be provided which is discussed in Section 1(d) of the *ROSES Summary of Solicitation*.

2. Submission and Evaluation Guidelines

2.1 General Considerations

Each Principal Investigator (PI) is allowed to submit one and only one Step-1 proposal to this program element. The expectation is that the Principal Investigator (or science PI) will invest a substantial portion of their time, but no less than 30%, to the investigation. Significant involvement of the PI is key for organizing the science team throughout the course of the project. The team should plan for regular meetings, at least on an annual basis, in order to coordinate research activities. Costs for attendance at these meetings should be included in the proposal budget.

Within the proposing team, the PI and Co-Investigators (Co-Is) must each have specific and defined tasks in the project, and the tasks must be essential to the completion of the project. It is expected that one of the team members (the PI or a Co-I) will be in charge of coordinating the observations.

All proposals with non-U.S. participants must be compliant with the policies stated in the *NASA Guidebook for Proposers*, including the requirement that they must be endorsed by the respective government agency or funding/sponsoring institution for the entire period of performance for the proposed investigation. Otherwise, use of unpaid Collaborators is discouraged.

Proposals may be declared noncompliant based on either the Step-1 or Step-2 proposal if they are outside the scope of the HSO-Connect program (see Section 2.2 below) or if they fail to meet submission guidelines specified below (Section 3).

2.2 Limitations and Scope

Proposals outside the scope of the HSO-Connect opportunity include the following:

- Proposals for the same or essentially the same work submitted concurrently to other program elements in Appendix B or E, as specified in B.1 Section 1; including those with PI and Co-Is rearranged;
- Investigations that do not require PSP observations and analysis;
- Investigations that do not address any of the HSO-Connect program objectives listed in Section 1;
- Work for which the proposing organization (or investigators) are already funded by NASA. Proposals involving currently funded investigators, in particular those that are part of the PSP mission team, must include a description in a separate subsection of the scientific/technical/management section that specifies how the new proposed effort is different and not duplicative with currently supported efforts;
- Investigations that propose usage of proprietary data. For this call, the term proprietary data refers to any non-NASA observations that will not be made publicly available within twelve months of collection;
- Model or tool development where this effort constitutes more than 30% of a 3-year effort.

3. Two-Step Submission Guidelines

To provide adequate notice to potential reviewers, this program uses a two-step proposal submission process. The overall description of a two-step process can be found in Section IV(b)vii of the ROSES *Summary of Solicitation*.

3.1 Step-1 Proposal Content

A Step-1 proposal is required and must be submitted electronically by the Step-1 due date (see below and Table 2 and Table 3 of ROSES) by an organization Authorized Organizational Representative (AOR). No budget or other elements are required. Step-1 proposals will be checked for compliance, but they will not be evaluated. Only proposers who submit a Step-1 proposal and who are "invited" can submit a full (Step-2) proposal.

The Step-2 proposal title and science goals, must be the same as those in the Step-1 proposal. Step-2 investigators (Principal Investigator, Co-Investigators, Collaborators, Consultants, and Other Professionals) must be the same as those in the Step-1 proposal. The expected format and evaluation criteria are described below. Submission of the Step-1 proposal does not obligate the offerors to submit a Step-2 proposal later.

3.1.1 *Step-1 Proposal Content and Format*

Proposers should refer to the "Instructions for Submitting a Step-1 Proposal" under "Other Documents" on the NSPIRES page for this program element. The Step-1 proposal is restricted to the 4000-character Proposal Summary text box on the NSPIRES web interface cover pages.

The Step-1 proposals must include the following:

- The science goals and objectives to be addressed by the proposal, including the identification as to which of the three HSO-Connect science objectives will be addressed (see Section 1.1);
- A brief, general description of planned coordinated observations that will support addressing the science goals;
- A brief description of the methodology to be used, including what models, and analysis will be used for completing the investigation.

No PDF attachment is required or permitted for Step-1 proposal submission. All information will be entered within the 4000-character Proposal Summary text box on the NSPIRES web interface cover pages. Proposers will be notified by NSPIRES whether they are invited to submit their Step-2 proposals.

3.1.2 *Step-1 Compliance*

Step-1 proposals may be declared noncompliant if they fail to meet submission guidelines or if they are outside the scope of the HSO-Connect program. PIs of noncompliant proposals will not be invited through NSPIRES to submit the associated Step-2 proposal and will receive a letter to this effect.

3.1.3 *Suggested Reviewers*

Along with the submission of Step-1 proposals, proposers are strongly encouraged to provide names and contact information of up to five experts qualified to review their proposal. These experts must not be from the institutions of the PI or Co-Is. This information can be supplied in response to the cover page question associated with the Step-1 proposal.

3.2 Step-2 Proposals

A Step-2 (full) proposal must be submitted electronically by the Step-2 due date (see Tables 2 and 3 of ROSES). The Step-2 proposal must be submitted via NSPIRES by the organization Authorized Organizational Representative (AOR). A budget and other specified information is required. The Step-2 proposal title and science goals, must be the same as those in the Step-1 proposal. Step-2 investigators (Principal Investigator, Co-Investigators, Collaborators, Consultants, and Other Professionals) must be the same as those in the Step-1 proposal. Proposers must have submitted a Step-1 proposal and have been invited to submit a Step-2 proposal. Proposers that received a noncompliant letter are not eligible to submit a Step-2 proposal.

The process for preparation and submission of the Step-2 (full) proposals is the same for any other ROSES proposal. Instructions for the formatting and content of ROSES proposals are given in the *ROSES Summary of Solicitation* and, for topics not addressed there, refer to the *NASA Guidebook for Proposers*. Proposers must follow these instructions, except where they are overridden by the instructions given in the Heliophysics Research Program Overview (B.1) or in this program element.

3.3 Step-2 Proposal Content

Proposals are restricted to twenty (20) pages for the Scientific/Technical/Management section and must include the following sections with the preferred order:

- Identification of science objectives. This includes the identification as to which of the overarching HSO-Connect program objectives will be addressed; the specific science question(s) under the chosen science objective to be addressed; the perceived impact of the proposed work to the state of knowledge in the field; references to existing work in the field should be limited to that which is needed to justify the value of the science proposed;
- An implementation plan for coordinated observations and the rationale as to how they would support addressing the proposed science questions;
- The methodologies to be employed in conducting the proposed research; the proposal must demonstrate (1) that the data are appropriate to address the science objectives, and (2) that the methodologies employed are both appropriate and feasible to make substantial progress on the science objectives;
- A general plan of work, the management structure for the proposal personnel, and a description of the expected contribution to the proposed effort by the PI and each person as identified in the proposal, whether or not they derive support from the proposed budget. Postdoctoral fellows and students need not be named.

3.4 Step-2 Compliance and Evaluation Criteria

3.4.1 *Step-2 Compliance*

Non-compliant Step-2 proposals will be returned without review. Step-2 proposals may be declared noncompliant if:

- The title has changed from that of their Step-1 proposal,

- Investigators have been changed from that of the Step-1 proposal,
- The science scope/goals have changed from that of their Step-1 proposal,
- Proposals with the same (or essentially the same) team and objectives as a full (Step-2) proposal submitted to another Heliophysics program.

Step-2 proposals that are not compliant with formatting requirements (e.g., margins, font sizes, line spacing) may be rejected without review. See Section IV(b)ii of the *ROSES Summary of Solicitation* and the *NASA Guidebook for Proposers* for details.

3.4.2 *Evaluation Criteria*

Compliant proposals will be evaluated according to the criteria specified in the *NASA Guidebook for Proposers*. These criteria are intrinsic scientific and technical merit, relevance to NASA's objectives, and cost realism/reasonableness.

The evaluation of scientific and technical merit will include the following:

- Compelling nature and scientific priority of the proposed investigation's science goals and objectives, including the importance of the problem to the field of Heliophysics; the unique value of the investigation to make scientific progress in the context of current understanding, and the importance of carrying out the investigation now.
- Appropriateness and feasibility of the methodology, including the appropriateness of the selected data, models, and analysis for completing the investigation and the feasibility of the methodology for ensuring scientific success.

Based on the applicable two factors listed above, the evaluation will consider the overall potential science impact and probable success of the investigation.

Relevance to and priority within the HSO-Connect program will be assessed vs. the topics discussed in Section 1.1. Each proposal must demonstrate that the investigation is relevant and of high priority.

Cost reasonableness includes assessing the amount of work to be accomplished versus the amount of time proposed. Open-ended proposals or those with a large number of science questions to be addressed typically do not fare well in this evaluation. Only necessary Co-Investigators and Collaborators should be included, and their specific tasks and roles in the investigation must be clearly laid out in the proposal work plan.

3.4.3 *Limited Risk Waiver*

Generally, proposals that rely on future data are non-compliant or are given major weaknesses for high-risk. However, to enhance the science return from the Heliophysics System Observatory via coordinated observations, the risks inherent to dependency on future observations is waived for this call. This includes dependency on the occurrence of space weather conditions such as flares, coronal mass ejections, or solar energetic particle events. While the review will evaluate the soundness of the proposed plan for coordinated observations, proposals will not be given weaknesses because of the risk of inadequate future observations, or possible absence thereof, as long as reasonable assumptions of their availability are made. As noted in Section 1.4, a contingency plan must be presented to address how the research will be carried out in the event these data sources do not materialize or are significantly delayed.

4. Available Funds

It is expected that there will be approximately ~$2.3M available in Year One to support new Heliophysics HSO-Connect investigations selected through this program element. Due to the scope and complexity, annual funding is expected to fall into the ~$500K-$800K range per investigation.

5. Award Types

The HSO-Connect program will award funds through three vehicles: (1) grants, (2) interagency transfers, and (3) awards to NASA Centers. The HSO-Connect program will not award contracts.

6. Summary Table of Key Information

Expected program budget for first year of new awards	~$2.3M
Number of new awards pending adequate proposals of merit	3-4
Maximum duration of awards	3 years
Due date for Step-1 proposal	See Tables 2 and 3 of this ROSES NRA
Due date for full Step-2 proposals	See Tables 2 and 3 of this ROSES NRA
Planning date for start of investigation	6 months after full proposal due date.
Page limit for the central Science-Technical-Management section of full proposal	20 pp; see also Table 1 of the *ROSES Summary of Solicitation* and Section 3.7 of the *NASA Guidebook for Proposers*
Relevance	This program is relevant to the Heliophysics questions and goals in the NASA Science Plan. Proposals that are relevant to this program are, by definition, relevant to NASA.
General information and overview of this solicitation	See the *ROSES Summary of Solicitation*.
Detailed instructions for the preparation and submission of proposals	Please see *ROSES Summary of Solicitation* Section I(g) Order of Precedence and the *NASA Guidebook for Proposers*.
Submission medium	Electronic proposal submission is required; no hard copy is permitted.
Web site for submission of Step-1 and Step-2 proposal via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Web site for submission of Step 1 and Step-2 proposal via Grants.gov	http://grants.gov (help desk available at support@grants.gov or (800) 518-4726)
Funding opportunity number for downloading an application package from Grants.gov	NNH19ZDA001N-HSOC

Point of contact concerning this program	Arik Posner Heliophysics Division Science Mission Directorate NASA Headquarters Washington, DC 20546-0001 Telephone: (202) 358 0727 Email: arik.posner@nasa.gov

APPENDIX C. PLANETARY SCIENCE RESEARCH PROGRAM

C.1 PLANETARY SCIENCE RESEARCH PROGRAM OVERVIEW

Table of Contents

1. Introduction

The Planetary Science Research Program supports investigations to help ascertain the content, origin, and evolution of the Solar System and the potential for life elsewhere, consistent with the strategy for Planetary Science Exploration embodied in the 2014 NASA Science Plan. The Planetary Science Research portfolio contains specific program elements aimed at addressing these strategic objectives.

1.1 Changes from Recent Years

This Planetary Science Research Overview has been substantially revised in recent years. Proposers who have not submitted recently are encouraged to read C.1 in its entirety. Several recent changes to program element C.1 are:

- Section 3.1 includes a revised description regarding the prohibition of duplicate proposals.
- Section 3.6.1 includes updated information regarding Data Management Plans (DMPs). Information pertaining to the following has been added: (1) the inclusion of physical astromaterial and biomaterial samples; (2) software/code; and (3) a revised method for DMP submission, as part of the main proposal.
- Program elements supporting the publication of geologic maps have been clarified in Section 3.8.
- Information pertaining to Planetary Major Equipment and Facilities (C.17), Early Career Fellowships and Awards (C.18 and C.19), and Topical Workshops, Symposia, and Conferences (E.2) has been added to program element C.1.
- The Habitable Worlds program is a Cross-Divisional program with the Astrophysics and Heliophysics Divisions (see program element E.4).
- No contracts will be issued in response to proposals submitted to any program elements in Appendix C, unless otherwise noted in the individual program elements.

1.2 Program Elements Covered by this Overview

This document pertains to all of the program elements in Appendix C of ROSES, as well as the cross-divisional research program element E.4 Habitable Worlds, but not E.3 the Exoplanet Research Program.

2. Proposal Submission Processes

Program elements covered by C.1, Planetary Overview, use a variety of submission methods: sometimes nothing is requested or required in advance of the full proposal submission, sometimes a notice of intent (NOI) is requested, sometimes an NOI or a Step-1 proposal is required for subsequent proposal submission. See below and sections IV(b)vi-viii of the ROSES *Summary of Solicitation* for more information. Of course, the submission method being used will be clearly stated in the text of the program element, but it is also indicated in Tables 2 and 3 (the tables of due dates) as follows: If a program element does not request NOIs then "N/A" will appear in the NOI/Step-1 due date column. If a program element merely requests an NOI then a date will appear in that column. If a program element requires an NOI then "(mandatory)" will appear below the due date and, finally, If a program element requires a Step-1 proposal then "(Step-1)" will appear below the due date in the NOI/Step-1 due date column in Tables 2 and 3.

2.1 NOI submission process

An NOI is a brief plain text summary of what the proposer intends to submit and may be submitted without endorsement from or action by the Authorized Organizational Representative (AOR). For more information see Section IV(b)vi of the ROSES *Summary of Solicitation* and the how to Create and Submit NOI tutorial on the NSPIRES web page at https://nspires.nasaprs.com/tutorials/index.html. As noted above, sometimes the submission of an NOI is mandatory. Note that NOIs cannot be submitted via Grants.gov, even if the proposal will ultimately be submitted via that system.

2.2 Two-step submission process

To facilitate the early recruitment of a conflict-free review panel and ensure that proposals are submitted to the appropriate program, many program elements covered by program element C.1 will use a two-step proposal submission process (see Section IV. (b) vii of the ROSES *Summary of Solicitation*). For program elements using the two-step process, a Step-1 proposal is required and must be submitted electronically by an AOR prior to the separate Step-1 deadline. No budget is required. Only proposers who submit a Step-1 proposal are eligible to submit a full, Step-2 proposal. Such Step-2 proposals must address the same broad scientific goals proposed in the Step-1 proposal. The PI cannot be changed and proposers who want to add funded investigators between the Step-1 and Step-2 proposals must inform the point(s) of contact identified in the summary table of key information and cc sara@nasa.gov at least two weeks in advance of the Step-2 due date. Additions of funded investigators within two weeks of the Step-2 deadline require explicit permission from the NASA point of contact. Submission of a Step-1 proposal does not obligate the proposer to submit a Step-2 (full) proposal later.

The Scientific/Technical/Management section of a Step-1 proposal is restricted to the 4000-character text box on the NSPIRES web interface cover pages, unless otherwise noted in the program element (e.g., C.17, PMEF). PDF attachments will not be accepted through NSPIRES for Step-1 proposals submitted to most program elements covered by program element C.1.

A Step-1 proposal must cover the following topics:

- The goals and objectives of the proposed work;
- The approach and methodology to be used to address the goals and/or objectives; and
- The reasons why the work proposed is within the scope of the program element, and why this program element is the most appropriate for the work proposed.

Following the submission of a Step-1 proposal, most proposers will be notified through NSPIRES whether the Step-1 proposal has been designated as "encouraged" or "discouraged," at which point the proposer will be able to create a Step-2 proposal. No evaluation of intrinsic merit will be performed on Step-1 proposals. The perceived relevance of the proposed work to the particular program element will be the main factor in deciding whether submission of a Step-2 proposal will be encouraged. Please note that the Step-2 proposal relevance evaluation is independent of the Step-1 evaluation.

In rare cases, for example, when the Step-1 proposal is not compliant with the requirements outlined above, or the proposed work cannot be funded because of NASA, SMD, or Planetary Science Division (PSD) policy, a Step-1 proposal may be declined by the selection official. In such a case, a Step-2 proposal cannot be submitted.

2.3 Direct submission process

As mentioned above, some program elements do not accept NOIs or Step-1 proposals. In these cases, AORs simply submit the (full) proposal by to the published deadline. See Section 2.4 for additional requirements for a full proposal.

2.4 Full or Step-2 Proposal submission process

"Full" and "Step-2" proposals are synonymous, meaning the real proposal that is peer reviewed, with the term "Step-2" mainly used in program elements that use the two-step submission process.

Table 1 of the NASA ROSES *Summary of Solicitation* provides a checklist of required information to be included in full proposals. Proposers may also refer to the PDF entitled "Instructions for Submitting a Step-2 Proposal" that appears under "Other Documents" on the NSPIRES page for the program of interest.

All proposals submitted to ROSES must strictly conform to the instructions regarding proposal format and content. Non-compliance will be taken into consideration, either before or during the selection process. In particular, any detected violation of these rules determined by the selecting official to give the proposer an advantage over competing proposers is grounds for the proposal to be rejected without review or declined following review.

Note that the order of precedence guidelines, described in Section I(g) of the ROSES *Summary of Solicitation*, *NASA Guidebook,* and ROSES instructions, may be superseded or modified by this document (program element C.1) for all covered program elements, and that each individual program element may have its own rules that supersede all of the above.

In previous years, problems with the following aspects of proposal formatting have been noted. Planetary Science proposals must adhere to the following formatting rules, as outlined in Section IV(b)ii of the ROSES *Summary of Solicitation*:

- Length of the Scientific/Technical/Management section: 15 pages, unless otherwise specified in the program element.
- Margins: 1 inch on all sides, with a page size of 8.5 × 11 inches.
- Font: 12-point or larger. The selected font must meet the requirement of having, on average, no more than 15 characters per inch (e.g., Times New Roman and Arial). Proposers may not adjust the character spacing or otherwise condense a font from its default appearance.
- Line spacing: Font and line spacing settings must produce text that contains no more than 5.5 lines per inch. Proposers may not adjust line spacing settings for a selected font below single spaced.
- Figure captions*:* Captions must follow the same font and spacing rules as the main text*.*
- Figures and tables: For text within figures and tables, font and spacing rules listed above do not apply, but all text must be judged to be legible to reviewers without magnification above 100%. Expository text necessary for the proposal may not be located solely in figures or tables, or their captions.

3. Requirements for Full Proposals

3.1 Prohibition on Duplicate Proposals

Proposers may not submit full proposals for the same, or essentially the same, work to more than one program element covered by program element C.1 concurrently. This prohibition is active for a particular submitted proposal until the PI is notified through NSPIRES that the proposal was declined or until the proposal is withdrawn. The prohibition on duplicate proposals applies across ROSES years as well (e.g., a duplicate of a pending ROSES-2018 proposal may not be submitted in response to ROSES-2019). If a second proposal is submitted while a duplicate proposal is still pending in another program element, only the first proposal will be evaluated; the duplicate proposal may not be evaluated or considered and may be returned without review.

If a second proposal contains substantive changes in areas that are critical to the intrinsic merit evaluation, such as the goals, objectives, or methodology, then it is not considered to be a duplicate proposal.

Changes to a proposal that would fall outside of the merit evaluation are not considered substantive, and two proposals with only changes in these areas may be considered duplicates. Examples of proposal sections not considered in merit evaluation include:

- Current and pending support section;
- Relevance statement;
- Budget section; and

- Data management plan.

In addition, minor changes to aspects of a proposal covered by the merit evaluation (team, concepts, implementation, target, etc.) may not be considered substantive.

If it is unclear if changes to a proposal are substantial enough for that proposal to not be considered a duplicate proposal, or it is unclear to which program a proposal should be submitted, proposers should contact the point of contact for the program element most likely to be appropriate for the proposal, before the NOI or Step-1 proposal deadline.

3.2 Restriction on Funding for Mission-Related Activities

The Planetary Science R&A programs are not intended to augment mission project budgets or to provide additional support for mission scientists to carry out activities within the scope of a mission. These programs are also not intended to provide support for expansion of mission teams (with the exception of participating scientist/guest investigator programs). If the proposal team contains individuals associated with a mission team (regardless of their role[s] on the proposal or on the mission) the proposal must demonstrate that the proposed work is not being used for the above purposes. This applies during all phases of the mission (A through F), unless otherwise specified in the program element. This demonstration should be included in the Scientific/Technical/Management section.

Regardless of whether any members of the proposal team are affiliated with a relevant mission, proposals will be evaluated for the degree of overlap with mission activities. Proposals for work close in scope to a mission's activities may be declined for programmatic reasons.

3.3 Award Durations and Types

The typical award duration is three years. Proposals for less than three years are encouraged for projects that can be completed on shorter timescales. For those program elements that permit longer awards, funding for more than three years must be explicitly justified in the proposal, i.e., to allow the completion of individual tasks that require more than three years. In these cases, the proposal must contain a discussion of why it is impractical or impossible to complete such tasks within three years.

Note that no contracts will be issued for awards made under the program elements covered by program element C.1 unless otherwise noted in the individual program element.

3.4 Use of Mission Data

Spacecraft mission data to be used in proposed work must be available in the Planetary Data System (PDS) or an equivalent, publicly accessible archive at least 30 days prior to the full proposal due date, unless otherwise specified in the program call.

3.5 Discussion of Relevance

All proposals will be evaluated for relevance to the individual program element to which the proposal has been submitted (see Section VI (a) of the ROSES *Summary of Solicitation*).

Some program elements covered by program element C.1 require an explicit relevance statement be placed into a mandatory (4000-character) text box on the cover pages via the NSPIRES web interface. For those program elements that require it, this required relevance text is outside of the 15-page Scientific/Technical/Management section and the relocation of the relevance discussion does not decrease that 15-page limit. This requirement supersedes the default in the *NASA Guidebook for Proposers* and the ROSES *Summary of Solicitation*. For these calls, the omission of a relevance statement on the cover pages is sufficient reason for a proposal to be returned without review.

Whether or not an explicit statement of relevance is required, all proposals will be evaluated for their relevance to the program element to which they have been submitted. Proposers are urged to consult the program element to which they are proposing for detailed information, and to check if an explicit relevance statement is required and/or how relevance will be evaluated.

3.6 Data Management Plans and Archiving

3.6.1 Data Management Plans

To broaden access to the results of NASA-funded research, proposals submitted to ROSES must include a data management plan (DMP). The guiding philosophy behind this requirement is that all relevant data should be made publicly available (i.e., without fee or restriction of use) at the time of publication, or at the earliest practical time thereafter, through a stable and long-term supported data repository.

Individual program elements may provide instructions that supersede and/or amplify the requirements described here. For example, the Planetary Data Archiving, Restoration and Tools (PDART, program element C.4) program element includes the data management discussion in the body of the proposal. The instrument development, Early Career Award and Planetary Major Equipment calls (program elements C.12 PICASSO, C.13 MatISSE, C.17 PMEF, C.18 ECF Start-up, C.19 ECA, C.20 DALI, and C.21 LunaTech) do not require DMPs. However, even for those programs, if those awards result in datasets and peer-reviewed publications, the requirements (laid out here and in the ROSES *Summary of Solicitation*) regarding public release still apply.

Proposers requiring a DMP are strongly encouraged to use the PSD DMP template, which may be downloaded as a Word document, or a LaTeX template in the form of a .txt file, from the SARA web page at: https://science.nasa.gov/templates-planetary-science-division-appendix-c-roses-proposals.

DMPs must be placed in a special section of the proposal, entitled "Data Management Plan." All proposals to program elements that require DMPs must contain this section. The DMP may not exceed two pages in length, and should immediately follow the references and citations for the Scientific/Technical/Management (S/T/M) portion of the proposal. The two-page DMP section does not count against the 15-page limit of the S/T/M section. Formatting requirements for DMPs are the same as for the S/T/M section. When appropriate or required, letters of support from data archives (e.g., Section 3.6.2 of this document) must be included in a Statements of Commitment and Letters of Support, Feasibility and Endorsement section of the proposal (see ROSES *Summary of Solicitation*, Table 1).

The DMP must cover any data needed to validate the scientific conclusions of peer-reviewed publications, particularly data underlying figures, maps, and tables.

The DMP should also cover any other data and software that would enable future research or the replication/reproduction of published results. Software, whether a stand-alone program, an enhancement to existing code, or a module that interfaces with existing codes, created as part of a NASA award should be made publicly available when it is practical and feasible to do so, and when there is scientific utility in doing so. Stand-alone code that is not straightforward to implement, or whose utility is significantly outweighed by the costs to share it, is not expected to be made available. NASA expects that the source code, with associated documentation sufficient to enable use of the code, will be made publicly available via GitHub (https://github.com/NASA-Planetary-Science), the PDS (for mission-specific code, when appropriate), or an appropriate community-recognized depository (for instance, the homepage of the code base for which a module was developed). Archiving software in a public repository does not require the proposer to maintain the code. Awards that derive from proposals that include plans to post code in GitHub will contain a Rights in Data clause reflecting this expectation.

The DMP should also cover any physical materials that are planned to be collected, purchased, or produced during the course of the research. These include astromaterials such as meteorites, micrometeorites, and cosmic dust; for astrobiology research, this would include biomaterials produced, analog materials collected or synthesized, or analytical standards developed. The DMP should demonstrate that any such materials with scientific value that are not consumed during the proposed research will be made publicly available. Proposers are also encouraged, but not required, to discuss how other physical materials collected, purchased, or synthesized during the planned research would be made publicly available when it is practical and feasible to do so, and when there is scientific utility in doing so.

For proposals that use non-mission data (e.g., laboratory results, Earth-based observations) that are not publicly available (in the PDS or other archive, in the literature, etc.), the project is expected to make the data available following the Data Management Plan guidelines.

"Data" does not include preliminary and other unpublished data, data in prepublication documents, private communications, or certain other types of information that have been specifically exempted from the DMP requirement.

In the case of a project that would produce no data, as defined above, or only data specifically exempted, the DMP should state that no data preservation or data sharing is needed, but must also explain why. In a case where no appropriate archive exists for a particular data set, the DMP should discuss alternative methods for making the data publicly available.

The DMP must contain the following elements, as appropriate to the project, in adequate detail for review:

- A description of data types, volume, formats, and (where relevant) standards;
- A description of the schedule for data archiving and sharing;

- A description of the intended repositories for archived data, including mechanisms for public access and distribution;
- A discussion of how the plan enables long-term preservation of data;
- A discussion of roles and responsibilities of team members in accomplishing the DMP. (If funds are required for data management activities, these should be covered in the normal budget and budget justification sections of the proposal.)

DMPs will be reviewed as part of the overall NASA research proposal review process. Proposals that do not address each of these items in their DMP, even if determined to be selected or selectable for funding, may not be funded until an adequate DMP is submitted. Funded researchers, research institutions, and NASA centers are responsible for ensuring and demonstrating compliance with the DMPs approved as part of their awards. Awardees who do not fulfill the intent of their DMPs may have continuing funds withheld and this may be considered in the evaluation of future proposals.

For more information on DMPs, please see the Planetary Science Division Frequently Asked Questions (FAQs) on Data Management Plans in ROSES, which will appear under "Other Documents" on the NSPIRES webpage for the Planetary Science Division program elements.

3.6.2 Data Archiving in the Planetary Data System (PDS)

For proposals where derived data products will be deposited in the Planetary Data System, these data products must be in PDS4 format. Guidelines for planning for the submission data in this format to the PDS are available at http://pds.nasa.gov/pds4.

Proposers intending to make use of the PDS should refer to the most recent version of the following documents for information on PDS compliance:

- Proposer's Archive Guide: https://pds.nasa.gov/home/proposers/proposing-programs.shtml
- Standards Reference: https://pds.nasa.gov/datastandards/documents

Proposers should communicate with the PDS Discipline Node responsible for curating similar data (links to the PDS Discipline Nodes are at http://pds.nasa.gov/) to discuss procedures and requirements prior to proposing to a Planetary Science Division ROSES program element. Proposers intending to archive data or products in the PDS must obtain and include confirmation, in the form of a letter of support from the appropriate Discipline Node, that the PDS is willing to accept their submission. This letter must be included in the proposal package and placed in a section for Statements of Commitment and Letters of Support, Feasibility and Endorsement (see ROSES *Summary of Solicitation*, Table 1).

3.7 Table of Personnel and Work Effort

All proposals must include a Table of Personnel and Work Effort. If the program element allows contracts, and it is anticipated by the proposer that the proposal will result in a contract, this table must be within the budget narrative section. All other proposals should include this table as a separate section before the Budget Justification section, and follow the instructions presented here.

Proposers are strongly encouraged to use the PSD Table of Personnel and Work Effort template, which may be downloaded as a Word document, a LaTeX template, or a pdf from the SARA web page at https://science.nasa.gov/templates-planetary-science-division-appendix-c-roses-proposals.

The Table of Personnel and Work Effort should list the names (if known) and titles of every person who will do work on the proposal, regardless of whether that person would receive money, and regardless of their role on the project. It should cover all personnel, including those covered by any sub-awards, sub-contracts, or who work at any NASA center or federal agency that may receive money separately from the main award. The table must have entries covering each proposed award year (do not provide a separate table divided by federal fiscal years), and should distinguish between the effort to be funded by NASA and non-funded efforts. All work efforts listed in the table should be made in fractions of a work-year.

Note that this section may not contain any narrative description of tasks to be performed by proposal personnel; such information should be placed in the 15-page Scientific/Technical/ Management section of the proposal.

3.8 Publication of Geologic Maps

Geologic mapping is an investigative process designed to go beyond standard image analyses to determine the geologic history of a region of interest, whether it is local, regional, or global. Thus, geologic maps are key tools to aid in identification of this geologic history. Below are some guidelines about where to propose geologic mapping investigations.

3.8.1 Program Elements Supporting Geologic Mapping

If a geologic map would be created as part of a hypothesis-driven science investigation (i.e., to address specific scientific objectives or questions about a region of interest), and uses data from planetary missions identified in a Data Analysis Program (DAP), then the proposal should be submitted to the appropriate DAP. For example:

- Pluto and Charon maps: New Frontiers DAP (program element C.7);
- Lunar maps: Lunar DAP (program element C.8);
- Mars maps: Mars DAP (program element C.9);
- Cassini-based Saturnian satellite maps: Cassini DAP (program element C.10);
- Dawn-based Vesta or Ceres maps: Discovery DAP (program element C.11); and
- MESSENGER-based Mercury maps: Discovery DAP (program element C.11).

If a geologic map would be created as part of a hypothesis-driven science investigation using data from missions not covered by a current DAP (e.g., Venus missions), or as part of a comparative planetology science investigation not responsive to a single DAP, then the proposal should be submitted to whichever of the non-DAP research program elements the proposal is most relevant (e.g., Solar System Workings, Emerging Worlds, Habitable Worlds).

If a geologic map would be created without an accompanying hypothesis-driven science investigation, then the mapping proposal should be submitted to PDART (program element C.4).

3.8.2 Maps Published by the U.S. Geological Survey

Proposals that include the publication of a Scientific Investigations Map (SIM) by the U.S. Geological Survey (USGS) should check the relevant box on the proposal cover page and clearly indicate this intention in the Proposal Summary, as well as in the text of the proposal. Investigators who choose to produce a geologic map as a USGS product will be required to follow current guidelines for the production and submission of digital products, including the generation of maps that are compatible with Geographic Information System (GIS) software packages for review, edit, and publication. To support this requirement, the USGS will provide a GIS project that contains the projected, geographically rectified, and scaled mapping base or mosaic, as well as other relevant global- or regional-scale data sets (if available and needed). Investigators selected to publish USGS geologic maps will be expected to (1) provide peer reviews for two geologic maps generated by other planetary mappers during their grant period, and (2) attend the annual Planetary Geologic Mappers Meeting to present their map status to the mapping community and receive updates on current guidelines. Proposers should include travel funding to attend the Planetary Geologic Mappers Meeting, justifiable because of NASA requirements. Further information pertaining to the production of USGS geologic maps (e.g., map bases, scales, extents, formats, guidelines) is available at http://planetarymapping.wr.usgs.gov/, or by contacting Jim Skinner at the USGS (jskinner@usgs.gov).

Investigators who intend to produce a USGS geologic map are required to include a Confirmation of Technical Specification document, obtained from the USGS Map Coordinator, in their Step-2 (full) proposal. This document should identify the (1) latitude/longitude boundaries of the map region, (2) scale of the proposed map, (3) required base map, (4) projection of the base map, and (5) key supplemental data. This document is only a confirmation and does not fulfill any requirement that the mapping effort be described and justified within the 15-page body of the proposal. Selection of a proposal for funding is contingent upon the inclusion of this document. Investigators are encouraged to contact the USGS early in the proposal preparation process. For the USGS Map Coordinator's contact information, please refer to http://planetarymapping.wr.usgs.gov/Page/view/Contacts.

3.9 Access to the Antarctic

Unless otherwise stated in a program element, Appendix C is no longer accepting proposals for work in Antarctica.

3.10 Additional Funding for Relevant Instrumentation Construction or Upgrade

The Planetary Major Equipment and Facilities (PMEF) program element (C.17) allows proposals for upgrading the analytical, computational, telescopic, and other instrumentation required by investigations for certain program elements sponsored by the Planetary Science Division Research and Analysis Program. All new analytical instrumentation requests, as well as requests for upgrades to existing instruments, costing more than $50,000 must be requested according to the PMEF guidelines in C.17. Two types of instrumentation requests are permitted: (1) a PMEF request may be made as a special section that is appended to a new research proposal in an eligible program element; or (2) a stand-alone PMEF proposal may be prepared and submitted to a special PMEF proposal deadline. All requests for facility instruments must now be of the second type. See C.17 for details on how to prepare both types of PMEF requests. Program elements eligible for PMEF are listed in C.17.

3.11 Planetary Science Division Early Career Fellowship Program

The purpose of the Planetary Science Division (PSD) Early Career programs (described in program elements C.18 and C.19) is to support the development of the individual research programs of outstanding scientists early in their careers and to stimulate research careers in the areas supported by PSD. They support future leaders of the PSD community, not only for high impact science and technologies, but also for service to the community.

Those who were already named Early Career Fellows in prior years may submit proposals for start-up funds in response to program element C.18, Early Career Fellowship Start-Up Program for Named Fellows. For those who have not already been named fellows, information on how to apply for the new early career award may be found in program element C.19, Planetary Science Early Career Award Program.

3.12 Topical Workshops

All proposals for topical conferences, workshops, or symposia related to the Planetary Science Division Research and Analysis Program must be submitted in response to program element E.2, Topical Workshops, Symposia, and Conferences, of this NRA. Proposers to E.2 should specifically identify the PSD research program element to which the conference, workshop, or symposium is most closely related, and refer to the goals and objectives of that program element in demonstrating relevance.

4. Resources Available to Proposers

4.1 Data and Information Resources

4.1.1 The Planetary Data System (PDS)

The Planetary Data System (PDS) archives and distributes scientific data from NASA planetary missions, astronomical observations, and laboratory measurements. The archives can be found through the PDS home page: http://pds.nasa.gov/. PDS is supported by six science discipline nodes (Atmospheres, Geosciences, Imaging, Planetary Plasma Interactions, Rings, and Small Bodies) distributed around the U.S. Each node houses data from NASA's planetary missions, and documentation necessary to use those data. Data searches and requests can be initiated from the PDS home page or at any of the science discipline node pages accessible there. Guides and tools for using data, preparing an archive, and archiving data can be found at http://pds.nasa.gov/tools/. Contact the PDS Operator (pds_operator@jpl.nasa.gov) or the appropriate node's point-of-contact for assistance.

4.1.2 The National Space Science Data Center (NSSDC)

The NSSDC archives digital and other data from historic and completed flight missions, and its archives are complementary to those of the PDS. NSSDC data include lunar and planetary photographs, digital planetary images, tabular and experiment data from numerous flight missions, and cartographic products. Investigators are responsible for acquiring the data needed for their proposal. Modest requests for data are free of charge, although charges will be incurred for large-volume requests. Requests from U.S. investigators for data products and information may be made through the Coordinated Request and User Support Office at the NSSDC (nssdc-request@lists.nasa.gov). For more information, see http://nssdc.gsfc.nasa.gov/nssdc/obtaining_data.html.

4.1.3 The Lunar and Planetary Institute (LPI)

LPI provides one of the most concentrated and easily accessible collections of data and other information in lunar and planetary science, including extensive digital map and imagery collections, computational tools for the lunar community, and a vast collection of educational products and resources. These resources, along with an extensive range of electronic tools to enhance science activities and effective communication within the planetary science community, can be found on the LPI's website: http://www.lpi.usra.edu.

4.1.4 Regional Planetary Image Facilities (RPIFs)

RPIFs contain nearly half a million images of the planets, and their satellites, taken from Earth and from crewed and uncrewed spacecraft. RPIFs also contain topographic and geologic maps produced from these images. The RPIFs, located at institutions worldwide, are intended for use by individuals and groups who use photographic and cartographic materials of the planets and satellites in their research programs. These programs include geologic, photometric, colorimetric, photogrammetric, and atmospheric dynamical studies. Send inquiries to the director of the nearest RPIF. Note that although these centers may be used for onsite study and selection of planetary and satellite images, they are not facilities for the production of photographs for users. Instead, such materials may be obtained from the NSSDC (see above). Additional information, including a list of RPIF locations worldwide, can be found on the RPIF home page: http://www.lpi.usra.edu/library/RPIF.

4.1.5 Planetary Cartography Program

NASA has a long-term agreement with the USGS to provide a variety of cartographic support functions for NASA researchers through its Planetary Cartography Program. This support includes:

- Integrated Software for Imagers and Spectrometers (ISIS, http://isis.astrogeology.usgs.gov/);
- Search capability for raw planetary image data (PILOT, http://pilot.wr.usgs.gov);
- On-demand production of higher-level data products (Map Projection On the Web, http://astrocloud.wr.usgs.gov/, and Map-A-Planet, http://www.mapaplanet.org/);
- Coordination of IAU approval of nomenclature http://planetarynames.wr.usgs.gov/;
- Training in planetary GIS methods (MRCTR GIS Lab, http://astrogeology.usgs.gov/facilities/mrctr);

- Training in the generation of topographic data from stereo images (Photogrammetry Guest Facility, http://astrogeology.usgs.gov/facilities/photogrammetry-guest-facility).

For cartography support beyond what is provided by the Planetary Cartography Program, the USGS is willing to join proposal teams to produce or assist in the production of specific cartographic tools or products. However, the USGS is required to recoup the full cost of such activities in the proposal budget. Visit http://astrogeology.usgs.gov/ or email laz@usgs.gov for further information.

4.2 Astromaterials

NASA's Astromaterials Acquisition and Curation Office at the NASA Johnson Space Center provides access to all NASA-controlled samples of astromaterials, including those returned by the Apollo program and the Genesis and Stardust missions, a subset of particles returned by the Japan Aerospace Exploration Agency (JAXA) Hayabusa mission, interplanetary dust particles collected by high-altitude aircraft, meteorites collected in Antarctica by U.S. field parties, and a variety of space-flown microparticle impact collectors. Peer review of sample requests are provided by the Curation and Analysis Planning Team for Extraterrestrial Materials (CAPTEM). For information on how to obtain any of the specimens in these collections, see http://curator.jsc.nasa.gov/ or contact:

Office of the Curator
Code KT
Johnson Space Center
National Aeronautics and Space Administration
Houston, TX 77058-3696

4.3 Research Facilities

The following facilities are available to supported investigators. If their use is anticipated, this use must be discussed and justified in the submitted proposals (especially note the provision for such discussion in the proposal section entitled Facilities and Equipment). Also note, per the directions in the *NASA Guidebook for Proposers*, that a letter of support may be required from any facility required for the proposed effort that is not under the direct control of the proposing team.

4.3.1 NASA-provided High-End Computational (HEC) Facilities

Those investigators whose research requires high-performance computing should refer to the *Summary of Solicitation*, Section I(d), "NASA-provided High-End Computing Resources." This section describes the opportunity for successful proposers to ROSES to apply for computing time on either of two NASA computing facilities, i.e., at the NASA Goddard Space Flight Center's (GSFC's) Computational and Information Sciences and Technology Office, or at the NASA Ames Research Center's (ARC's) Advanced Supercomputing Division. Proposers needing access to these facilities should follow the instructions in Section I(d) of the ROSES *Summary of Solicitation*. Further information on computing capabilities may be found at the NASA High-End Computing website: http://www.hec.nasa.gov/.

4.3.2 Planetary Aeolian Facility (PAL)

The Planetary Aeolian Facility at the NASA Ames Research Center consists of wind tunnels that can be used to simulate atmosphere-surface interactions on Earth, Mars and Titan. For more information, contact David Williams (David.Williams@asu.edu) or consult the PAL Guidebook for Proposers at: https://rpif.asu.edu/documents/PAL_Proposers_Guidebook_2019_v7.pdf.

4.3.3 Reflectance Experiment Laboratory (RELAB)

The RELAB facility at Brown University provides a mechanism for researchers to obtain high-quality laboratory spectra of natural or synthetic materials for use in compositional, geologic, and remote sensing applications. RELAB is partially supported by NASA as a multiuser spectroscopy facility, and researchers are invited, but not required, to visit the laboratory in person during sample measurements. Laboratory time and most sample measurements are made available at no charge to investigators funded by NASA. If a proposal to NASA requires acquisition of new spectra via RELAB in the VIS/NIR or mid-IR, then the scope and justification must be provided in the submitted proposal. Data acquired as part of NASA-funded research are made available to the investigator immediately after measurement and are made publicly available three years after measurement. Additional information about this facility, a RELAB user's manual, sample submittal forms, and access to RELAB spectroscopy data can be found at http://www.planetary.brown.edu/relab/. For further information, contact the Science Manager of RELAB, Ralph Milliken (Ralph_Milliken@brown.edu) or the Operations Manager, Takahiro Hiroi (Takahiro_Hiroi@brown.edu).

4.3.4 NASA Ames Vertical Gun Range (AVGR)

The NASA AVGR is a national facility funded by the NASA Science Mission Directorate to enable investigations of impact phenomena and processes. Exploratory or proof-of-concept programs requiring a limited number of experiments can be accommodated at no cost. More extensive programs are subject to review, to assess feasibility and cost effectiveness. Any need for extensive use of the AVGR should be explicitly described in the proposal. The proposal budget should include an estimate of usage costs. A letter of support from the AVGR is required. For more information, potential users of the AVGR should contact John Karcz (john.s.karcz@nasa.gov).

4.3.5 NASA Venus In-situ Chamber Investigations (VICI)

The NASA Venus In-situ Chamber Investigations (VICI) is a pressure chamber that enables testing of components and small instruments under temperatures and pressures that simulate Venus surface conditions. Lower temperatures and pressures can also be accommodated. Exploratory or proof-of-concept programs requiring a limited number of experiments/tests can be accommodated for minimal cost. Extensive use of the chamber should be described in the proposal and is subject to review by VICI personnel, to assess feasibility and cost effectiveness. Any use of the chamber and its corresponding costs should be included in the proposal budget. A letter of support from the VICI facility is required. For additional information, please contact Natasha Johnson (natasha.m.johnson@nasa.gov).

4.3.6 NASA Glenn Extreme Environment Rig (GEER)

The Glenn Extreme Environment Rig (GEER) is a simulation rig designed to provide an asset to the scientific and engineering communities to perform laboratory experiments and/or technology developments, or instrument/hardware qualifications, in extreme simulated environments. When fully operational, GEER can accurately simulate the temperatures, pressures, and chemistry of the atmospheres of planetary bodies, including the conditions found on the surface of Venus. The chamber is cylindrical, with an interior diameter and length of three feet and four feet, respectively. The chamber is rated for pressures up to 100 bar at 500°C. Eight individually controllable gas streams are available. Interested parties should contact Dan Vento (Daniel.M.Vento@nasa.gov) or Tibor Kremic (Tibor.Kremic@nasa.gov) for questions regarding status, availability, and any proposal related intentions. Some additional information on the GEER is available at http://microgravity.grc.nasa.gov/SSPO/SS/Extreme/.

C.2 EMERGING WORLDS

NOTICE: This program element continues to use a two-step proposal submission process, described in Section 2 of C.1 The Planetary Science Division Research Program Overview.

New in ROSES-2019, studies of certain properties of lunar materials are within scope of Emerging Worlds, see last bullet of subsection 2.2.

1. Introduction

Research in the area of "Emerging Worlds" aims to answer the fundamental science question of how the Solar System formed and evolved. It helps to advance the strategic science goal to "explore and observe the objects in the Solar System to understand how they formed and evolve" through basic research that supports planetary exploration, aids in the development of missions, and provides context for the interpretation of all Solar System observations that are relevant to its formation and evolution. A wide range of investigations will be covered, including, but not limited to, theoretical studies, analytical and numerical modeling, sample-based studies of extraterrestrial materials, laboratory studies, and synthesis of previous work.

2. Scope of Program

The Emerging Worlds program solicits research proposals to conduct scientific investigations related to understanding (2.1) the formation of our Solar System; and/or (2.2) the early evolution of our Solar System.

2.1 Formation of our Solar System

For the purposes of this solicitation, the "formation of our Solar System" is considered to begin with the onset of the collapse of the molecular cloud from which the Solar System formed. Therefore, the following research areas are within scope of Emerging Worlds:

- Studies of the materials present and processes that led to the onset of Solar System formation.
- Studies of all aspects of materials present and processes occurring in and affecting the protoplanetary disk, including those occurring on bodies of any size during this stage of Solar System evolution.
- Studies related to the accretion of Solar System bodies after dissipation of the protoplanetary disk.

Studies of the formation of planetary systems in general fall within the scope of Emerging Worlds, but only if the proposal makes an explicit, clear and cogent case that the specific research proposed will result in increased understanding of the formation of our own Solar System. Studies of exoplanetary systems that do not have direct consequences for our Solar System are not in scope of Emerging Worlds.

2.2 Early evolution of the Solar System

For the purposes of this solicitation, "early evolution" is defined as follows. The absolute ages of processes that are considered "early" depend on the context. Please note the usage of the phrase “most prominent” in the bullets below: the intent of Emerging Worlds is to focus on processes that were characteristic of an early epoch of the Solar

System and played a role in establishing the structure of the Solar System or the bodies within it.

- For studies of the dynamical evolution of the Solar System, Emerging Worlds focuses on processes that happened and were most prominent between the time of Solar System formation and the time that large planetary bodies were in or near their modern configuration.
- For studies of the chemistry and physics of collisions and impacts in the Solar System, Emerging Worlds focuses on those processes that occurred and were most prominent during the dynamical evolution of the Solar System up to the time that large planetary bodies were in or near their modern orbital configuration, and which had significant effect on the structure of the target body or its planetary system.
- For studies of the large planetary bodies themselves, Emerging Worlds focuses on the period of planetary evolution through the end of the major period of accretion or the time of global differentiation (the separation into compositionally distinct layers, including their atmospheres, cryospheres, and hydrospheres), whichever is later. Such studies could be about the process of accretion or differentiation, or other processes that occur on or within large Solar System bodies through this period.
- For studies of processes that occurred on small bodies, the intent is to cover processes that can be reasonably inferred to have occurred and were most prominent up to the time that large planetary bodies were in or near their modern configuration.
- New for ROSES-2019: For studies of the Moon, sample-based and experimental studies of the chemical, petrological, and isotopic properties of lunar materials are within scope of Emerging Worlds. Studies that focus on active, ongoing processes remain out of scope of Emerging Worlds.

2.3 Programmatic priorities

Emerging Worlds prioritizes investigations that directly address outstanding problems in the origin and evolution of our Solar System. Proposals should clearly explain the problem(s) to be solved or the hypothesis(es) to be tested, and present a work plan that will allow the investigation to solve these problems or test these hypotheses within the funding period.

2.4 Long-term projects

The Emerging Worlds program recognizes that some projects may require more than a single funding period to bring to completion. Proposals that seek to do this are acceptable: they must clearly explain the problem(s) to be solved or the hypothesis(es) to be tested, and present a complete work plan that will allow the proposing team to ultimately reach the scientific objectives, even if such completion may not be possible within a single award period. The work plan must include detailed milestones to be accomplished during the initial award period, as well as milestones envisaged for future work. Selection of such a proposal does not constitute a guarantee of future funding for the completion of the project, and subsequent peer-reviewed proposals would be required in order to continue the work past the initial award period.

2.5 Demonstration of relevance

As stated in program element C.1, Section 3.5, all proposals, including those submitted to this program element, will be evaluated for relevance to the solicitation. Although, proposals submitted to this program element do not require a separate or explicit statement of relevance, proposers are strongly encouraged to address the question of relevance in the Scientific/Technical/Management portion of the proposal.

To be found relevant to the solicitation, all proposals submitted to this program element must demonstrate how they will advance our understanding of the origin or early evolution of the Solar System, as defined in Sections 2.1 and 2.2.

3. Programmatic Information

3.1 Exclusions

Proposers are advised to read each of the calls referenced below prior to submitting proposals.

3.1.1 *Studies of Exoplanets*

General studies of the formation of planetary systems may be relevant to either the Exoplanet Research Program (XRP, program element E.3) or Emerging Worlds. Those proposals which make an explicit, clear and cogent case that the specific research proposed will result in increased understanding of the formation of our own Solar System may be submitted to Emerging Worlds. Others should refer to the XRP solicitation.

3.1.2 *Studies of habitability*

Research aimed at investigating the habitability of planetary bodies in our Solar System or in other planetary systems should be submitted to the Habitable Worlds program element (program element E.4).

3.1.3 *Earth Science Studies*

Emerging Worlds does not, in general, support Earth science investigations, including research on terrestrial analog samples, unless relevance to the formation and early evolution of other planetary bodies or planetary science in general can be firmly established. Terrestrial research should address: key geochemical processes in early planetary evolution; terrestrial history in terms of general Solar System processes; or the reasons for differences in early evolution among the various planetary bodies; including Earth, the Moon, and parent bodies of meteorites. Proposals to analyze terrestrial samples should clearly explain the nature of the planetary connection, as this will be a key factor in determining relevance to Emerging Worlds.

3.1.4 *Mission Data Analysis*

NASA solicits proposals that use, analyze, and/or enhance the scientific return of certain planetary missions through its data analysis programs (DAPs). Emerging Worlds does not accept proposals that are eligible for submission to a DAP. The DAP solicitations should be consulted prior to the submission of any proposal that uses planetary mission data.

3.1.5 *Returned Sample Analysis*

Through the Laboratory Analysis of Returned Samples (LARS) program (program element C.16), NASA solicits proposals focused on the analysis of astromaterials returned by planetary missions (e.g., Stardust, Genesis, Hayabusa), and on the development of analytical methods for samples returned from these or future sample-return missions. The Emerging Worlds program element does not accept proposals that are eligible for submission to LARS. (Note that LARS does not support work on samples returned by the Apollo program; relevant work on Apollo samples may be submitted to Emerging Worlds.)

3.1.6 *Observations*

Observational proposals that are within the scope of the Solar System Observations program (which must have new observations within our Solar System as a primary element) are not in scope of Emerging Worlds, and should instead be submitted to Solar System Observations (program element C.6). Proposals with an observational component that are not in the scope of Solar System Observations must make an explicit, clear and cogent case that the observational data will be used to understand the formation and early evolution of our Solar System in order to be in scope for Emerging Worlds.

3.1.7 *Solar System Workings*

Investigations into processes that do not satisfy the definition of "early evolution" in Section 2.2, above, should be submitted to Solar System Workings (program element C.3).

3.1.8 *Planetary Data, Archiving, Restoration, and Tools (PDART)*

Proposals whose primary goals are to generate higher-order data products, archive and restore data sets or products, create or consolidate reference databases, generate new reference information, digitize data, and/or to develop or validate software tools may be in the scope of PDART (program element C.4) rather than Emerging Worlds.

3.1.9 *Studies of the Sun*

Emerging Worlds does not solicit proposals whose primary focus is on the formation or early evolution of the Sun (or protosun).

3.2 Duration and Size of Awards

Typical proposals to Emerging Worlds seek three years of funding or fewer. Please refer to program element C.1, Section 3.3, for instructions on submitting requests for more than three years. Projects to demonstrate or develop a new technique or a new application of an established technique, usually for less than three years duration, may also be proposed.

Awards made in Emerging Worlds in the first five years of its existence (selections made from ROSES-2014 though ROSES-2018) averaged ~$160,000 per year, but with a wide range, depending on the nature of the work proposed. The 2014-2018 Emerging Worlds selections are included in the spreadsheet on the SARA grant stats web page, and abstracts are made available through NSPIRES. Proposers may refer to the

Frequently Asked Questions (FAQs) for this program to view a histogram of award sizes for prior years, for information purposes only. Proposers should request what they actually need to conduct the research proposed.

Awards resulting from proposals submitted to this program are expected to be funded in their first year with next year's Fiscal Year (FY) dollars.

3.3 Additional Funding for Relevant Instrumentation Construction or Upgrade

Proposers to Emerging Worlds are eligible to request funds for major equipment under the Planetary Major Equipment and Facilities (PMEF) program. See program element C.17 for information on how to append a PMEF request to a regular Emerging Worlds research proposal or submit a stand-alone PMEF proposal to supplement an existing Emerging Worlds award.

3.4 Topical Workshops

The Emerging Worlds program does not accept proposals for topical conferences, workshops, or symposia; such proposals may be submitted in response to program element E.2 Topical Workshops, Symposia, and Conferences. Proposers should specifically identify the Emerging Worlds program as the relevant SMD program element and refer to the goals and objectives of the Emerging Worlds program in demonstrating relevance.

3.5. Mission data, facilities, and resources

Refer to ROSES program element C.1, Section 4, for a detailed list of the data and astromaterials resources, and facilities available to proposers to this program element, and how to use them.

3.6 Use of mission data

Proposals to this program element must follow the rules for use of mission data given in program element C.1, Section 3.4.

3.7 Data Management Plans (DMPs)

Proposals submitted to this program element must include a Data Management Plan (see program element C.1). This must be placed in a special section, not to exceed two pages in length, immediately following the References and Citations section for the Scientific/Technical/Management portion of the proposal.

3.8 Geologic Maps

Proposers who plan investigations involving geologic mapping should consult program element C.1 for guidance on submission and requirements for publication of U.S. Geological Survey (USGS) maps. The scientific goal of such a geologic map product should be clearly explained and justified.

3.9 Planetary Science Early Career Award

Details of the new Planetary Science Early Career Award (ECA) program are given in program element C.19. The aim of this program is to support research and professional development of outstanding early-career scientists, and to help stimulate research careers in areas supported by the Planetary Sciences Division. This program is an

ECA-participating ROSES program element. Proposals from eligible PIs, or Science PIs if applicable, selected from this program in 2019 may become the 'parent award' for future ECA proposals (i.e., in 2020 or later).

4. Proposal Preparation, Submission, and Evaluation

4.1 Two-step proposals

This program element uses a two-step proposal submission process described in program element C.1, Section 2. Proposers are reminded that Step-1 proposals are mandatory and must be submitted by the proposing organization.

4.2 Proposal formatting and content

Proposals must follow all formatting and content requirements described in program element C.1 and in the *NASA Guidebook for Proposers*. See section 2.3 of program element C.1 for a discussion of the consequences of non-compliance.

Although proposals are expected to conform to all of the rules outlined above, proposers should be especially aware of the following ways to avoid common errors:

- Do not add an extra page containing the abstract prior to the main body of the proposal. The abstract is limited to the cover pages generated by NSPIRES.
- Do not add a table of symbols or abbreviations as an extra page beyond the 15-page Science/Technical/Management (STM) section. Such definitions must fit within the 15 pages.
- Do not describe team members' roles and responsibilities in the table of work effort or budget sections. Only list job titles in these sections.
- Do not put information on instrument calibration or performance in the Facilities and Equipment section beyond what is needed simply to describe the instrument. If such information is critical to the work, put it in the STM section.
- Do not include work statements from Co-Is in the budget sections covering sub-awards/subcontracts. These may only appear in the STM section.
- Do not set figure captions in a smaller typeface than the minimum permitted for the body text.

Also, we recommend, but do not require, the following practices for clarity in writing proposals:

- Please do not use numbered callouts to bibliographic references in the STM section. Use the author name(s) and year.
- There is no need to present budgets broken down by federal fiscal years. Budgets should be organized by award years.
- Place clear titles on all subsections of your budget.

4.3 Modular proposals

NASA has the option of funding only part of a proposal, if that part of the proposal receives a significantly better evaluation on intrinsic merit, relevance, or cost, or if only part of the overall project fits within the program budget. In order to be considered for this type of descoping, a proposal must be modular, with clearly identified (numbered), separable "tasks." A descopable task is a self-contained sub-project, which in and of itself is relevant to Emerging Worlds and of high scientific merit. Proposals that do not enumerate modular tasks will not generally be considered for descoped funding. Note that a proposal containing identified tasks does not require presentation of a separate budget for each task.

4.4 Evaluation of proposals

All proposals will be evaluated for Intrinsic Merit, Cost, and Relevance, as specified in Section VI(a) of the ROSES *Summary of Solicitation*.

5. Summary of Key Information

Expected program budget for first year of new awards	~$5M
Number of new awards pending adequate proposals of merit	~30, see Section 3.2
Maximum duration of awards	4 years; shorter-term proposals (1-3 years) are typical; fourth year must be well justified.
Due date for Step-1 proposals	See Tables 2 and 3 of this ROSES NRA.
Due date for Step-2 proposals	See Tables 2 and 3 of this ROSES NRA.
Planning date for start of investigation	~6 months after Step-2 proposal due date
Page limit for the central Science/Technical/Management section of proposal	15 pp; see also Table 1 of the ROSES *Summary of Solicitation* and the *NASA Guidebook for Proposers.*
Relevance	This program is relevant to the Planetary Science questions and goals in the NASA Science Plan. Proposals that are relevant to this program are, by definition, relevant to NASA.
General information and overview of this solicitation	See the *ROSES Summary of Solicitation*.
Detailed instructions for the preparation and submission of proposals	Please see ROSES *Summary of Solicitation* Section I(g) Order of Precedence, Table 1, and the *NASA Guidebook for Proposers*.
Submission medium	Electronic proposal submission is required; no hard copy is permitted.
Web site for submission of proposals via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Web site for submission of proposals via Grants.gov	http://grants.gov (help desk available at support@grants.gov or (800) 518-4726)
Funding opportunity number for downloading an application package from Grants.gov	NNH19ZDA001N-EW

Point of contact concerning this program	Melissa Morris Planetary Science Division Science Mission Directorate NASA Headquarters Washington, DC 20546-0001 Telephone: (202) 774-8476 Email: HQ-EMERGINGWORLDS@mail.nasa.gov

C.3 SOLAR SYSTEM WORKINGS

NOTICE: November 7, 2019. This amendment changes the text, due dates and a point of contact for this program element: 1) The exclusion of certain types of lunar research from Solar System Workings (SSW) in Section 2.1 has been removed, giving proposers the option of submitting work on lunar materials in response to this call. 2) The points of contact in Section 5 of C.3 Solar System Workings have been updated. 3) NOIs are now requested by November 22, 2019 and proposals are due February 6, 2020. New text is in bold and deleted text is struck through.

August 22, 2019. The points of contact in Section 5 have been updated. Deleted text is struck through. The generic shared email box hq-ssw@mail.nasa.gov remains the address to which all inquiries should be sent.

Amended June 4, 2019. This program element is accepting proposals that involve Antarctic fieldwork, see Section 4.5. New text is in bold and deleted text is struck through. The due dates remain unchanged.

Proposals to this program element are subject to a relevance requirement in addition to and that supersedes those detailed in the ROSES *Summary of Solicitation*, see Section 2.6 ~~2.5~~ of this program element. Proposals that do not fulfill these requirements may be returned without review.

1. Scope of Program

The Solar System Workings (SSW) program element supports research into atmospheric, climatological, dynamical, geologic, geophysical, and geochemical processes occurring on planetary bodies, satellites, and other minor bodies (including rings) in the Solar System. This call seeks to address the physical and chemical processes that affect the surfaces, interiors, atmospheres, exospheres, and magnetospheres of planetary bodies.

The Solar System Workings program is open to investigations relevant to surfaces and interiors of planetary bodies, planetary atmospheres, rings, orbital dynamics, and exospheres and magnetospheres. The Solar System Workings program values the potential of interdisciplinary efforts to solve key scientific questions. The program also values research in comparative planetology. Research supported by this call may cover a wide range of investigations including theoretical studies, data synthesis relevant to the physical and chemical processes affecting planetary systems, sample-based studies of extraterrestrial materials, laboratory studies that examine physical or chemical properties and processes, studies of sample or analog materials of other Solar System bodies, field studies of terrestrial analogs of planetary environments, and theoretical, analytical, and numerical modeling of physical or chemical processes.

This program seeks to understand processes that occur throughout the Solar System, as well as those specific to individual objects and systems, but inform our understanding of the fundamental processes at work. A non-exhaustive list of areas of research called for in this program element follows. For conciseness in this list, the term ‘planetary’ refers to Solar System objects other than the Sun (ranging in size from small objects, like comets and asteroids, through natural satellites, and up to planets) and structures (such as atmospheres, ionospheres, and ring systems).

- Surfaces and Interiors
  - *Interior structure*. Determine the internal structure, chemistry, and dynamics of Solar System objects and identify and understand the physical and chemical processes that occur within these structures.
  - *Planetary magnetism*. Determine the configuration of planetary magnetic fields and understand how and why they are formed and vary through time. Catalog remnant magnetic fields in order to probe the history of planetary dynamos, as well as core-mantle structures and dynamics.
  - *Mantle Evolution.* Understand the chemical evolution and physical structure of mantles and how they change over time.
  - *Lithospheres*. Identify objects with evidence of active or ancient tectonics and understand the processes and inputs that cause tectonic activity to start or stop. Understand the role that regional and global stress fields play in the formation of large-scale surface features and how those features inform studies of the global structure and dynamics.
  - *Volcanism.* Identify the physical and chemical variations in volcanic activity throughout the Solar System. Investigate how volcanic activity can provide insight into interior processes. Understand how volcanic activity can modify planetary surfaces and atmospheres.
  - *Evolution and modification of surfaces.* Characterize and understand the chemical, mineralogical, and physical features of planetary surfaces (such as geologic formations and impact craters) and fluid inventories that interact with the surface (including hydrospheres, cryospheres, atmospheres, and other volatile reservoirs). Develop theoretical and experimental bases for understanding these features in the context of the varying conditions through time after formation.
- Planetary atmospheres
  - *Composition and evolution*. Characterize the chemical composition (including isotope and trace species) of planetary atmospheres and of atmospheric structures (such as haze layers). Understand the vertical mixing, convective profiles, and chemical processes that control the stability of, the losses from, and the evolution of planetary atmospheres. Determine where atmospheric composition deviates from that expected from solar-nebula material and understand alternative sources and their implications for atmospheric evolution.
  - *Dynamics and thermal structure*. Identify and investigate varied features of Solar System atmospheres, such as Venus’ greenhouse effect and Martian dust storms. Accurately describe wind patterns and cloud features; determine their temporal variability, their role in heat and momentum transfer, and other atmospheric processes. Characterize vertical structure and the transport of mass and heat at all scales, including the effects of coupling with planetary surfaces and with the environment above the atmosphere.

- *Climate change*. Characterize planetary climates over short and long time scales by reconstructing the history of atmospheric volatile inventories and understanding the chemical processes that affect them. Resolve the role that atmospheric circulation, dynamics, surface (e.g., volcanic activity) and external (e.g., solar radiation) conditions, and disruptive events play in providing stability for, cyclic modulation of, or perturbations in the global climate. Compare climates and atmospheres among different planetary bodies at present and over time.

- Rings
  - *Composition and structure*. Determine the three-dimensional structure of ring systems and the effects that moons and moonlets have on them. Characterize the chemical and size composition of ring system particles, including transient, diffuse, and dust rings.
  - *Processes and evolution*. Understand the physical and chemical processes active in ring systems and the interactions these systems have with planetary atmospheres, magnetospheres, and planetary bodies. Model the effects these interactions have in order to identify temporal changes of the rings on short and long timescales.
- Orbital dynamics
  - *Orbital characteristics and evolution.* Understand the gravitational interactions among groups of planetary bodies (e.g., satellites of a planet, an asteroid family, planets and other Sun-orbiting objects) and how they affect orbital characteristics and stability. Characterize the non-gravitational forces acting on objects and understand their effect on orbital characteristics. Identify and characterize dust populations from planetary sources, and understand their dynamics within in the Solar System.
  - *Orbital relationships.* Characterize the creation, and understand the evolution, of asteroid families. Understand the effects of orbital relationships (such as orbital resonances between satellites) on planetary interiors, surfaces (including liquids and ices), and atmospheres.
- Plasma environments
  - *Fundamental plasma processes.* Understand the role that localized plasma waves and plasma processes (including reconnection and instabilities) have in regulating large-scale dynamics; characterize the energy that is produced and carried by these phenomena and how they couple distant regions.
  - *Sources and sinks of mass and energy*. Characterize the neutral and plasma sources in planetary magnetospheres (including induced magnetospheres), considering the contribution of internal sources (such as moons or rings), the solar wind, and planetary atmospheres (including cometary outgassing). Understand the relative importance of sources of charged and neutral particle energization. Characterize and understand the mass and energy exchange with other objects or structures (such as the planet, the solar wind, or rings) and the loss from the system.
  - *Magnetospheric processes and dynamics*. Characterize magnetospheric processes and dynamics; determine how they cause mass and energy to flow through the system and couple these processes to the ionosphere and solar

wind. Identify similarities and differences in magnetospheric processes and dynamics between the planets. Determine the relative importance of dynamics driven by internal and external energy sources across the magnetospheres, and understand how the different planetary magnetic field configurations affect these dynamics. Refine and exploit our understanding of electromagnetic radiation (e.g., auroral emissions and planetary radio signals) and particle emissions (e.g., dust streams and energetic charged and neutral particles) in order to remotely study dynamics and processes.

- o *Plasma interactions with structures and bodies*. Determine mass and energy exchange with atmospheres and surfaces; understand the physical and chemical processes that this coupling may drive. Describe the interactions between the magnetospheric plasma and planetary objects, dust, and gas populations; characterize the energy flow and chemical processes within these coupled systems. Characterize the processes associated with space weathering and its effects on optical, spectroscopic, physical, and mechanical properties.

Due to the broad nature of this program's mandate, it is open to a wide range of targets of interest and methods of investigation, but only accepts scientific investigations. Each proposal must present a scientific investigation to be conducted, what data and resources will be used, the investigation's methodology, and how the investigation will achieve closure of the proposal's goals. Although this program encourages the utilization of data from planetary missions and studies that produce data products (e.g., cartographic products, calibration data, moments calculations) to inform science investigations, it does not accept proposals eligible for funding by the Data Analysis Programs or the Planetary Data Archiving, Restoration, and Tools Program (see Section 2.1).

2. Programmatic Information **[Text added and subsection numbers updated 110719]**

2.1 Exclusions

Proposers are advised to read each of the calls listed below prior to submitting proposals and to contact the appropriate Points of Contact with any questions.

Early Solar System studies. Proposals to conduct research to understand the formation and early evolution of the Solar System should be submitted to program element C.2, Emerging Worlds. The scope of Solar System Workings covers processes that occur after this period. For evolved bodies, Solar System Workings focuses on processes occurring after the end of global planetary differentiation; for primitive bodies, the focus is on processes that were not mainly active in the early Solar System. Processes that occur on regional or local scales on planetary bodies (such as impact cratering) are generally covered by Solar System Workings, even if they resulted in localized magmatism and/or differentiation.

Studies of Habitability. Research aimed at investigating the habitability of planetary bodies in our Solar System or in other planetary systems should be submitted to the Habitable Worlds program element (E.4).

Lunar Materials: The following exclusion of lunar materials is being removed from this program element for ROSES-2019 on November 7, 2019. However, in ROSES-2020 this exclusion may return to SSW.

~~Lunar Materials. For studies of the Moon, sample-based and experimental studies of the chemical, petrological, and isotopic properties of lunar materials should be submitted to program element C.2, Emerging Worlds. Studies that focus on active, ongoing processes on the Moon remain within scope of Solar System Workings.~~

Mission Data Analysis. NASA solicits proposals that use, analyze, and/or enhance the scientific return of certain planetary missions through its Data Analysis Programs (DAPs). Solar System Workings does not accept proposals that are eligible for submission to a DAP. The DAP program elements should be consulted prior to the submission of any proposal that uses planetary mission data. If a proposal is not appropriate for any Data Analysis program element and does fit within the bounds of Solar System Workings, submission to this program element is encouraged.

Studies of Exoplanets. Proposals to understand exoplanetary systems are not supported by this program element. Those with ties to observational studies or future NASA missions (either directly or indirectly) should be submitted to the Exoplanet Research Program (see program element E.3 for further clarification and restrictions).

Earth Science Studies. Investigations that focus primarily on the Earth are not appropriate for the Solar System Workings program element; research opportunities supporting the Earth Science Research Program may be found in Appendix A of this ROSES solicitation. However, comparative studies of planetary bodies that apply investigations such as those listed in Section 1 of this call to Earth and one or more other planets, or investigations that use Earth as an analog to another body in our Solar System, are appropriate for this program element.

Data archiving, restoration, and tools. Proposals to Solar System Workings must include a science investigation. Proposals to produce a higher-order data product that enhances the science return from one or more missions, but does not include a science investigation, should be submitted to program element C.4, Planetary Data Archiving, Restoration, and Tools (PDART).

Observations. Solar System Workings does not fund ground- or space-based surveys, but proposals that include analysis and interpretation of existing observations of Solar System objects may be submitted to this program. Observational proposals that are within the scope of the Solar System Observations program (which must have new observations within our Solar System as a primary element) should be submitted to Solar System Observations (program element C.6).

Conferences, workshops, and symposia. Proposals for topical conferences, workshops, or symposia related to the Solar System Workings program may not be proposed through this program element. Proposers are encouraged to pursue such submissions through ROSES program element E.2, Topical Workshops, Symposia, and Conferences. Proposers should specifically identify the Solar System Workings program as the relevant SMD program element and refer to the goals and objectives of the Solar System Workings program in demonstrating relevance.

2.2 Lunar Materials [This section was added November 7, 2019]

Proposals to this call may include sample-based and experimental studies of lunar materials. Since proposals using lunar materials will be permitted in ROSES-2020 program element C.2, Emerging Worlds, which has a review period overlapping that of ROSES-2019 SSW, a proposal using lunar materials may only be submitted to either ROSES-2019 SSW *or* ROSES-2020 Emerging Worlds, not both. If similar proposals are submitted to both programs, one proposal may be returned either whole or in part without review. Regardless of the program element to which the proposal using lunar materials is submitted, the proposer must follow that program's instructions to demonstrate relevance.

2.**3** Duration of Awards

Typical proposals to Solar System Workings seek three years of funding or fewer. Please refer to program element C.1, Section 3.3, for instructions on submitting requests for more than three years. Pilot studies and projects to demonstrate or develop a new technique or a new application of an established technique, usually for less than three years in duration, may also be proposed.

2.**4** Additional Funding for Relevant Instrumentation Construction or Upgrade

Proposers to Solar System Workings are eligible to request funds for major equipment under the Planetary Major Equipment and Facilities (PMEF) program. See program element C.17 for information on how to append a PMEF request to a regular Solar System Workings research proposal or submit a stand-alone PMEF proposal to supplement an existing Solar System Workings award.

2.**5** Planetary Science Division Early Career Award Program

Details of the new NASA Planetary Science Early Career Award (ECA) program are given in program element C.19. The aim of this program is to support research and professional development of outstanding early-career scientists, and to help stimulate research careers in areas supported by the Planetary Science Division. SSW is an ECA-participating ROSES program element. Proposals from eligible PIs, or Science PIs if applicable, selected from this program in 2019 may become the 'parent award' for future ECA proposals (i.e., in 2020 or later).

2.**6** Relevance Statement Requirement

Proposals to this program must discuss relevance in a (4000-character max) text box on the cover pages via the NASA Solicitation and Proposal Integrated Review and Evaluation System (NSPIRES) web interface for this program element. This section is outside of the 15-page Scientific/Technical/Management section and the relocation of the relevance discussion does not decrease that 15-page limit. This requirement supersedes the *NASA Guidebook for Proposers* and the *ROSES Summary of Solicitation*, and the omission of this section is sufficient reason for a proposal to be returned without review. The relevance of the proposal no longer needs to be discussed within the 15-page Scientific/Technical/Management section.

The relevance discussion must explicitly refer to this program element and the section of the program element to which the proposal is responsive. If the proposed work is close in scope to research covered by any other program element, this discussion must also justify why it is more relevant to this program element than that other program element. This discussion may not be used to address the proposal's intrinsic merit, budget justification, or any other factor that remains in the 15-page main body, or any other section, of the proposal.

3. Proposal Submission Process and Formatting

This program element requests a Notice of Intent (NOI) by the due date given in Tables 2 and 3 of this NRA. An NOI is not required to submit a full proposal. Proposals are due by the date given in Tables 2 and 3 of this NRA.

Proposals must follow all formatting requirements described in program element C.1 and in the *NASA Guidebook for Proposers*. Violation of these rules is sufficient grounds for a proposal to be rejected.

4. Resources: Information, Data, and Facilities

4.1 Limits on Use of Mission Data

Proposals to this program element must follow the rules for use of mission data given in program element C.1, Section 3.4. If the data to be analyzed have issues that might represent an obstacle to analysis, the proposers must demonstrate clearly and satisfactorily how such potential difficulties will be overcome.

4.2 Facilities and Data Sources Available to Proposers

Please refer to ROSES program element C.1, Section 4, for a detailed list of the data and astromaterials resources, and facilities available to proposers to this program element, and how to use them. If their use is anticipated, this should be discussed and justified in the submitted proposals (especially note the provision for such discussion in the proposal section entitled Facilities and Equipment). Also note that, per the directions in the *NASA Guidebook for Proposers*, a letter of support may be required from any facility required for the proposed effort.

4.3 Data Management Plans (DMPs)

Proposals submitted to this program element must include a Data Management Plan (see program element C.1, Section 3.6). This must be placed in a special section, no longer than two pages in length, that immediately follows the References and Citations section for the Scientific/Technical/Management portion of the proposal.

4.4 Geologic Maps

Proposers who plan investigations involving geologic mapping should consult program element C.1, Section 3.8, for guidance on submission and requirements for publication of U.S. Geological Survey (USGS) maps. The scientific goal of such a geologic map product should be clearly explained and justified.

4.5 Antarctica **[This section was modified June 4, 2019]**

The Solar System Workings program is ~~not currently~~ accepting proposals for work in Antarctica.

For projects that require Antarctic fieldwork, proposers must include all costs associated with this fieldwork in their proposal budgets.

For Antarctic fieldwork supported by the United States Antarctic Program (USAP), these costs include those required for physical qualification exams, airfare, lodging, and per diem for travel to Christchurch, New Zealand (departure point for Antarctica, include seven days in Christchurch as margin for weather-related delays), any required cargo transportation (origin to Pt. Heuneme, California, and return), and any specialty materials or large quantities of stocked materials required in Antarctica. Proposers must also include costs associated with logistics support provided by the USAP via the National Science Foundation (NSF).

To obtain these costs, complete an Antarctic Logistics Requirements and Field Plan, and return to Jessie Crain, Antarctic Research Support Manager jlcrain@nsf.gov. Requirements for this document, and other guidance for conducting field work in the Antarctic, are may be found at: https://www.nsf.gov/geo/opp/ant/solicitation_resources/prop_prep_info.jsp. Please allow one month for processing to receive the USAP cost estimate. Projects receiving U.S. Antarctic Program support for fieldwork in the Antarctic shall include the following acknowledgement in publications resulting from the project: "Logistical support for this project in Antarctica was provided by the U.S. National Science Foundation through the U.S. Antarctic Program".

5. Summary of Key Information

Expected program budget for first year of new awards	$9-10M
Number of new awards pending adequate proposals of merit	50-70
Maximum duration of awards	4 years; shorter-term proposals (1-3 years) are typical; fourth year must be explicitly and well justified.
Due date for NOIs	See Tables 2 and 3 of this ROSES NRA.
Due date for proposals	See Tables 2 and 3 of this ROSES NRA.
Planning date for start of investigation	~6-8 months after proposal due date
Page limit for the central Science/Technical/Management section of proposal	15 pp; see also Table 1 of the ROSES *Summary of Solicitation* and the *NASA Guidebook for Proposers*
Relevance	This program is relevant to the planetary science questions and goals in the NASA Science Plan. Proposals that are relevant to this program are, by definition, relevant to NASA. See Section 2.**6** ~~5~~ of this program element for special relevance requirements.

General information and overview of this solicitation	See the *ROSES Summary of Solicitation*.
General requirements for content of proposals	See Section 3 of the *NASA Guidebook for Proposers* and Section IV and Table 1 of *the ROSES Summary of Solicitation*.
Detailed instructions for the submission of proposals	See https://nspires.nasaprs.com/tutorials/ Sections 3.22-4.4 of the *NASA Guidebook for Proposers* and Section IV(b) of *the ROSES Summary of Solicitation*.
Submission medium	Electronic proposal submission is required; no hard copy is permitted.
Web site for submission of proposals via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Web site for submission of proposals via Grants.gov	http://grants.gov (help desk available at support@grants.gov or (800) 518-4726)
Funding opportunity number for downloading an application package from Grants.gov	NNH19ZDA001N-SSW
Points of contact concerning this program, all of whom share the following email and postal address: hq-ssw@mail.nasa.gov Planetary Science Division Science Mission Directorate NASA Headquarters Washington, DC 20546-0001	Email to hq-ssw@mail.nasa.gov is strongly preferred. **[List last updated November 7, 2019]** Delia Santiago-Materese Email: delia.santiago-materese@nasa.gov Adrian Brown Email: adrian.j.brown@nasa.gov **Lucas Paganini** **Email: lucas.paganini@nasa.gov** Henry Throop Email: henry.throop@nasa.gov Shoshana Weider Email: shoshana.weider@nasa.gov ~~Thomas Wagner~~ ~~Email: thomas.wagner@nasa.gov~~ ~~Jennifer Heldmann~~ ~~Email: jennifer.heldmann@nasa.gov~~ ~~Rebecca McCauley Rench~~ ~~Email: rebecca.l.mccauleyrench@nasa.gov~~ ~~Mitchell Schulte~~ ~~Email: mitchell.d.schulte@nasa.gov~~

C.4 PLANETARY DATA ARCHIVING, RESTORATION, AND TOOLS

This program element continues to use a two-step proposal submission process described in Section 2 of C.1 The Planetary Science Division Research Program Overview.

Proposals to this program element are subject to a relevance requirement in addition to and that supersedes those detailed in the ROSES *Summary of Solicitation*, see Section 2.1 of this program element. Proposals that do not fulfill these requirements may be returned without review.

1. Scope of Program

1.1 Programmatic Overview

The Planetary Data Archiving, Restoration, and Tools (PDART) program solicits proposals to generate higher-order data products, archive and restore data sets or products, create or consolidate reference databases, generate new reference information, digitize data, and develop or validate software tools.

The objective of this program element is to increase the amount and quality of digital information and data products available for planetary science research and exploration, and to produce tools that would enable or enhance future scientific investigations. Although it is expected that a small amount of data analysis, interpretation, or modeling may be performed to validate any generated products, this program element does not accept proposals in which the main focus is hypothesis-based planetary science.

For all types of proposals, the products of selected proposals must be made available to the scientific community. Data products must be archived in the NASA Planetary Data System (PDS) or an equivalent archive (see Section 2.2 for a definition of an equivalent archive). All proposals will be evaluated on the perceived impact of the new products, datasets, or tools on future planetary science research and exploration.

Proposers to this program element will not provide a data management plan via the NSPIRES cover pages or as a two-page addendum. Instead, that is superseded by instructions in the sections below that place more detailed descriptions into the body of the Scientific/Technical/Management section of proposals.

1.2 Data Product Generation

Proposals to generate new high-order data products or to improve or expand current high-order data products are encouraged. Source data may be derived from NASA or other spaceflight missions, astronomical observations, sample analyses, or other sources. These new data products may include, but are not limited to, cartographic products and calibrated or corrected datasets.

1.3 Data Set Restoration and Archiving

Proposals to archive complete datasets and/or to restore and archive incomplete datasets (e.g., to reextract, rereduce, and/or recalibrate data to fill in fragmentary datasets) will be considered. Such proposals must include: 1) an archiving plan (see

Section 4.3); 2) a description of how the data will be obtained; 3) a detailed plan for how the data will be restored, if relevant; and 4) a description of documentation, calibration data, and related software necessary to read and interpret the original and new datasets.

1.4 Reference Database Creation

Proposals that create and/or consolidate reference databases useful for planetary science research will be considered. These databases may include, but are not limited to, spectral libraries, chemical and physical properties of materials, and photographic catalogs. The burden is on the proposal to demonstrate the demand for a proposed database and its likelihood of advancing the current state of knowledge or resolving a significant planetary question or problem.

1.5 Generation of New Reference Information

Proposals to make laboratory measurements, conduct experiments, or otherwise generate new reference information that is intended for general use in planetary science will be considered. Examples may include, but are by no means limited to, spectral data, phase diagrams and equations of state, physical laws, optical constants, partition coefficients, and thermodynamic properties of materials. Where the main product of the proposal is a reference dataset, the proposal must include a plan to deposit the data in the NASA PDS or an equivalent archive. The burden is on the proposal to demonstrate the demand for a proposed reference product and its likelihood of advancing the current state of knowledge or resolving a significant planetary question or problem.

1.6 Data Digitization

Proposals to recover datasets that currently are available only on media not readable by modern computing equipment, or to digitize data that are only available in analog form (e.g., printed matter, photographs, and manuscripts) will be considered. PDART will consider proposals that include the rental of specialty equipment and/or the hiring of independent expertise to accomplish those tasks. Regardless of the method, the proposal must demonstrate the capability and provide a plan to recover or digitize the data. The burden is on the proposal to demonstrate the demand for the digitized product and its likelihood of advancing the current state of knowledge or resolving a significant planetary question or problem.

1.7 Software Tool Development and Validation

Proposals to develop and disseminate software tools that facilitate the use of existing datasets or that would enable or enhance future science investigations of interest to the Planetary Science Division will be considered. PDART does not support extensive application of these tools, but it is expected that the validity of the tools will be demonstrated during the course of the proposed work. Proposals are expected to include a plan to disseminate the tools for use by the planetary community. In addition to any other dissemination mechanisms, investigators developing software tools are required to archive the source code, and all relevant documentation, at NASA's PSD Github site (https://github.com/NASA-Planetary-Science). It is expected that user interfaces and/or executables will be made publically available at no cost. Accordingly, awards made under this program element will contain a "Rights in Data" clause reflecting this expectation.

This program element will also accept proposals to fund the development or enhancement of numerical models, with the expectation that the funded model will be made publicly available. In these instances, the proposal will be judged on 1) how the enhancement would result in an improvement in the results previously produced by this or similar models, and 2) how the enhancement would enable scientific investigations not currently possible with, or improve investigations relative to, models currently in use.

2. Programmatic Information

2.1 Relevance Statement Requirement

Step-2 proposals to this program element must discuss relevance in a (4000-character maximum) text box on the cover pages via the NSPIRES web interface for this program element. This section is outside of the 15-page Scientific/Technical/Management Section and the relocation of the relevance discussion does not decrease that 15-page limit. This requirement supersedes the *NASA Guidebook for Proposers* and the *ROSES Summary of Solicitation*, and the omission of this discussion is sufficient reason for a proposal to be returned without review.

The relevance discussion must explicitly refer to the objectives of this program element and the section of this appendix to which the proposal is responsive. If the proposed work is close in scope to research covered by any other program element, this discussion must also justify why it is more relevant to this program element than that other program element. This discussion may not be used to address the proposal’s intrinsic merit, budget justification, or any other factor that remains in the 15-page main body, or any other section, of the proposal.

2.2 Merit Evaluation Criterion

As PDART’s goals differ from other programs, the review of proposals submitted to this program element will include merit factors not listed in the *NASA Guidebook for Proposers*. In addition to the *Guidebook* criteria, all submitted proposals will be evaluated on the following PDART-specific merit factors:

1. The perceived impact of the new products, datasets, or tools on future planetary science research and exploration. This factor includes an evaluation of the proposal’s end products against the state-of-the-art and the demand for the proposed product.
2. The uniqueness and/or time criticality of the proposed new products, datasets, or tools. For this factor, historical significance may also be considered but cannot be the sole justification for the effort.
3. The credibility of the proposed plan for dissemination and archiving. This factor includes both the format that the data products/tools would be in and how they would be made available for the scientific community. For those proposals that would use an archive other than NASA’s PDS or Github sites, this factor includes an evaluation of whether the repository is a PDS-equivalent archive (Section 2.3).
4. Any applicable factors described in Sections 1.2-1.7.

2.3 Definition of a PDS-equivalent archive

Equivalence of an archive to the NASA PDS is defined by a number of factors that cover accessibility, reliability, usability, and other qualities.

Proposed archives are required to have the following features:

1. The Archive shall be managed by someone other than the major data provider. (Independence)
2. The Archive shall be managed for the long-term (25 years at least). (Sustainability)
3. The Archive shall be accessible to the public (lay and scientific) without preapproval. (Open Accessibility)
4. The Archive shall ensure that data are searchable. (Searchability)
5. The Archive shall ensure that data are citable. (Citability)
6. The Archive shall be considered by its user community as the "standard" archive for the subfield. (Preeminence)
7. The Archive shall require that data products be submitted in standardized formats and file types. (Standardization)

Proposed archives are preferred (but not required) to have the following features:

1. The Archive should conduct independent peer reviews of data to assess usability and completeness of data packages. (Peer Review)
2. The Archive should include documentation for its holdings such as user guides, calibration descriptions, etc. (Documentation).

The following are some examples of PDS-equivalent archives: The HIgh-resolution TRANsmission molecular absorption database (HITRAN), Infrared Processing and Analysis Center (IPAC) Infrared Science Archive (IRSA), NASA Space Science Data Coordinated Archive (NSSDCA), Coordinated Data Analysis Web (CDAWeb). In addition, the PDS imaging node annex (PDS IMG annex) is considered by PDART to be PDS-equivalent for certain geospatial products which cannot be ingested into the PDS. If a proposed work effort would deliver data products to an archive other than PDS or one of those listed here, the proposal must demonstrate that it meets the requirements above.

2.4 Exclusions

PDART does not support scientific investigations whose primary emphasis is data analysis, fundamental planetary research, or instrument development. Proposers are encouraged to consult C.1 Planetary Science Research Program Overview for the appropriate program element to which they should submit.

Proposals whose primary focus is on data to be used in investigations solicited by the Astrophysics, Heliophysics, or Earth Science Divisions are encouraged to consult Appendices D, B, and A respectively for information on the appropriate program elements to which they should be submitted.

The PDART element does not fund proposals primarily to acquire new ground- or space-based observations or surveys; such proposals should be submitted to the Solar System Observations program (see program element C.6).

Investigators funded by spaceflight missions who wish to apply to this program element must clearly demonstrate in their proposal how the proposed research does not overlap and is not redundant with duties or responsibilities already funded by their respective mission(s). See C.1, The Planetary Science Division Research Program Overview, for more information.

Proposals for topical conferences, workshops, or symposia related to this program element may not be proposed through this program element. Proposers are encouraged to pursue such submissions through ROSES E.2 Topical Workshops, Symposia, and Conferences.

2.5 Duration and Size of Awards

The maximum funded duration of awards from C.4 is three years. Proposals for funding of less than three years are highly encouraged for projects that can be completed on shorter timescales. The appropriateness of the proposed funding period will be reviewed and adjustments may be requested.

The 2018 PDART selections are posted to the spreadsheet on the SARA grant stats web page. The average year-one award size in PDART is ~$130K, but the award sizes for this program span a wider than typical range, depending on the nature of the work. Proposers are encouraged to request what is actually needed to conduct the proposed work. As always, the number of new awards will also depend on the available budget.

2.6 Data Management Plans (DMPs)

Because data archiving is an integral part of PDART and evaluated as part of the merit, a data management plan should be integrated as part of the Science/Technical/Management portion of the proposal, no additional DMP section is required for this program element.

2.7 Additional Funding for Relevant Instrumentation Construction or Upgrade

Proposers to PPR are eligible to request funds for major equipment under the Planetary Major Equipment and Facilities (PMEF) program. See program element C.17 for information on how to append a PMEF request to a regular PPR proposal or submit a stand-alone PMEF proposal to supplement an existing PPR award.

2.8 Planetary Science Early Career Award

Details of the new Planetary Science Early Career Award (ECA) program are given in program element C.19. The aim of this program is to support research and professional development of outstanding early-career scientists, and to help stimulate research careers in areas supported by the Planetary Sciences Division. This program is an ECA-participating ROSES program element. Proposals from eligible PIs, or Science PIs if applicable, selected from this program in 2019 may become the 'parent award' for future ECA proposals (i.e., in 2020 or later).

3. Proposal Submission Process

This program element uses a two-step proposal submission process described in C.1, Section 2.

Proposers are reminded that Step-1 proposals are mandatory and must be submitted by the proposing organization.

Proposals must follow all formatting requirements that are described in program element C.1 and in the *NASA Guidebook for Proposers*. Violation of these rules is sufficient grounds for a proposal to be rejected.

4. Resources: Information, Data, and Facilities

4.1 Limits on Use of Data

For proposals that generate higher-order data products from NASA mission or NASA instrument data or otherwise use such data in the development or testing of software, the data to be used in proposed investigations must be available in the Planetary Data System (PDS) or equivalent publicly accessible archive at least 30 days prior to the proposal submission date. Spacecraft data that have not been obtained yet (i.e., future mission data) or those that have not been accepted for distribution in approved archives are not eligible for use in investigations. Regardless of the archive(s) used, if the data to be analyzed have issues that might represent an obstacle to analysis, the proposers must demonstrate clearly and satisfactorily how such potential difficulties will be overcome. This 30-day rule does not apply to unarchived data from missions prior to the creation of the PDS if the dataset in question will be archived to PDS through the proposed project.

Proposals to digitize and/or archive data not currently available in a public archive must demonstrate that the data to be used are available (such as a letter of support, if they are owned by a private entity, or a detailed plan to locate and obtain the data from a known repository), in a format suitable for the proposed work, and of sufficient quality to achieve the goals set forth in the proposal. The proposal should further demonstrate a familiarity with the data and an understanding of the work required to prepare the data for future analysis and/or delivery to an appropriate public archive.

4.2 Facilities and Data Sources Available to Proposers

Proposers are strongly advised to read C.1 The Planetary Science Division Research Program Overview, for information on facilities and data sources that are available to supported investigators. If their use is anticipated, this should be discussed and justified in the submitted proposals (especially note the provision for such discussion in the proposal section entitled Facilities and Equipment). Also note that, per the directions in the *NASA Guidebook for Proposers*, a letter of support may be required from any facility required for the proposed effort that is not under the direct control of the proposal PI or Co-Is.

4.3 Data Archiving and Map Publication

Selected investigations are expected to result in data products or tools that are of broad use to the science community, including maps, data with improved calibrations, *etc*. PDART requires that data produced by selected investigations be archived in the Planetary Data System (http://pds.nasa.gov/), or a PDS-equivalent archive, by the end of the award period. Proposers should communicate with the PDS Discipline Node responsible for curating similar data (links to the PDS Discipline Nodes are at http://pds.nasa.gov/) to discuss procedures and requirements prior to proposing and to help with discerning the most efficient way to archive the proposed data products. Proposers intending to archive data or products in the PDS must obtain and include a letter of confirmation from the appropriate Discipline Node that the PDS is willing to accept their submission. It is the proposer's responsibility to conform to PDS standards.

Proposed investigations of any planetary or satellite surface that are intended to result in the publication of a Scientific Investigations Map (SIM) by the U.S. Geological Survey (USGS) should check the relevant box on the proposal Cover Page and clearly indicate this intention in the Proposal Summary, as well as in the text of the proposal. Investigators that intend to produce a USGS geologic map are required to include in their Step-2 (full) proposal a confirmation of technical specification document obtained from the USGS Map Coordinator. Proposers are advised to read C.1, The Planetary Science Division Research Program Overview, for the USGS's information on and requirements for map production and publication.

5. Summary of Key Information

Expected program budget for first year of new awards	~$2-2.4M
Number of new awards pending adequate proposals of merit	See Section 2.5
Maximum duration of awards	3 years
Due date for Step-1 proposals	See Tables 2 and 3 of this ROSES NRA.
Due date for Step-2 proposals	See Tables 2 and 3 of this ROSES NRA.
Planning date for start of investigation	~8 months after proposal due date.
Page limit for the central Science/Technical/Management section of proposal	15 pp; see also Table 1 of the ROSES *Summary of Solicitation* and the *NASA Guidebook for Proposers.*
Relevance	This program is relevant to the Planetary Science questions and goals in the NASA Science Plan. Proposals that are relevant to this program are, by definition, relevant to NASA. See Section 2.1
General information and overview of this solicitation	See the *ROSES Summary of Solicitation*.
Detailed instructions for the preparation and submission of proposals	Please see ROSES *Summary of Solicitation* Section I(g) Order of Precedence and the *NASA Guidebook for Proposers*.
Submission medium	Electronic proposal submission is required; no hard copy is permitted.
Web site for submission of proposals via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Web site for submission of proposals via Grants.gov	http://grants.gov (help desk available at support@grants.gov or (800) 518-4726)

Funding opportunity number for downloading an application package from Grants.gov	NNH19ZDA001N-PDART
Points of contact concerning this program all of whom share the following postal address: Planetary Science Division Science Mission Directorate NASA Headquarters Washington, DC 20546-0001	Sarah Noble – Lead Discipline Scientist Telephone: (202) 358-2492 Email: sarah.noble-1@nasa.gov Adrian Brown – Discipline Scientist Telephone: (650) 604-0297 Email: adrian.j.brown@nasa.gov KC Hanson – Discipline Scientist Telephone: (202) 358-1077 Email: kenneth.hansen@nasa.gov Lindsay Hays – Discipline Scientist Telephone: (650) 604-3668 Email: lindsay.hays@nasa.gov

C.5 EXOBIOLOGY

NOTICE: This program element requests a Notice of Intent (NOI) in place of a Step-1 proposal. These NOIs will not be evaluated, and therefore no response will be provided to a submission of an NOI. NOI and proposal due dates are given in Tables 2 and 3 of ROSES.

PIs of awards from this program element may become members of the newly established Astrobiology Program Research Coordination Networks that are relevant to their selected research. For more information, see Section 2.12 of this program element.

Proposals to this program element are subject to a relevance requirement in addition to and that supersedes those detailed in the ROSES *Summary of Solicitation*, see Section 2.6 of this program element. Proposals that do not fulfill these requirements may be returned without review.

1. Scope of Program

The goal of NASA's Exobiology is to understand the origin, evolution, distribution, and future of life in the Universe. Research is centered on the origin and early evolution of life, the potential of life to adapt to different environments, and the implications for life elsewhere. This research is conducted in the context of NASA's ongoing exploration of our stellar neighborhood and the identification of biosignatures for *in situ* and remote sensing applications. For further information on the science scope of Astrobiology, within which exobiology is located, please refer to the Astrobiology Strategy which can be found on the Astrobiology web page https://astrobiology.nasa.gov/research/astrobiology-at-nasa/astrobiology-strategy/.

The areas of research emphases in this solicitation are as follows:

- Prebiotic Evolution

Research in the area of prebiotic evolution seeks to understand the planetary and molecular processes that set the physical and chemical conditions within which living systems may have arisen. A major objective is determining what chemical systems could have served as precursors of metabolic and replicating systems on Earth and elsewhere, including alternatives to the current DNA-RNA-protein basis for life. This would also include models of early environments on the Earth in which organic chemical synthesis could occur. Laboratory and theoretical, as well as related data-analysis, studies will be considered.

Topics not included are the formation and stability of habitable planets, the formation of complex organic molecules in space and their delivery to planetary surfaces. Proposals on these topics should be submitted to C.2 Emerging Worlds.

- Early Evolution of Life and the Biosphere

The goal of research into the early evolution of life and the biosphere is to determine the nature of the most primitive organisms and the environment in which they evolved. The opportunity is taken to investigate two natural repositories of evolutionary history available on Earth: the molecular record in living organisms and the geological record.

These paired records are used to: (i) determine when and in what setting life first appeared and the characteristics of the first successful living organisms; (ii) understand the phylogeny and physiology of microorganisms, including extremophiles, whose characteristics may reflect the nature of primitive environments; (iii) determine the original nature of biological energy transduction, membrane function, and information processing, including the construction of artificial chemical systems to test hypotheses regarding the original nature of key biological processes; iv) investigate the development of key biological processes and their environmental impact; v) investigate the evolution of genes, pathways, and microbial species subject to long-term environmental change relevant to the origin of life on Earth and the search for life elsewhere; and vi) study the coevolution of microbial communities, and the interactions within such communities, that drive major geochemical cycles, including the processes through which new species are added to extant communities.

- Evolution of Advanced Life

Research associated with the study of the evolution of advanced life seeks to determine the biological and environmental factors leading to the origin of eukaryotes and the development of multicellularity on Earth and the potential distribution of complex life in the Universe. This research includes studies of the processes associated with endosymbiosis and the origin and early evolution of those biological factors that are essential to multicellular life, such as developmental programs, intercellular signaling, programmed cell death, the cytoskeleton, cellular adhesion control and differentiation, in the context of the origin of advanced life.

Proposals aimed at investigation into evolution of individual taxa or properties specifically of advanced multicellular life (e.g. neural systems, bipedalism, intelligence) are not solicited at this time.

- Large scale environmental change and Macro-evolution

Research associated with the study of the macro-evolution of life on Earth includes an evaluation of environmental factors such as the influence of latitudinal differences or extraterrestrial (e.g., bolide impacts, orbital and solar variations, gamma-ray bursts, etc.) and planetary processes ("Snowball Earth" events, rapid climate change, etc.) on the large-scale evolution of life on Earth. Of particular interest are mass extinction events.

- Biosignatures and Life Elsewhere

Research in this area focuses on relating what is known about the origin of life on Earth to the potential for the origin and establishment of life under conditions prevailing on other planetary bodies and basic research on the formation and retention of biosignatures under non-Earth conditions (e.g., Mars, Europa). This includes studies that constrain or extend concepts of possible chemical evolution relevant to the origin, evolution, and distribution of life. As part of the focus on biosignatures, this area includes research on the forms in which prebiotic organic matter formed on planetary surfaces has been preserved and the range of planetary environments amenable to life. Additionally, research focused on defining, understanding or characterizing "techno-signatures" as specific types of biosignatures indicative of intelligent life are included in this area. However, since the Exobiology Program does not solicit proposals to apply biosignatures to particular environments, proposals to search for technosignatures are not included.

Biosignature studies of samples from Earth sites thought to be analogues of other planetary environments that might potentially harbor life will be considered as part of NASA's broader interest in the search for life in the Universe.

2. Programmatic Information

2.1 General Information

Proposals are sought for new projects within the scope of the Astrobiology program. Proposals submitted in response to this program element should be for new work that is not currently supported by the program or for investigations that would extend to their next logical phase those tasks that have been funded in the Astrobiology program, but whose periods of performance expired in the last year or are expiring in the first half of this year.

Although there is a place in the program for exploration of novel and relevant environments, selection preference will be given to hypothesis-driven research projects.

2.2 Program Exclusions

Research aimed at investigating the habitability of planetary bodies in our Solar System other than Earth or in other planetary systems should be submitted to the Habitable Worlds program (E.4).

Proposals focused on the formation and stability of habitable planets and the formation of complex organic molecules in space and their delivery to planetary surfaces should be submitted to the Emerging Worlds program (C.2).

Proposals aimed at the identification and characterization of radio signals from extrasolar planets that may harbor intelligent life are not solicited at this time.

2.3 Pilot Studies

Proposals for one to two-year pilot studies to demonstrate or develop a new technique or a new application of an established technique are encouraged. Such proposals may also include the demonstration of a technique new to the proposer, but not new to the field in general.

2.4 Additional Funding for Relevant Instrumentation Construction or Upgrade

Proposers to Exobiology are eligible to request funds for major equipment under the Planetary Major Equipment and Facilities (PMEF) program. See program element C.17 for information on how to append a PMEF request to a regular Exobiology research proposal or submit a stand-alone PMEF proposal to supplement an existing Exobiology award.

2.5 Development of Astrobiology Instruments

This solicitation does not request proposals for the development of advanced instrument concepts and technologies as precursors to astrobiology flight instruments. Such proposals should be submitted to the Planetary Instrument Concepts for the Advancement of Solar System Observations (PICASSO; see program element C.12) Program (for technology readiness levels [TRLs] 1-3+) or the Maturation of Instruments for Solar System Exploration (MatISSE; see program element C.13) Program (for TRLs

4-6). Proposals for science-driven field campaigns that are expected to produce new science results, as well as new operational or technological capabilities, should be submitted to the Planetary Science and Technology from Analog Research (PSTAR) program (see program element C.14).

2.6 Relevance Statement Requirement

Proposals must discuss relevance to this program element in a (4000-character max) text box on the cover pages via the NSPIRES web interface for this program element. This section is outside of the 15-page Scientific/Technical/Management Section and the relocation of the relevance discussion does not decrease that 15-page limit. This requirement supersedes the *NASA Guidebook for Proposers* and the *ROSES Summary of Solicitation*, and the omission of this section is sufficient reason for a proposal to be returned without review.

The relevance discussion must explicitly refer to this program element and the section of the solicitation to which the proposal is responsive. If the proposed work is close in scope to research covered by any other program element, this discussion must also justify why it is more relevant to this program element than that other program element. This discussion may not be used to address the proposal's intrinsic merit, budget justification, or any other factor that remains in the 15-page main body, or any other section, of the proposal.

2.7 Duration of Awards

Typical proposals to Exobiology seek three years of funding or fewer. Please refer to section 3.3 of C.1, the Planetary Science Research Program Overview, for instructions on submitting requests for more than three years. The appropriateness of the proposed funding period will be reviewed and adjustments may be requested. Programmatic balance may limit the opportunities for funding in some areas.

2.8 Topical Workshops, Symposia, and Conferences

The Exobiology program does not accept proposals for topical conferences, workshops, or symposia; such proposals may be submitted in response to program element E.2 Topical Workshops, Symposia, and Conferences. Proposers should specifically identify the Exobiology program as the relevant SMD program element and refer to the goals and objectives of the Exobiology program in demonstrating relevance.

2.9 Planetary Science Early Career Award

Details of the new Planetary Science Early Career Award (ECA) program are given in program element C.19. The aim of this program is to support research and professional development of outstanding early-career scientists, and to help stimulate research careers in areas supported by the Planetary Sciences Division. This program is an ECA-participating ROSES program element. Proposals from eligible PIs, or Science PIs if applicable, selected from this program in 2019 may become the 'parent award' for future ECA proposals (i.e., in 2020 or later).

2.10 NASA Postdoctoral Program Fellows

Grantees in the program are eligible to serve as mentors to NASA Postdoctoral Program (NPP) Fellows. The tenure of a Fellow must begin before the end of the

Exobiology award but may extend beyond it. Proposals from potential Fellows must be submitted through the standard NPP process. The Astrobiology Program expects to select no more than three Fellows associated with Exobiology research this year. More information about the NASA Postdoctoral Program may be found at http://npp.usra.edu/.

2.11 Antarctica

The Exobiology Program is no longer accepting proposals for work in Antarctica.

2.12 Research Coordination Networks (RCNs)

PIs of proposals selected for funding from this program element that cover a research topic related to the newly established Research Coordination Networks are eligible to elect to become members of the Steering Committees of these RCNs (For more information, see: https://astrobiology.nasa.gov/news/astrobiology-program-faqs/). Relevance to an RCN is not an evaluation criterion for proposals to this program element, and eligibility for participation in an RCN does not indicate that additional research funding will be provided. RCNs bring together scientists from many disciplines with different objectives. The goals of the currently active RCNs are:

- NExSS: to investigate the diversity of exoplanets and to learn how their history, geology, and climate interact to create the conditions for life. (For more information see https://nexss.info/.)
- NfoLD: to investigate life detection research, including biosignature creation and preservation, as well as related technology development. (For more information see https://nfold.org.)
- PCE3: to investigate the delivery, synthesis, and fate of small molecules under the conditions of the Early Earth, and the subsequent formation of proto-biological molecules and pathways that lead to systems harboring the potential for life. (For more information see http://prebioticchem.info/)

Information about the additional RCNs that are being established can be found here: https://astrobiology.nasa.gov/news/how-many-astrobiology-research-coordination-networks-will-be-established/

3. Resources: Information, Data, and Facilities

3.1 Limits on Use of Mission Data

Proposals to this program element must follow the rules for use of mission data given in section 3.4 of C.1, the Planetary Science Research Program Overview. If the data to be analyzed have issues that might represent an obstacle to analysis, the proposers must demonstrate clearly and satisfactorily how such potential difficulties will be overcome.

3.2 Facilities and Data Sources Available to Proposers

Refer to section 4 of C.1, the Planetary Science Research Program Overview, for a detailed list of the data and astromaterials resources, and facilities available to proposers to this program element, and how to use them. If their use is anticipated, this should be discussed and justified in the submitted proposals (especially note the provision for such discussion in the proposal section entitled Facilities and Equipment).

Also note that, per the directions in the *NASA Guidebook for Proposers*, a letter of support may be required from any facility required for the proposed effort.

3.3 Data Management Plans (DMPs)

Proposals submitted to this program element must include a Data Management Plan (see C.1, Section 3.6), and since samples are an important component of Exobiology Research, please discuss both data and sample management as part of the Data Management Plan. This must be placed in a special section, not to exceed two pages in length, immediately following the References and Citations section for the Scientific/Technical/Management portion of the proposal.

3.4 Geologic Maps

Proposers who plan investigations involving geologic mapping should consult C.1, Section 3.8, for guidance on submission and requirements for publication of U.S. Geological Survey (USGS) maps. The scientific goal of such a geologic map product should be clearly explained and justified.

4. Proposal Submission Process

This program element requests a Notice of Intent (NOI) by the due date given in Tables 2 and 3 of this NRA. An NOI is not required to submit a full proposal and is submitted by the PI, not the Authorized Organizational Representative (AOR). Proposals submitted by the AOR are due by the date given in Tables 2 and 3 of this NRA.

Proposals must follow all formatting requirements that are described in program element C.1 and in the *NASA Guidebook for Proposers*. Violation of these rules is sufficient grounds for a proposal to be rejected.

5. Summary of Key Information

Expected program budget for first year of new awards	~$3M
Number of new awards pending adequate proposals of merit	~20
Maximum duration of awards	4 years; shorter term proposals (1-3 years) are typical; fourth year must be explicitly and scientifically justified.
Due date for NOIs	See Tables 2 and 3 of this ROSES NRA.
Due date for proposals	See Tables 2 and 3 of this ROSES NRA.
Planning date for start of investigation	6 months after proposal due date.
Page limit for the central Science/Technical/Management section of proposal	15 pp; see also Table 1 of the ROSES *Summary of Solicitation* and the *NASA Guidebook for Proposers.*
Relevance	This program is relevant to the Planetary Science questions and goals in the NASA Science Plan. Proposals that are relevant to this program are, by definition, relevant to NASA.

General information and overview of this solicitation	See the *ROSES Summary of Solicitation*.
Detailed instructions for the preparation and submission of proposals	Please see ROSES *Summary of Solicitation* Section I(g) Order of Precedence and the *NASA Guidebook for Proposers*.
Submission medium	Electronic proposal submission is required; no hard copy is permitted.
Web site for submission of NOIs and proposals via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Web site for submission of NOIs and proposals via Grants.gov	http://grants.gov (help desk available at support@grants.gov or (800) 518-4726)
Funding opportunity number for downloading an application package from Grants.gov	NNH19ZDA001N-EXO
NASA point of contact concerning this program	Lindsay Hays Planetary Science Division Science Mission Directorate NASA Headquarters Washington, DC 20546-0001 Telephone: 650-604-3668 Email: lindsay.hays@nasa.gov Caucus email: HQ-EXO@mail.nasa.gov

C.6 SOLAR SYSTEM OBSERVATIONS

NOTICE: The Near-Earth Object Observations (NEOO) sub-element is no longer solicited as part of this program element. When NEOO is next solicited it will be as a separate element in ROSES Appendix C announced no fewer than 90 days in advance of the proposal due date. We do not anticipate soliciting NEOO until ROSES 2020.

This program element continues to use a two-step proposal submission process described in Section 2 of C.1 The Planetary Science Division Research Program Overview.

1. Scope of Program

Solar System Observations (SSO) supports primarily ground-based and limited airborne- and space-based astronomical observations of bodies in our Solar System. Proposals are solicited for observations over the entire range of wavelengths, from the ultraviolet to radio, that contribute to the understanding of the nature and evolution of the Solar System and its individual constituents.

Full PI-led suborbital missions involving balloons, sounding rockets, or aircraft are not being solicited until further notice. Hosted payloads on already-funded suborbital platforms will be considered.

The Near-Earth Object Observations (NEOO) sub-element is not solicited as part of this program element (see NOTICE above).

Proposals to this program element must contain as a primary element new observations of Solar System objects (excluding Earth and Sun) during the period of the award's performance. They must also support NASA Solar System exploration objectives that are not being met by current spacecraft missions, or that would directly support specific flight missions, either in development or operations, but have not been planned by those missions. Those objectives are discussed in more detail in the 2018 NASA Science Plan available at https://science.nasa.gov/about-us/science-strategy/.

Ground-based observations over any range of wavelengths that complement NASA missions returning significant amounts of data within the next three years are especially encouraged. Such observations may be made at any currently operating ground-based facility, public or private, including those supported by NASA. Investigations proposing to use existing airborne or space-based assets are only permitted if those missions do not already provide a funded observer program.

Proposals to utilize data to be obtained from large surveys, or other sources where the data are obtained in a continuous routine manner for general use, must include a member of the data collection team as a Co-Investigator (Co-I) or as a Collaborator and must utilize data acquired during the award period of performance in order to meet the requirement for an element of new observation.

Considered proposals must include detailed scientific analysis and publication plans.

2. Programmatic Considerations

2.1 Additional Funding for Relevant Instrumentation Construction or Upgrade

Proposers to Solar System Observations are eligible to request funds for major equipment under the Planetary Major Equipment and Facilities (PMEF) program. See program element C.17 for information on how to append a PMEF request to a regular Solar System Observations research proposal or submit a stand-alone PMEF proposal to supplement an existing Solar System Observations award.

2.2 Proposals Utilizing Goldstone Planetary Radar

Proposals intending to use the planetary radar capabilities of the Deep Space Network Goldstone complex must contact the JPL Goldstone Solar System Radar (GSSR) Task Manager listed below for information on costs associated with using the Goldstone radar, which must be included in the proposal.

GSSR Task Manager:

Martin Slade
M/S 238-420
Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, CA 91109
Telephone: (818) 354-2765
Email: Martin.A.Slade@jpl.nasa.gov

3. Resources: Information, Data, and Facilities

3.1 Limits on Use of Mission Data

Proposals to this program element must follow the rules for use of mission data given in program element C.1, section 3.4. If the data to be analyzed have issues that might represent an obstacle to analysis, the proposers must demonstrate clearly and satisfactorily how such potential difficulties will be overcome.

3.2 Facilities and Data Sources Available to Proposers

Please refer to ROSES program element C.1, section 4, for a detailed list of the data and astromaterials resources, and facilities available to proposers to this program element, and how to use them. If their use is anticipated, this should be discussed and justified in the submitted proposals (especially note the provision for such discussion in the proposal section entitled Facilities and Equipment). Also note that, per the directions in the *NASA Guidebook for Proposers*, a letter of support may be required from any facility required for the proposed effort.

3.3 Data Management Plans (DMPs)

Proposals submitted to this program element must include a Data Management Plan (see program element C.1, Section 3.6). This must be placed in a special section, not to exceed two pages in length, immediately following the References and Citations section for the Scientific/Technical/Management portion of the proposal.

3.4 Geologic Maps

Proposers who plan investigations involving geologic mapping should consult program element C.1, Section 3.8, for guidance on submission and requirements for publication of U.S. Geological Survey (USGS) maps. The scientific goal of such a geologic map product should be clearly explained and justified.

3.5 Planetary Science Early Career Award

Details of the new Planetary Science Early Career Award (ECA) program are given in program element C.19. The aim of this program is to support research and professional development of outstanding early-career scientists, and to help stimulate research careers in areas supported by the Planetary Sciences Division. This program is an ECA-participating ROSES program element. Proposals from eligible PIs, or Science PIs if applicable, selected from this program in 2019 may become the 'parent award' for future ECA proposals (i.e., in 2020 or later).

4. Proposal Submission Process

This program element uses a two-step proposal submission process described in program element C.1, Section 2.

Proposers are reminded that Step-1 proposals are mandatory and must be submitted by the proposing organization.

Proposals must follow all formatting requirements that are described in program element C.1 and in the *NASA Guidebook for Proposers*. Violation of these rules is sufficient grounds for a proposal to be rejected.

5. Summary of Key Information

Expected program budget for first year of new awards	~$1M
Number of new awards pending adequate proposals of merit	~8-10
Maximum duration of awards	Typical awards are 3 years. Up to 5 years permitted.
Due date for Step-1 proposals	See Tables 2 and 3 of this ROSES NRA.
Due date for Step-2 proposals	See Tables 2 and 3 of this ROSES NRA.
Planning date for start of investigation	~7 months after Step-2 proposal due date.
Page limit for the central Science/Technical/Management section of proposal	15 pp; see also Table 1 of the ROSES *Summary of Solicitation* and the *NASA Guidebook for Proposers.*
Relevance	This program is relevant to the Planetary Science questions and goals in the NASA Science Plan. Proposals that are relevant to this program are, by definition, relevant to NASA.
General information and overview of this solicitation	See the *ROSES Summary of Solicitation*.

Detailed instructions for the preparation and submission of proposals	Please see ROSES *Summary of Solicitation* Section I(g) Order of Precedence, Table 1, and the *NASA Guidebook for Proposers*.
Submission medium	Electronic proposal submission is required; no hard copy is permitted.
Web site for submission of Step-1 and Step-2 proposals via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Web site for submission of Step-1 and Step-2 proposals via Grants.gov	http://grants.gov/ (help desk available at support@grants.gov or (800) 518-4726)
Funding opportunity number for downloading an application package from Grants.gov	NNH19ZDA001N-SSO
NASA points of contact concerning this program: Planetary Science Division Science Mission Directorate NASA Headquarters Washington, DC 20546-0001	Doris Daou Email: doris.daou-1@nasa.gov Kelly Fast Email: kelly.e.fast@nasa.gov

C.7 NEW FRONTIERS DATA ANALYSIS PROGRAM

NOTICE: This program requires a Notice of Intent (NOI). Proposals that are not preceded by the mandatory NOI may be returned without review. No feedback will be provided in response to the NOI.

Proposals to this program element are subject to a relevance requirement in addition to and that supersedes those detailed in the ROSES *Summary of Solicitation*, see Section 2.2 of this program element. Proposals that do not fulfill these requirements may be returned without review.

The scope of this program element also differs slightly from the other Planetary Science Division Data Analysis Programs. Proposers are expected to carefully read the solicitation and should email the program point of contact with any questions sufficiently ahead of the NOI deadline. In addition, the NSPIRES page has an FAQ that holds answers to common questions about this program.

1. Scope of Program

1.1 Programmatic Overview

The objective of the New Frontiers Data Analysis Program (NFDAP) is to enhance the scientific return from New Frontiers missions by broadening scientific participation in the analysis and interpretation of data returned by these missions. Other mission and non-mission data sets may be used to supplement these data in a supporting role, but all proposals require the use of data from at least one New Frontiers mission.

This program solicits research proposals to conduct scientific investigations utilizing or enhancing the utilization of data obtained by the New Frontiers missions. For the purposes of this solicitation, "data" is understood to include both uncalibrated and calibrated data as well as higher-order data products produced from the mission data.

Investigations using New Frontiers Mission data may also use mission data supported by a separate Data Analysis program for outer Solar System single-body or comparative-planetology studies that require the use of those New Frontiers mission data for at least one of the bodies of focus.

All proposals to NFDAP must identify and address a clear objective with science research that would be a significant, not incremental, advance in the state of knowledge of the research topic. Tasks responsive to this call include 1) data analysis tasks, 2) non-data-analysis tasks that are necessary to analyze or interpret the data, and 3) non-data-analysis tasks that significantly enhance the use or facilitate the interpretation of mission data. These tasks may incorporate theory, modeling, laboratory studies, correlative analyses, and/or other research. Proposals that include non-data-analysis tasks to enhance the use or facilitate the interpretation of mission data must incorporate the results of such tasks in the analysis or interpretation of mission data to be responsive to this call.

1.2 Mission Data and Produced Data Products

Higher-order mission data products produced as part of funded research must be made publicly available, following the guidelines described in Section 3.6 of C.1, Planetary Science Overview ("Data Management Plans and Archiving"). Proposed data products for delivery to the PDS must be clearly described, appropriate time and effort for delivery and ingestion must be budgeted, and the proposal must include a letter from the manager of the appropriate PDS data node. For additional information, refer to the PDS Proposer's Archiving guide at https://pds.nasa.gov/home/proposers/proposing-programs.shtml. Data products, including maps, improved calibrations, etc., must be submitted to the PDS or the USGS, as appropriate, by the end of the funded research period, unless the investigator explicitly makes a case in the proposal for a later date. Each research proposal must constitute a stand-alone scientific investigation, with stated lines of inquiry, and result in one or more peer-reviewed publications.

2. Programmatic Information

2.1 Exclusions

Proposals to this program must include a science investigation. Proposals to produce a higher-order data product that enhances the science return from one or more missions, but without a larger science investigation, must be submitted to the Planetary Data Archiving, Restoration, and Tools (PDART) Program, C.4.

2.2 Relevance Statement Requirement

Proposals to this program must discuss relevance in a (4000-character max) text box on the cover pages via the NSPIRES web interface for this program element. This section is outside of the 15-page Scientific/Technical/Management Section and the relocation of the relevance discussion does not decrease that 15-page limit. This requirement supersedes the *NASA Guidebook for Proposers* and the *ROSES Summary of Solicitation*, and the omission of this section is sufficient reason for a proposal to be returned without review. The relevance discussion must explicitly refer to this program element and the section of the solicitation to which the proposal is responsive. If the proposed work is close in scope to research covered by any other program element, this discussion must also justify why it is more relevant to this program element than that other program element. This discussion may not be used to address the proposal's intrinsic merit, budget justification, or any other factor that remains in the 15-page main body, or any other section, of the proposal.

3. Data, Facilities, and Archiving

3.1 Use of Mission Data

Proposals to this program element must follow the rules for use of mission data given in program element C.1, The Planetary Science Division Research Program Overview, Section 3.4.

- Mission information can be accessed via the NASA websites.
    - Juno: https://www.nasa.gov/mission_pages/juno/main/index.html
    - New Horizons: https://www.nasa.gov/mission_pages/newhorizons/main/index.html

- OSIRIS-REx: https://www.nasa.gov/mission_pages/osiris-rex/index.html

- Mission data information can be accessed via the PDS webpages.
  - Juno: https://pds-atmospheres.nmsu.edu/data_and_services/atmospheres_data/JUNO/juno.html
  - New Horizons: http://pds-smallbodies.astro.umd.edu/data_sb/missions/newhorizons/index.shtml
  - OSIRIS-Rex: https://pds-smallbodies.astro.umd.edu/data_sb/missions/orex/index.shtml

3.2 Facilities and Data Sources Available to Proposers

Proposers are advised to read Section 4 of program element C.1 for information on facilities and data sources that are available to supported investigators. If their use is anticipated, this should be discussed and justified in the submitted proposals (especially note the provision for such discussion in the proposal section entitled Facilities and Equipment). Also note that, per the directions in the *NASA Guidebook for Proposers*, a letter of support may be required from any facility required for the proposed effort.

3.3 Data Archiving and Map Publication

Proposals submitted to this program element must include a Data Management Plan (see program element C.1, Section 3.6). This must be placed in a special section, no longer than two pages in length, immediately following the References and Citations section for the Scientific/Technical/Management portion of the proposal.

Selected investigations may result in data products and software tools that are of broad use to the science community, including maps, data with improved calibrations, etc. NASA strongly encourages that such data be archived in the Planetary Data System (http://pds.nasa.gov/), or equivalent public archive, by the end of the award period. Proposers are advised to read program element C.1, The Planetary Science Division Research Program Overview, for information on including an archiving plan in the proposal.

Proposed investigations of any planetary or satellite surface that are intended to result in the publication of a Scientific Investigations Map (SIM) by the U.S. Geological Survey (USGS) should check the relevant box on the proposal Cover Page and clearly indicate this intention in the Proposal Summary, as well as in the text of the proposal. The scientific goal of such a geologic map product should be clearly explained and justified. Proposers are advised to read program element C.1, Section 3.8, for the USGS' information on and requirements for map production and publication.

4. Mandatory Notice of Intent

To facilitate the early recruitment of a conflict-free review panel and ensure that proposals are submitted to the appropriate category, an NOI will be required for all submissions to this program element. Proposals that are not preceded by an NOI may be returned without review. The PI may not be changed after NOI submission and proposers who want to add funded investigators between the NOI and the proposal submission must inform the point of contact identified in the summary table of key information at least two weeks in advance of the proposal due date. Additions of funded investigators within two weeks of the proposal deadline require explicit permission from the NASA point of contact. Submission of an NOI does not obligate the proposer to submit a full proposal later.

5. Planetary Science Early Career Award

Details of the new Planetary Science Early Career Award (ECA) program are given in program element C.19. The aim of this program is to support research and professional development of outstanding early-career scientists, and to help stimulate research careers in areas supported by the Planetary Sciences Division. This program is an ECA-participating ROSES program element. Proposals from eligible PIs, or Science PIs if applicable, selected from this program in 2019 may become the 'parent award' for future ECA proposals (i.e., in 2020 or later).

6. Summary of Key Information

Expected program budget for first year of new awards	~ $1.5 M/Year
Number of new awards pending adequate proposals of merit	~ 8-12 total
Maximum duration of awards	3 years
Due date for mandatory Notice of Intent (NOI)	See Tables 2 and 3 of this ROSES NRA.
Due date for proposal	See Tables 2 and 3 of this ROSES NRA.
Planning date for start of investigation	~6 months after proposal due date.
Page limit for the central Science-Technical-Management section of proposal	15 pp; see also Table 1 of the ROSES *Summary of Solicitation* and the *NASA Guidebook for Proposers*.
Relevance	This program is relevant to the Planetary Science questions, and goals in the NASA Science Plan. Proposals that are relevant to this program are, by definition, relevant to NASA.
General information and overview of this solicitation	See the *ROSES Summary of Solicitation*.
Detailed instructions for the preparation and submission of proposals	Please see ROSES *Summary of Solicitation* Section I(g) Order of Precedence and the *NASA Guidebook for Proposers*.
Submission medium	Electronic proposal submission is required; no hard copy is permitted
Web site for submission of NOI and proposal via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Web site for submission of proposal via Grants.gov	http://grants.gov (help desk available at support@grants.gov or (800) 518-4726)

Funding opportunity number for downloading an application package from Grants.gov	NNH19ZDA001N-NFDAP
NASA point of contact concerning this program	Henry Throop Planetary Science Division Science Mission Directorate NASA Headquarters Washington, DC 20546-0001 Email: HQ-NFDAP@mail.nasa.gov Telephone: (202) 358-3709

C.8 LUNAR DATA ANALYSIS PROGRAM

NOTICE: This program element continues to use a two-step proposal submission process described in Section 2 of C.1 The Planetary Science Division Research Program Overview.

1. Scope of Program

1.1 Program Overview

The Lunar Data Analysis Program (LDAP) program funds research on the analysis of recent lunar missions in order to enhance their scientific return. LDAP broadens scientific participation in the analysis of mission data sets and funds high-priority areas of research that support planning for future lunar missions.

LDAP supports scientific investigations of the Moon using publicly available (released) data. These include the following missions:

Lunar Crater Observation and Sensing Satellite (LCROSS),
Moon Mineralogy Mapper (M3),
Lunar Reconnaissance Orbiter (LRO),
Gravity Recovery and Interior Laboratory (GRAIL),
Acceleration, Reconnection, Turbulence, and Electrodynamics of the Moon's Interaction with the Sun (ARTEMIS),
Lunar Atmosphere and Dust Environment Explorer (LADEE),
Lunar Prospector (LP),
Deep Impact Lunar Flyby,
Non-U.S. missions: Kaguya, Chang'e 1, Chang'e 2, Chandrayaan-1, Chang'e 3.

Any proposal may incorporate the investigation of data from more than one mission.

An investigator may propose a study (e.g., scientific, landing site science, cartographic, topographic, geodetic research, etc.) based on analysis of lunar data collected by spacecraft at the Moon (listed above). Proposals may incorporate the analysis of data from more than one mission. Moreover, data analyses that require the use of older mission data sets (e.g., Apollo, Clementine) are allowable in the context of enhancing the analysis and understanding of the data from the missions listed above. The use of older data sets as complementary/supplementary data sets to the missions listed above for the purpose of creating a needed data product (e.g., maps) for analysis is allowable. Additional information about NASA and other lunar missions can be found at NASA's National Space Science Data Center (NSSDC) at: http://nssdc.gsfc.nasa.gov/planetary/planets/moonpage.html.

LDAP solicits proposals that enhance the scientific return of lunar missions through the use of mission data. Tasks responsive to this call include 1) data analysis tasks, 2) nondata-analysis tasks that require the use of lunar mission data, and 3) nondata-analysis tasks that significantly enhance the use or facilitate the interpretation of lunar mission data. These tasks may incorporate theory, modeling, laboratory studies, correlative analyses, and/or other research. Nondata-analysis tasks that are responsive to this call are defined as tasks that are necessary to analyze (or help analyze) the lunar mission data. All proposals must include a complete science investigation. Proposals that include nondata-analysis tasks that do not incorporate the results of such tasks in the analysis of lunar mission data will not be deemed responsive to this call. Proposals whose principle objective is the production of data products for use by other researchers are appropriate for submission to program element C.4 Planetary Data Archiving, Restoration, and Tools (PDART).

Investigations are welcome in the following high priority areas of lunar research:

- Identification and/or characterization of potential landing sites of high lunar science return (e.g., geomorphology, regolith, radiation, and compositional properties);
- Modeling of the lunar gravitational field, global topography, and global lunar figure;
- Enhancement of the lunar geodetic network to enable precision lunar landing;
- Identification, distribution, transport, and characterization of volatiles in and on the Moon;
- Determination of the size and state of the lunar core;
- Determination of lunar lithospheric thickness;
- Lunar "change detection" (i.e., detection of surface or atmospheric changes as a function of time);
- Characterization of the global variability and structure of the lunar exosphere and/or dust environment;
- Identification/characterization of lunar mineralogy as a function of location and depth.

A description of science research priorities for lunar exploration can be found in the documents: *The Scientific Context for Exploration of the Moon (2007),* obtained at http://books.nap.edu/catalog.php?record_id=11954, and *Vision and Voyages for Planetary Science in the Decade 2013-2022 (2011),* obtained at http://www.nap.edu/catalog.php?record_id=13117. Both documents are published by the Space Studies Board of the National Research Council.

LDAP will consider requests for support of new ground-based observations of the Moon provided that such requests are clearly described and that the observations are essential to the success of the work proposed. Requests to support such tasks are only allowable in the context of enhancing the analysis and understanding of the data from the missions listed above.

Investigators interested in proposing mostly theoretical, modeling, laboratory, or field studies that do not directly use spacecraft data are advised that such studies are not appropriate for LDAP, but may be suitable for submission to the C.2 Emerging Worlds or C.3 Solar System Workings Programs.

1.2 Sources of Information and Data

The LDAP program supports research investigations relevant to the scientific interpretation of lunar mission data that are now in the public domain. LDAP supports investigations that use only publicly available and released data. Data to be used in proposed investigations must be available in the Planetary Data System (PDS) (http://pds.nasa.gov) or an equivalent publicly accessible archive at least 30 days prior to the submission due date for LDAP Step-2 proposals. Spacecraft data that have not been placed in the public domain may not be proposed for use in LDAP investigations. (Once a proposal has been awarded, investigators are free to augment the proposed dataset under analysis with data deposited in the PDS (or an equivalent publically available archive) subsequent to 30 days prior to the LDAP submission date.)

Whether from the PDS or another source, if the data to be analyzed are not certified or otherwise have issues that might represent an obstacle to analysis, the obligation is on the proposer to clearly demonstrate that such potential difficulties can be overcome. Likewise, this requirement applies to proposals that make use of planetary data from international missions that do not have their data deposited in the PDS.

In all cases, it is the responsibility of the LDAP investigator to acquire any necessary data; therefore, before submitting a proposal, proposers must demonstrate in their proposal that the necessary data are available. Proposers who wish to use photographic and cartographic materials may access such data through the nearest Regional Planetary Image Facility (RPIF). RPIF locations are listed on the RPIF home page at http://www.lpi.usra.edu/library/RPIF.

1.2.1 Flight Team Member Requirements

Members of current spacecraft flight teams who wish to apply to the LDAP program must clearly demonstrate that their proposed investigation will use only released and publicly available data. Flight team members must scrupulously comply with the 30 days prior to submission rule (above). Additionally, proposals from current flight team members must rigorously demonstrate how the proposed LDAP research does not overlap – and is not redundant with – data analysis duties/responsibilities already funded within their respective mission. This requirement applies to all members of the proposal team.

1.3 Data Products and Data Archiving and Map Publication

Investigators may propose to produce data products (e.g., cartographic products, such as geologic, topographic, or mineral maps, and/or calibration data). Such investigations must have associated scientific tasks. Proposers interested in producing data products that do not have associated scientific tasks are directed to the Planetary Data Archiving Restoration and Tools Program (program element C.4 PDART). Proposers who plan investigations involving geologic mapping should consult program element C.1, Section 3.8, for guidance on submission and requirements for publication of U.S. Geological Survey (USGS) maps. The scientific goal of such a geologic map product should be clearly explained and justified.

A plan for archiving and making products readily available must be included in any proposed investigation that will result in the production of data products. NASA reserves the option to require the archiving in the Planetary Data System (http://pds.nasa.gov/) of any data products resulting from LDAP selected proposals.

Proposals submitted to this program element must include a Data Management Plan (see program element C.1, Section 3.6). This must be placed in a special section, not to exceed two pages in length, immediately following the References and Citations section of the Scientific/Technical/ Management portion of the proposal.

Proposers should refer to the most recent versions of the following documents for information on PDS compliance:

Document	Hyperlink
Proposer's Archive Guide	https://pds.nasa.gov/home/proposers/proposing-programs.shtml
Standards Reference	http://pds.nasa.gov/pds4/doc/sr/

Additional information on the PDS may be obtained from the following individuals:

Contact	Title	Email
William Knopf	Program Executive	william.knopf-1@nasa.gov
Thomas Morgan	Project Manager	thomas.h.morgan@nasa.gov

2. Programmatic Information

2.1 NASA Provided High-End Computational (HEC) Facilities

Those investigators whose research requires high-performance computing should refer to the *ROSES Summary of Solicitation*, Section I(d), "NASA-provided High-End Computing Resources." This section describes the opportunity for successful proposers to this program to apply for computing time on either of two NASA computing facilities at the Goddard Space Flight Center's Computational and Information Sciences and Technology Office or at the Ames Research Center's Advanced Supercomputing Division.

2.2 The Two-Step Submission Process

This program element uses a two-step proposal submission process described in program element C.1, Section 2.

Proposers are reminded that Step-1 proposals are mandatory and must be submitted by the proposing organization.

Proposals must follow all formatting requirements that are described in program element C.1 and in the *NASA Guidebook for Proposers*. Violation of these rules is sufficient grounds for a proposal to be rejected.

2.3 Duration and Size of Awards

The maximum duration of awards from this program element is four years (not including no cost extensions). It is anticipated that most proposals will seek funding for up to three years. Proposals seeking funding for less than three years are highly encouraged for projects that can be completed on shorter timescales. The appropriateness of the proposed funding period will be reviewed and adjustments may be requested. Please refer to program element C.1, Section 3.3, for instructions on submitting requests for more than three years.

Since this is a new program with a new scope, the budget and expected number of new awards is somewhat uncertain, as it may depend on the distribution of topics proposed and the number of proposals submitted. As always, the number of new awards will also depend on the available budget for next Fiscal Year.

The average award size from this program in ROSES-2014 through 2016 was $100K-120K per year, but with a wide range, depending on the nature of the work proposed. When the 2018 LDAP selections are made, that data will be contained on a spreadsheet on the SARA grant stats web page. Proposers are encouraged to request specifically what is needed to conduct the proposed research.

2.4 Facilities and Data Sources Available to Proposers

Please refer to ROSES program element C.1, section 4, for a detailed list of the data and astromaterials resources, and facilities available to proposers to this program element, and how to use them. If their use is anticipated, this should be discussed and justified in the submitted proposals (especially note the provision for such discussion in the proposal section entitled Facilities and Equipment). Also note that, per the directions in the *NASA Guidebook for Proposers*, a letter of support may be required from any facility required for the proposed effort.

2.5 Planetary Science Early Career Award

Details of the new Planetary Science Early Career Award (ECA) program are given in program element C.19. The aim of this program is to support research and professional development of outstanding early-career scientists, and to help stimulate research careers in areas supported by the Planetary Sciences Division. This program is an ECA-participating ROSES program element. Proposals from eligible PIs, or Science PIs if applicable, selected from this program in 2019 may become the 'parent award' for future ECA proposals (i.e., in 2020 or later).

3. Summary of Key Information

Expected program budget for first year of new awards	~$1.3M
Number of new awards pending adequate proposals of merit	See Section 2.3
Maximum duration of awards	Four years, but see also Section 2.3
Due date for Step-1 proposals	See Tables 2 and 3 of this ROSES NRA.
Due date for Step-2 proposals	See Tables 2 and 3 of this ROSES NRA.
Planning date for start of investigation	6 months after the Step-2 proposal due date
Page limit for the central Science/Technical/Management section of proposal	15 pp; see also Table 1 of the ROSES *Summary of Solicitation* and the *NASA Guidebook for Proposers.*
Relevance	This program is relevant to the Planetary Science questions, and goals in the NASA Science Plan. Proposals that are relevant to this program are, by definition, relevant to NASA.
General information and overview of this solicitation	See the *ROSES Summary of Solicitation*.

Detailed instructions for the preparation and submission of proposals	Please see ROSES *Summary of Solicitation* Section I(g) Order of Precedence, Table 1, and the *NASA Guidebook for Proposers*.
Submission medium	Electronic proposal submission is required; no hard copy is permitted.
Web site for submission of proposals via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Web site for submission of proposals via Grants.gov	http://grants.gov/ (help desk available at support@grants.gov or (800) 518-4726)
Funding opportunity number for downloading an application package from Grants.gov	NNH19ZDA001N-LDAP
NASA points of contact concerning this program	Robert A. Fogel Planetary Science Division Science Mission Directorate NASA Headquarters Washington, DC 20546-0001 Telephone: (202) 358-2289 Email: rfogel@nasa.gov

C.9 Mars Data Analysis

NOTICE: Amended August 21, 2019. Insight has been added to the list of Missions in Section 1 to allow the inclusion of Insight Mission data in proposals to MDAP. Consequently, the due dates have been delayed. Step-1 proposals are now due by September 20, 2019 and Step-2 proposals by November 20, 2019. New text is in bold.

This program element takes proposals via a two-step proposal submission process described in Section 2 of C.1 The Planetary Science Division Research Program Overview.

Proposals to this program element are subject to a relevance requirement in addition to and that supersedes those detailed in the ROSES *Summary of Solicitation*, see Section 2.2 of this program element. Proposals that do not fulfill these requirements may be returned without review.

1. Scope of Program

The objective of the Mars Data Analysis Program (MDAP) is to enhance the scientific return from missions to Mars conducted by NASA and other space agencies. These include, but are not limited to, the following missions: **Insight,** Mars Pathfinder (MPF), Mars Global Surveyor (MGS), Mars Odyssey (MO), Mars Exploration Rovers (MER), Mars Express (MEX), Mars Reconnaissance Orbiter (MRO), Phoenix (PHX), Mars Science Laboratory (MSL), Mars Atmosphere and Volatile EvolutioN (MAVEN), and ExoMars Trace Gas Orbiter (TGO). Any proposal may incorporate the investigation of data from more than one mission. Additional information about these missions, as well as references containing preliminary science results, can be found on the Mars Exploration Program (MEP) homepage at: http://mars.nasa.gov.

MDAP broadens scientific participation in the analysis of mission data sets and funds high-priority areas of research that support planning for future Mars missions. Investigations that use data derived from other sources (e.g., ground-based radar, Hubble) will also be considered. MDAP supports scientific investigations of Mars using publicly available (released) data.

Investigations submitted to this program must demonstrate how the research to be undertaken will directly improve our understanding of open science questions at Mars relevant to current hypotheses. Tasks responsive to this call include 1) data analysis tasks, 2) nondata-analysis tasks that are necessary to analyze or interpret the data, and 3) nondata-analysis tasks that significantly enhance the use or facilitate the interpretation of mission data. These tasks may incorporate theory, modeling, laboratory studies, correlative analyses, and/or other research, as long as the primary focus of the work is data analysis. All proposals must include a complete science investigation. Proposals that include nondata-analysis tasks to enhance the use or facilitate the interpretation of mission data must incorporate the results of such tasks in the analysis or interpretation of mission data to be responsive to this call. MDAP does not support field studies or the acquisition of new astronomical observations or collection of new data from spacecraft at Mars.

An investigator may also propose in the following areas of Mars research that support planning for future Mars missions, provided that the investigation makes use of publicly-available Mars mission data:

- Improved atmospheric models that further the understanding and forecasting of Mars atmospheric conditions that affect the orbital trajectories of spacecraft and/or the safe passage of spacecraft through the atmosphere, including aerobraking and aerocapture.
- Characterization of potential landing sites for future Mars exploration missions (e.g., geomorphology, distribution and size of rocks, pits, sand dunes, regional and local slopes, surface composition, and texture variability).
- Analysis and comparison of Mars orbital and surface data to increase the predictive accuracy of surface characteristics of Mars from orbit.

Members of active mission or instrument teams who wish to apply to MDAP must clearly demonstrate that their proposed investigation will use only released and publicly available data. Flight team members must scrupulously comply with the 30-days-prior-to-due date rule (above). Additionally, team members must clearly demonstrate how the proposed MDAP research does not overlap and is not redundant with activities already funded by their respective missions.

For more information about the type of research supported by the MDAP, please refer to the abstracts of currently funded investigations that are available online at: http://nspires.nasaprs.com/.

2. Programmatic Information

2.1 Program Exclusions

Investigators proposing studies that do not focus on the tasks listed in Section 1 are advised that such studies are not appropriate for MDAP, but may be suitable for submission to the other programs in Planetary Science.

Proposals to conduct comparative studies between Mars and other Solar System objects are not responsive to this call and are directed to the most appropriate core program in Planetary Science.

Proposals whose principle objective is the production of data products (e.g., cartographic products, such as geologic, topographic, or mineral maps, and/or calibration data) that are not part of a larger science investigation are directed to program element C.4 Planetary Data Archiving, Restoration and Tools (PDART).

MDAP also does not support:

- Proposals for organizing and/or hosting scientific meetings (which should be submitted to Topical Workshops, Symposia, and Conferences, E.2);
- Proposals for detector, instrumentation, or technology development; or
- Investigations whose primary emphasis is fundamental theory, the development of numerical models, or laboratory measurements (unless there is a direct and explicitly presented connection to and use of Mars mission data; in these cases, the primary focus of the proposed work must be data analysis and not simply

using data for model or measurement validation).

2.2 Relevance Statement Requirement

Step-2 proposals to this program element must discuss relevance in a (4000-character maximum) text box on the cover pages via the NSPIRES web interface for this program element. This section is outside of the 15-page Scientific/Technical/Management Section and the relocation of the relevance discussion does not decrease that 15-page limit. This requirement supersedes the *NASA Guidebook for Proposers* and the *ROSES Summary of Solicitation*, and the omission of this section is sufficient reason for a proposal to be returned without review.

The relevance discussion must explicitly refer to this program element and the section of the solicitation to which the proposal is responsive. If the proposed work is close in scope to research covered by any other program element, this discussion must also justify why it is more relevant to this program element than that other program element. This discussion may not be used to address the proposal's intrinsic merit, budget justification, or any other factor that remains in the 15-page main body, or any other section, of the proposal.

2.3 Planetary Science Early Career Award

Details of the new Planetary Science Early Career Award (ECA) program are given in program element C.19. The aim of this program is to support research and professional development of outstanding early-career scientists, and to help stimulate research careers in areas supported by the Planetary Sciences Division. This program is an ECA-participating ROSES program element. Proposals from eligible PIs, or Science PIs if applicable, selected from this program in 2019 may become the 'parent award' for future ECA proposals (i.e., in 2020 or later).

2.4 Data Management Plans (DMPs)

Program element C.1, section 3.6, discusses the requirements for DMPs in proposals to this program element. Please note that DMPs are mandatory for this program element, and must be placed in a special section not to exceed two pages in length, immediately following the References and Citations section of the Scientific/Technical/Management portion of the proposal.

2.5 Duration and Size of Awards

NASA anticipates that most proposals will seek three years of funding. Proposals for less than three years are encouraged for projects that can be completed on shorter timescales. In rare cases, funding for a proposed fourth year may be provided, if the need for the longer duration is sufficiently well justified. The appropriateness of the proposed funding period will be reviewed, and adjustments may be requested. Programmatic balance may limit the opportunities for funding in some areas. Proposers are encouraged to request what they actually need to conduct the research proposed.

2.6 Planetary Major Equipment and Facilities (PMEF) and development of instruments

Proposers to the Mars Data Analysis Program are not eligible to request funds for Planetary Major Equipment (PMEF; program element C.17).

This solicitation does not request proposals for the development of advanced instrument concepts and technologies as precursors to flight instruments. Such proposals may be submitted to program element C.12 Planetary Instrument Concepts for the Advancement of Solar System Observations (PICASSO), for technology readiness levels (TRLs) 1-3 or program element C.13 Maturation of Instruments for Solar System Exploration (MatISSE) for TRLs 4-6.

3. Resources: Information, Data, and Facilities

3.1 Limits on Use of Mission Data

For proposals that contain mission data analysis, planetary spacecraft mission data to be used in proposed investigations must be available in the Planetary Data System (PDS) or equivalent publicly accessible archive at least 30 days prior to the Step-2 proposal due date. Spacecraft data that have not been placed in the public domain may not be proposed for use in MDAP investigations. (Once a proposal has been awarded, investigators are free to augment the proposed dataset under analysis with data deposited in the PDS (or an equivalent publicly available archive) subsequent to 30 days prior to the MDAP Step-2 due date.) Spacecraft data that have not been obtained yet (i.e., future mission data) or those that have not been accepted for distribution in approved archives are not eligible for use in investigations. Note: For this program element, existing derived data products (e.g. data retrievals that required manipulation of the original spacecraft data set), if necessary to address the scientific questions, must also be publicly available in the literature or in a publicly accessible archive at least 30 days prior to the due date for proposals.

Regardless of the archive(s) used, if the data to be analyzed have issues that might represent an obstacle to analysis, the proposers must demonstrate clearly and satisfactorily how such potential difficulties will be overcome. Investigators funded by spacecraft missions who wish to apply, must demonstrate clearly how the proposed research does not overlap and is not redundant with data analysis, duties, or responsibilities already funded by their respective mission(s). Please see C.1 The Planetary Science Division Research Program Overview, for more information.

3.2 Facilities and Data Sources Available to Proposers

Refer to ROSES program element C.1, section 4, for a detailed list of the data and astromaterials resources, and facilities available to proposers to this program element, and how to use them. If their use is anticipated, this should be discussed and justified in the submitted proposal (especially note the provision for such discussion in the proposal section entitled Facilities and Equipment). Also note that, per the directions in the *NASA Guidebook for Proposers*, a letter of support may be required from any facility required for the proposed effort.

Documents that describe the research priorities for Mars exploration include:

- Mars Exploration Program Analysis Group (MEPAG) reports (http://mepag.jpl.nasa.gov/) including *Mars Scientific Goals, Objectives, Investigations, and Priorities* [2010 and subsequent updates];
- The recommendations of the Committee on the Planetary Science Decadal Survey of the National Research Council as described in the Space Studies Board report, *Visions and Voyages for Planetary Science in the Decade 2013-2022* [2011], available at http://www.nap.edu/catalog.php?record_id=13117; and
- *An Astrobiology Strategy for the Exploration of Mars* [2007], by the Space Studies Board of the National Research Council (http://www.nap.edu/catalog.php?record_id=11937).

Additional information is available on the MEP web site at: http://mars.nasa.gov/.

3.3 Geologic Maps

Proposers who plan investigations involving geologic mapping should consult program element C.1, Section 3.8, for guidance on submission and requirements for publication of U.S. Geological Survey (USGS) maps.

4. The Proposal Submission Process

This program element uses a two-step proposal submission process described in Section 2 of program element C.1.

Proposers are reminded that Step-1 proposals are mandatory and must be submitted by the proposing organization.

Proposals must follow all formatting requirements that are described in program element C.1 and in the *NASA Guidebook for Proposers*. Violation of these rules is sufficient grounds for a proposal to be rejected.

5. Summary of Key Information

Expected program budget for first year of new awards	~ $3.0M
Number of new awards pending adequate proposals of merit	~ 20
Maximum duration of awards	4 years
Due date for Step-1 proposals	See Tables 2 and 3 of this ROSES NRA.
Due date for Step-2 proposals	See Tables 2 and 3 of this ROSES NRA.
Planning date for start of investigation	9 months after proposal due date.
Page limit for the central Science/Technical/Management section of proposal	15 pp; see also Table 1 of the ROSES Summary of Solicitation and the *NASA Guidebook for Proposers*.
Relevance	This program is relevant to the Planetary Science questions, and goals in the NASA Science Plan. Proposals that are relevant to this program are, by definition, relevant to NASA. See Section 2.2.

General information and overview of this solicitation	See the *ROSES Summary of Solicitation*.
Detailed instructions for the preparation and submission of proposals	Please see ROSES *Summary of Solicitation* Section I(g) Order of Precedence and the *NASA Guidebook for Proposers*.
Submission medium	Electronic proposal submission is required; no hard copy is permitted.
Web site for submission of Step-1 and Step-2 proposals via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Web site for submission of Step-1 and Step-2 proposals via Grants.gov	http://grants.gov (help desk available at support@grants.gov or (800) 518-4726)
Funding opportunity number for downloading an application package from Grants.gov	NNH19ZDA001N-MDAP
Points of contact concerning this program	Mitch Schulte Planetary Science Division Science Mission Directorate NASA Headquarters Washington, DC 20546-0001 Telephone: (202) 358-2127 Email: mitchell.d.schulte@nasa.gov Adrian Brown Planetary Science Division Science Mission Directorate NASA Headquarters Washington, DC 20546-0001 Email: adrian.j.brown@nasa.gov

C.10 CASSINI DATA ANALYSIS PROGRAM

This program element continues to use a two-step proposal submission process described in Section 2 of C.1 The Planetary Science Division Research Program Overview.

Proposals to this program element are subject to a relevance requirement in addition to and that supersedes those detailed in the ROSES *Summary of Solicitation*, see Section 2.2 of this program element. Proposals that do not fulfill these requirements may be returned without review.

1. Scope of Program

1.1 Programmatic Overview

The objective of the Cassini Data Analysis Program (CDAP) is to enhance the scientific return of the Cassini mission by broadening the scientific participation in the analysis and interpretation of data returned by this mission. Other mission and nonmission data sets may be used with these data, but all proposals must require the use of data from the Cassini mission.

This program solicits research proposals to conduct scientific investigations utilizing data obtained by the Cassini mission. For the purposes of this solicitation, "data" is understood to include both uncalibrated and calibrated data, as well as higher-order data products produced from the mission data. Science investigations may include the use of data from any spacecraft not supported by a separate Planetary Science Division Data Analysis Program and may contain outer solar system comparative planetology studies that require the use of Cassini data for at least one of the bodies of focus.

All proposals to CDAP must identify and address a clear objective with science research that would be a significant, not incremental, advance in the state of knowledge of the research topic. Tasks responsive to this call include 1) data analysis tasks, 2) nondata-analysis tasks that are necessary to analyze or interpret the data, and 3) nondata-analysis tasks that significantly enhance the use or facilitate the interpretation of mission data. These tasks may incorporate theory, modeling, laboratory studies, correlative analyses, and/or other research. Proposals that include nondata-analysis tasks to enhance the use or facilitate the interpretation of mission data must incorporate the results of such tasks in the analysis or interpretation of mission data to be responsive to this call.

1.2 Mission Data and Produced Data Products

Higher-order mission data products produced as part of funded research must be made publicly available, following the guidelines described in Section 3.6 of C.1 Planetary Science Overview ("Data Management Plans and Archiving"). Proposed data products for delivery to the PDS must be clearly described, appropriate time and effort for delivery and ingestion must be budgeted, and the proposal must include a letter from the manager of the appropriate PDS data node. For additional information, refer to the PDS Proposer's Archiving guide at https://pds.nasa.gov/home/proposers/ (choose Proposers to Individual R&A Programs). Data products, including maps, improved calibrations, etc., must be submitted to the PDS or the U.S. Geological Survey (USGS), as appropriate, by the end of the funded research period, unless the investigator explicitly makes a case in the proposal for a later date. Each research proposal must constitute a stand-alone scientific investigation, with stated lines of inquiry, and result in one or more peer-reviewed publications.

2. Programmatic Information

2.1 Exclusions

Proposals to this program element must include a science investigation. Proposals to produce a higher-order data product that enhances the science return from one or more missions, but without a larger science investigation, must be submitted to the C.4 Planetary Data Archiving, Restoration, and Tools (PDART) program.

Proposals that use non-Cassini mission data that is supported by another Data Analysis Program will be evaluated as not being responsive to this solicitation and must rather be submitted to a more appropriate program element. Proposers are encouraged to read the other program elements in Appendix C.

2.2 Relevance Statement Requirement

Proposals to this program element must discuss relevance in a (4000-character max) text box on the cover pages via the NSPIRES web interface for this program element. This section is outside of the 15-page Scientific/Technical/Management Section and the relocation of the relevance discussion does not decrease that 15-page limit. This requirement supersedes the *NASA Guidebook for Proposers* and the *ROSES Summary of Solicitation*, and the omission of this section is sufficient reason for a proposal to be returned without review. The relevance discussion must explicitly refer to this program element and the section of the solicitation to which the proposal is responsive. If the proposed work is close in scope to research covered by any other program element, this discussion must also justify why it is more relevant to this program element than that other program element. This discussion may not be used to address the proposal's intrinsic merit, budget justification, or any other factor that remains in the 15-page main body, or any other section, of the proposal.

3. Data, Facilities, and Archiving

3.1 Use of Mission Data

Proposals to this program element must follow the rules for use of mission data given in C.1 The Planetary Science Division Research Program Overview, Section 3.4.

- Mission information can be accessed via the NASA website.
    - http://saturn.jpl.nasa.gov/
- Mission data information can be accessed via PDS webpages.
    - http://pds-atmospheres.nmsu.edu/data_and_services/atmospheres_data/Cassini/Cassini.html
    - http://pds-rings.seti.org/cassini/
    - http://pds-rings.seti.org/cassini/data.html

3.2 Facilities and Data Sources Available to Proposers

Proposers are advised to read Section 4 of C.1 for information on facilities and data sources that are available to supported investigators. If their use is anticipated, this should be discussed and justified in the submitted proposals (especially note the provision for such discussion in the proposal section entitled Facilities and Equipment). Also note that, per the directions in the *NASA Guidebook for Proposers*, a letter of support may be required from any facility required for the proposed effort.

3.3 Data Archiving and Map Publication

Proposals submitted to this program element must include a Data Management Plan (see C.1, Section 3.6). This must be placed in a special section, no longer than two pages in length, immediately following the References and Citations section for the Scientific/Technical/Management portion of the proposal.

Selected investigations may result in data products and software tools that are of broad use to the science community, including maps, data with improved calibrations, etc. NASA strongly encourages that such data be archived in the Planetary Data System (http://pds.nasa.gov/), or equivalent public archive, by the end of the award period. Proposers are advised to read C.1 The Planetary Science Division Research Program Overview, for information on including an archiving plan in the proposal.

Proposed investigations of any planetary or satellite surface that are intended to result in the publication of a Scientific Investigations Map (SIM) by the U.S. Geological Survey (USGS) should check the relevant box on the proposal Cover Page and clearly indicate this intention in the Proposal Summary, as well as in the text of the proposal. The scientific goal of such a geologic map product should be clearly explained and justified. Proposers are advised to read C.1, Section 3.8, for the USGS information on and requirements for map production and publication.

4. The Two-Step Submission Process

This program element uses the two-step proposal submission process outlined in C.1, Section 2.

Proposers are reminded that Step-1 proposals are mandatory and must be submitted by the proposing organization.

Proposals must follow all formatting requirements that are described in program element C.1 and in the *NASA Guidebook for Proposers*. Violation of these rules is sufficient grounds for a proposal to be rejected.

5. Planetary Science Early Career Award

Details of the new Planetary Science Early Career Award (ECA) program are given in program element C.19. The aim of this program is to support research and professional development of outstanding early-career scientists, and to help stimulate research careers in areas supported by the Planetary Sciences Division. This program is an ECA-participating ROSES program element. Proposals from eligible PIs, or Science PIs if applicable, selected from this program in 2019 may become the 'parent award' for future ECA proposals (i.e., in 2020 or later).

6. Summary of Key Information

Expected program budget for first year of new awards	~$2.5 M/Year
Number of new awards pending adequate proposals of merit	~12-20 total
Maximum duration of awards	3 years
Due date for Step-1 proposals	See Tables 2 and 3 of this ROSES NRA.
Due date for Step-2 proposals	See Tables 2 and 3 of this ROSES NRA.
Planning date for start of investigation	~6 months after Step-2 proposal due date.
Page limit for the central Science/Technical/Management section of proposal	15 pp; see also Table 1 of the ROSES Summary of Solicitation and the *NASA Guidebook for Proposers.*
Relevance	This program is relevant to the Planetary Science questions, and goals in the NASA Science Plan. Proposals that are relevant to this program are, by definition, relevant to NASA. See Section 2.2.
General information and overview of this solicitation	See the *ROSES Summary of Solicitation*.
Detailed instructions for the preparation and submission of proposals	Please see ROSES *Summary of Solicitation* Section I(g) Order of Precedence and the *NASA Guidebook for Proposers*.
Submission medium	Electronic proposal submission is required; no hard copy is permitted.
Web site for submission of Step-1 and Step-2 proposals via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Web site for submission of Step-1 and Step-2 proposals via Grants.gov	http://grants.gov (help desk available at support@grants.gov or (800) 518-4726)
Funding opportunity number for downloading an application package from Grants.gov	NNH19ZDA001N-CDAP
NASA point of contact concerning this program	K.C. Hansen Planetary Science Division Science Mission Directorate NASA Headquarters Washington, DC 20546-0001 Email: HQ-CDAP@mail.nasa.gov Telephone: (202) 358-1077

C.11 Discovery Data Analysis

NOTICE: Amended June 14, 2019. The Discovery missions previously retired from this program have been reinstated to Section 1.1, and the "Expected program budget for first year of new awards" and "Number of new awards pending adequate proposals of merit" in Section 5 have been changed. New text is in bold and deleted text is struck through. The due dates are unchanged.

This program element continues to solicit proposals via a two-step proposal submission process described in Section 2 of C.1 The Planetary Science Division Research Program Overview.

1. Scope of Program

The objective of the Discovery Data Analysis Program (DDAP) is to enhance the scientific return of Discovery Program missions and broaden the scientific participation in the analysis of data, both recent and archived, collected by Discovery missions.

1.1. Sources and Analysis of Mission Data

In the ROSES-2019 cycle, the scope of DDAP is limited to projects making use of data from the following missions **[Amended June 14, 2019]**:

- **NEAR**
- **Stardust**
- **Stardust-NExT**
- **Genesis**
- **Deep Impact**
- **EPOXI**
- MESSENGER
- Dawn
- Kepler/K2 (Solar System targets only)
- Rosetta

Despite Rosetta not having been a Discovery mission, Rosetta data analysis is supported by the Discovery program (in prior years through the Rosetta Data Analysis Program, and now through DDAP). Projects not making use of data from at least one of these missions are not in scope and are not responsive to the DDAP program element.

Spacecraft data used in DDAP investigations must be available in the Planetary Data System (PDS; https://pds.nasa.gov/), or equivalent publicly accessible archive(s), at least 30 days prior to the Step-2 due date for DDAP proposals. Spacecraft data that have not been placed in such archives are not eligible for use in DDAP investigations. In all cases, it is the responsibility of the DDAP investigator to acquire any necessary data. Investigators are encouraged to contact the archive for assistance in identifying specifics of available datasets.

Spacecraft data that have not yet been obtained (i.e., future mission data), or those that have not been made publicly available in approved archives, as indicated above, may not be proposed for use in DDAP investigations.

Members of mission or instrument teams who wish to apply to DDAP must clearly demonstrate that their proposed investigation will use only released and publicly available data. Flight team members must scrupulously comply with the 30-days-prior-to-due date rule (above). Additionally, team members must clearly demonstrate how the proposed DDAP research does not overlap and is not redundant with activities already funded by their respective mission.

Proposals to DDAP must include a science investigation. Proposals to produce a higher order data product that enhances the science return from one or more missions, but does not include a science investigation, should be submitted to the C.4 Planetary Data Archiving, Restoration, and Tools (PDART) program element.

Proposed work responsive to this call may include (1) data analysis tasks, 2) tasks that are not data analysis but are necessary to analyze or interpret the data, and 3) tasks that are not data analysis but that significantly enhance the use or facilitate the interpretation of Discovery mission data. These tasks may incorporate theory, modeling, laboratory studies, correlative analyses, and/or other research; however, proposals that include tasks that are not data analysis must also incorporate the results of these tasks into the analysis or interpretation of Discovery mission data in order to be responsive to this call.

1.2 Program Exclusions

The Discovery Data Analysis Program is not intended to overlap other active program elements. Therefore, DDAP does not support the analysis of:

- Lunar data (see LDAP, program element C.8);
- Mars data from Mars missions (see MDAP, C.9);
- Data from Cassini (see CDAP, C.10);
- Data from New Frontiers missions (see NFDAP C.7);
- Data from Kepler/K2 on objects outside the Solar System (see ADAP, D.2);
- Data from past Discovery missions not listed in Section 1.1 above.

DDAP also does not support:

- Proposals for organizing and/or hosting scientific meetings (which should be submitted to Topical Workshops, Symposia, and Conferences, E.2);
- Proposals for detector, instrumentation, or technology development (which are supported by other NASA programs); or
- Investigations whose primary emphasis is fundamental theory, the development of numerical models, or laboratory measurements (unless there is a direct and explicitly presented connection to Discovery mission data).

The Planetary Science Division solicits proposals whose work efforts are primarily analysis of planetary mission data through this and other Data Analysis Programs. If a proposal would analyze data within the scope of more than one of the data analysis programs in order to perform comparative studies across the Solar System, but is not appropriate to any one data analysis program, then submission to a Core Research Program (e.g., Solar System Workings, Emerging Worlds, Solar System Observations) is encouraged. If a proposal is not appropriate for one of the Data Analysis programs, but does fit within the bounds of a Core Research Program, it should be submitted to that Core Program.

2. The Two-Step Submission Process

This program element uses a two-step proposal submission process described in program element C.1, Section 2.

Proposers are reminded that Step-1 proposals are mandatory and must be submitted by the proposing organization.

Proposals must follow all formatting requirements that are described in program element C.1 and in the *NASA Guidebook for Proposers*. Violation of these rules is sufficient grounds for a proposal to be rejected.

3. Programmatic Information

3.1 Program-Specific Evaluation Criteria

As part of the evaluation of Intrinsic Merit, the following evaluation factors will be taken into account (not to the exclusion of other standard factors described in the *Proposers Guidebook*): (a) The extent to which datasets to be used in the proposed work are clearly and specifically identified in the proposal; (b) the extent to which the proposal demonstrates clearly that the public data are of sufficient quantity and quality to achieve the project's science goals; (c) the extent to which the proposal demonstrates familiarity with the data and an understanding of the work required to refine the data for the purposes of the analysis; and (d) the extent to which the proposal demonstrates that any known issues with the data, presenting obstacles to analysis, will be overcome.

3.2. Data Management and Archiving

Proposals submitted to this program element must include a Data Management Plan (DMP; see program element C.1, Section 3.6). This must be placed in a special section, not to exceed two pages in length, immediately following the References and Citations section for the Scientific/Technical/Management portion of the proposal.

Data products produced by funded DDAP investigations must be made publicly available, following the guidelines described in Section 3.6 of C.1 Planetary Science Overview ("Data Management Plans and Archiving"). Proposed data products for delivery to the PDS must be clearly described, appropriate time and effort for delivery and ingestion must be budgeted, and the proposal must include a letter from the manager of the appropriate PDS data node. For additional information, refer to the PDS Proposer's Archiving guide at https://pds.nasa.gov/home/proposers/proposing-programs.shtml. Data products, including maps, improved calibrations, etc., must be submitted to the PDS or the U.S. Geological Survey (USGS), as appropriate, by the end of the funded research period, unless the investigator explicitly makes a case in the proposal for a later date.

3.3 Progress Reports

An Annual Progress Report will be due no later than 60 days in advance of the anniversary date of the award. Awards to NASA Centers, including the Jet Propulsion Laboratory (JPL), always have an anniversary date of the start of the Federal fiscal year, October 1.

3.4 Duration of Awards

Typical proposals to this program seek three years of funding or fewer. Please refer to program element C.1, Section 3.3, for instructions on submitting requests for more than three years.

3.5 Planetary Science Early Career Award

Details of the new Planetary Science Early Career Award (ECA) program are given in program element C.19. The aim of this program is to support research and professional development of outstanding early-career scientists, and to help stimulate research careers in areas supported by the Planetary Sciences Division. This program is an ECA-participating ROSES program element. Proposals from eligible PIs, or Science PIs if applicable, selected from this program in 2019 may become the 'parent award' for future ECA proposals (i.e., in 2020 or later).

4. Resources: Information, Data, and Facilities

4.1 Limits on Use of Mission Data

Proposals to this program element must follow the rules for use of mission data given in program element C.1, Section 3.4 and further clarified in Section 1.1 above.

4.2 Facilities and Data Sources Available to Proposers

Proposers are advised to read C.1. The Planetary Science Division Research Program Overview, for information on facilities and data sources that are available to supported investigators. If their use is anticipated, this should be discussed and justified in the submitted proposals (especially note the provision for such discussion in the proposal section entitled Facilities and Equipment). Also note that, per the directions in the *NASA Guidebook for Proposers*, a letter of support may be required from any facility required for the proposed effort.

4.3 Geologic Maps

Proposers who plan investigations involving geologic mapping should consult program element C.1. Section 3.8, for guidance on submission and requirements for publication of U.S. Geological Survey (USGS) maps. The scientific goal of such a geologic map product should be clearly explained and justified.

5. Summary of Key Information

Expected program budget for first year of new awards	~$**2.5** ~~2.7~~ M **[Amended June 14, 2019]**
Number of new awards pending adequate proposals of merit	~**10-16** ~~12-17~~ **[Amended June 14, 2019]**
Maximum duration of awards	4 years; shorter-term proposals (1-3 years) are typical; fourth year must be explicitly and scientifically justified.
Due date for Step-1 proposals	See Tables 2 and 3 of this ROSES NRA.
Due date for Step-2 proposals	See Tables 2 and 3 of this ROSES NRA.
Planning date for start of investigation	~Six months after Step-2 proposal due date.

Page limit for the central Science/Technical/Management section of proposal	15 pp; see also Table 1 of the ROSES *Summary of Solicitation* and the *NASA Guidebook for Proposers*.
Relevance	This program is relevant to the Planetary Science questions and goals in the NASA Science Plan. Proposals that are relevant to this program are, by definition, relevant to NASA.
General information and overview of this solicitation	See the *ROSES Summary of Solicitation*.
Detailed instructions for the preparation and submission of proposals	Please see ROSES *Summary of Solicitation* Section I(g) Order of Precedence, Table 1, and the *NASA Guidebook for Proposers*.
Submission medium	Electronic proposal submission is required; no hard copy is permitted.
Web site for submission of proposals via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Web site for submission of proposals via Grants.gov	http://grants.gov (help desk available at support@grants.gov or (800) 518-4726)
Funding opportunity number for downloading an application package from Grants.gov	NNH19ZDA001N-DDAP
Point of contact concerning this program	Thomas S. Statler Planetary Science Division Science Mission Directorate NASA Headquarters Washington, DC 20546-0001 Email: thomas.s.statler@nasa.gov Telephone: 202-358-0272

C.12 PLANETARY INSTRUMENT CONCEPTS FOR THE ADVANCEMENT OF SOLAR SYSTEM OBSERVATIONS

NOTICE: Proposals to this program will be taken by a two-step process in which the Notice of Intent is replaced by a required Step-1 proposal submitted by an organization Authorized Organizational Representative. See Section 2, of C.1 Planetary Science Research Program Overview for the most recent guidance on how to submit a Step-1 and Step-2 proposal.

Proposals to develop instruments that can function in icy moon environments are particularly encouraged. See Section 1 for more details.

Proposals shall include an entry Summary Chart submitted as a separately uploaded appendix to the Step-2 proposal. See Section 1 for more details. Progress reports are due Semi-Annually. See Section 2.4 for more detail.

Data management plans are not required for this program element.

1. Scope of Program

The goal of the Planetary Instrument Concepts for the Advancement of Solar System Observations (PICASSO) program is to support the development of spacecraft-based instrument components and systems that show promise for use in future planetary missions in support of the Science Mission Directorate's (SMD) Planetary Science Division (PSD). Therefore, the proposed instrument component or system must address specific scientific objectives of likely future planetary science missions.

The PICASSO program seeks proposals to develop new proof-of-concept instruments or instrument components, including sampling technologies, that enable new science by significantly improving instrument measurement capabilities for planetary science missions (such as Discovery, New Frontiers, Mars Exploration, and other planetary programs, including those flown on commercial spacecraft). The objective of the program is to develop low Technology Readiness Level (TRL 1-3) instruments for use in planetary science missions to the point where they may be proposed in response to the Maturation of Instruments for Solar System Exploration (MatISSE) Program, C.13 of ROSES. In most cases that will mean demonstrating that meeting key performance targets is feasible. It is the responsibility of the proposer to demonstrate how their proposed technology addresses significant scientific questions relevant to stated NASA goals and not for NASA to attempt to infer this. Prospective proposers are encouraged to review the most recent Decadal Survey "Visions and Voyages for Planetary Science in the Decade 2013-2022" available at http://solarsystem.nasa.gov/2013decadal/, the goals of the Planetary Science Division as described in the 2014 Science Mission Directorate Science Plan available at http://science.nasa.gov/about-us/science-strategy/, and the astrobiology strategy at https://nai.nasa.gov/media/medialibrary/2016/04/NASA_Astrobiology_Strategy_2015_FINAL_041216.pdf. Proposed investigations may target any Solar System body except the Earth and Sun in order to advance the objectives outlined in the Science Plan.

PICASSO is an instrument hardware development program and as such does not support mission operation and system software or platform technologies such as materials and structures, power generation or conditioning, communications, small satellites, landers, rovers, or any spacecraft technology that does not directly address planetary science instrumentation. Integrating multiple existing instrument systems does not generally demonstrate the proof-of-concept of a new instrument element. In addition, PICASSO does not support proposals that seek to develop ground-based laboratory instruments, or Earth orbital instruments for astronomical or astrophysics space observations. Instrument systems that have already demonstrated key performance targets can be proposed to the MatISSE program (C.13) to be matured for fit, form and function, and testing in relevant use environments.

The nature of specific efforts selected for funding will vary, with emphasis given to innovative technologies that substantially improve instrument measurement capabilities. Explicit comparisons to the current state-of-the-art must quantitatively demonstrate the expected improvements and what new science such improvements would enable. It is anticipated that the science payloads on most future planetary science spacecraft will be limited to small, low-mass, and low power consumption instruments.

2. Programmatic Considerations

2.1 Special Requirements for Proposals

Proposals are solicited under this program element for instrument development only for the mission focus areas described in the Decadal Survey or the Science Plan. All proposals submitted to this program element must specify:

- The mission focus area for which the proposed instrument or component technology is applicable. Instruments that are applicable to more than one mission focus area will be given priority.
- The science objectives of the proposed instrument or component technology. The relationship between the science objectives and the instrumental capabilities must be clearly demonstrated. For those instruments applicable to more than one mission, focus area, or capable of meeting multiple science objectives, examples of science objectives for the proposed mission or missions must be given.
- A quantitative explanation of the key performance metric that is proposed to be advanced, with a quantitative comparison to the state-of-the-art. The state-of-the-art should be a comparison to a similar flight instrument if possible, otherwise a clear definition of the state-of-the-art should be described.
- A detailed description and justification for the entry Technology Readiness Level and a detailed plan for raising the instrument system to the proposed exit Technology Readiness Level. The plan must include a description of milestones, as well as discussions of how the proposed research will advance the Technology Readiness Level of the instrument by a minimum of one TRL. A full description of Technology Readiness Levels (TRLs) 1- 9 appears in Appendix E of NASA Procedural

Requirement 7123.1B and is available on the web at http://nodis3.gsfc.nasa.gov/displayDir.cfm?Internal_ID=N_PR_7123_001B_&page_name=AppendixE.

- How the proposed instrument system or component technology would address planetary protection requirements, as described in the NASA Procedural Requirements document, NPR 8020.12, Version D. Restrictions on operation and hardware cleanliness apply to all instrument systems that are intended to operate in environments where Earth life could proliferate – currently that is considered to be Mars, Europa, Enceladus, and anywhere in the Solar System where warm ice or liquid water is possible and includes instrument systems or component technology associated with detection of signs of life or biosignatures. To address this requirement the proposal shall, at a level appropriate to the exit TRL:
  - Establish whether the instrument will require planetary protection protocols.
  - If the instrument requires planetary protection protocols, describe which specific components could pose a challenge.
  - Describe possible mitigation strategies to meet planetary protection requirements.

  The instrument developer is encouraged to communicate informally with the Office of Planetary Protection regarding planetary protection categorization and associated requirements with a future mission interest as they relate to instrument design and development. For additional information, proposers may contact the NASA Planetary Protection Officer, Dr. Lisa Pratt at lisa.m.pratt@nasa.gov and cc Stephen.A.Rinehart@nasa.gov.

- An entry level Summary Chart, not counted in the page limit, shall be submitted as an appendix to the Step-2 Proposal. A template is available from the SARA web page at https://science.nasa.gov/researchers/templates-planetary-science-division-appendix-c-roses-proposals. The Summary Chart shall contain the following information:
  - Title, PI Name and Institution
  - Target (Mars subsurface, airless body surface, planetary body flyby or orbit, etc.)
  - Bulleted list of science that will be enabled by new instrument
  - Bulleted list of major objectives of proposed work
  - Co-Investigators (Co-Is)/Institutions
  - A figure illustrating and clarifying the proposed concept
  - Top level Milestones
  - Entry and exit technology readiness levels (TRL)

2.2 Additional Selection Considerations

In addition to the criteria specified in Section C.2 of the *NASA Guidebook for Proposers,* the following will also be considered when formulating PICASSO selection recommendations:

- The extent to which the instrument system or subsystem addresses a priority science goal of the mission or missions for which it would be a candidate for flight;
- The extent to which the proposed instrument system or subsystem is applicable to multiple Planetary Science missions;

- The Planetary Science Division strongly encourages proposers to investigate current and recent Small Business Innovative Research awards (http://sbir.gsfc.nasa.gov/abstract_archives) for possible teaming and leveraging of emerging technologies. Collaborations leveraging SBIR funded technologies will be given preference. In addition, selectable proposals that leverage funding from NASA technology development offices and programs such as those in the Space Technology Mission Directorate, will be given additional consideration.

2.3 Award Duration and Types

The typical award duration is three years. Proposals for less than three years are encouraged for projects that can be completed on shorter timescales. All awards will be in the form of Research and Technology Operating Plans (RTOP) to NASA centers, including JPL, interagency funds transfers for other Federal organizations, or grants to other institutions.

2.4 Technical Reporting Requirements

Once awarded, all Progress Reporting deliverables applicable to this PICASSO solicitation shall be submitted to the web-based Planetary Electronic Reporting System (ERS). A user account on ERS will be provided to the PI upon award. Due to NASA IT security requirements, all Principal Investigators (PIs) must register with the Identity Management and Account Exchange (IdMAX) system before a user account on ERS will be established. To create an IdMAX account, some personal information will be required. All submissions shall be made in PDF format.

The following deliverables shall be required of institutions that win awards. In cases where subcontract arrangements exist, consolidated project reports are the responsibility of the PI. The proposed budget should provide for these reporting requirements. In this context, "Annual" refers to a twelve-month task effort that commences at award.

2.4.1 *Semi-Annual Progress Report Deliverable*

The PI shall provide a written Semi-Annual Progress Report at the end of the first six-month calendar period commencing from the date of award and at six-month intervals thereafter. Grant recipients will have additional progress reporting requirements from the NSSC.

The Semi-Annual Report must:

1. Describe the primary findings, technology development results, and technical status, e.g., status of design, construction of prototype implementations, results of tests and/or proof-of-concept demonstrations, etc.;
2. Describe the work planned for the remainder of the project and critical issues that need to be resolved to successfully complete the remaining planned work;
3. Quantitatively summarize the cost and schedule status of the project, including any schedule slippage/acceleration;
4. Include an updated Summary Chart noting changes in team membership, milestones, schedule, and updates to the TRL;

5. Report any educational and outreach components of the project, e.g., graduate degrees, educational activities; technology infusion or patents applied for or granted; journal or conference publications; presentations at professional conferences, seminars, and symposia; demonstrations; media exposure; and, other activities that contributed to the overall success of the research project.

The release of the PI's annual budget allocation is contingent on the timely submission of the written Semi-Annual Progress Report deliverable.

2.4.2 *Final Report*

The PI shall provide a written Final Report at the completion of the activity. The Final Report is similar to the Semi-Annual Report and includes all of the products required in the Semi-Annual Report, with the following exceptions:

- The Final Review must provide conclusions of the work performed and make recommendations for follow-on activities that should be pursued;
- As this is the Final Report, there is no need to present future work plans or a cost profile.

The written Final Report shall include the following:

1. Background of the project, including the science rationale for conducting this technology development;
2. Results of all analyses, element, subsystem, or system designs and/or prototyping implementations and designs;
3. Performance analysis results of tests and/or demonstrations; estimation of reduction(s) in size, mass, power, volume, and/or cost; improved performance; description of newly enabled capability; and documentation of technology dependencies;
4. Tables, graphs, diagrams, curves, sketches, photographs, and drawings in sufficient detail to comprehensively explain the results achieved;
5. An updated TRL assessment;
6. At the end of the period of performance, the PI shall provide a final Accomplishments Chart which contains the following information:
    - Title, PI Name and Institution
    - Target (Mars subsurface, airless body surface, planetary body flyby or orbit, etc.)
    - Bulleted list of science that will be enabled by new instrument
    - Bulleted list of instrument development accomplishments
    - Co-Investigators (Co-Is)/Institutions
    - A figure illustrating and clarifying the proposed concept
    - Exit technology readiness level (TRL)

The written Final Report, Accomplishments Chart, and updated TRL assessment shall be uploaded to the ERS system on or before the designated anniversary date. Links to the templates for all of these documents can be found within the ERS system.

2.5 Planetary Science Early Career Award

Details of the new Planetary Science Early Career Award (ECA) program are given in program element C.19. The aim of this program is to support research and professional development of outstanding early-career scientists, and to help stimulate research careers in areas supported by the Planetary Sciences Division. This program is an ECA-participating ROSES program element. Proposals from eligible PIs, or Science PIs if applicable, selected from this program in 2019 may become the 'parent award' for future ECA proposals (i.e., in 2020 or later).

3. Resources: Information, Data, and Facilities

Proposers to this program are not required to provide a Data Management Plan. However, dissemination of the findings of the effort via conference presentations and journal articles is expected, and the plan for dissemination should be briefly described. Archiving conference presentations and journal articles in ERS is highly encouraged.

3.1 Facilities Available to Proposers

Proposers are advised to read Section 4 of program element C.1, The Planetary Science Division Research Program Overview, for information on facilities that are available to supported investigators. If their use is anticipated, this should be discussed and justified in the submitted proposals (especially note the provision for such discussion in the proposal section entitled Facilities and Equipment). Also note that, per the directions in the *NASA Guidebook for Proposers*, a letter of support may be required from any facility required for the proposed effort.

4. Proposal Submission Process

This program element uses a two-step proposal submission process described in program element C.1, Section 2.

Proposers are reminded that Step-1 proposals are mandatory and must be submitted by the proposing organization.

Proposals must follow all formatting requirements that are described program element C.1 and in the *NASA Guidebook for Proposers*. Violation of these rules is sufficient ground for a proposal to be rejected.

An entry level Quad Chart, not counted in the page limit, shall be submitted as an appendix to the Step-2 Proposal as a separate document uploaded to NSPIRES as document type “Appendix”. See Section 2.1 for more details regarding the Quad Chart.

5. Summary of Key Information

Expected program budget for first year of new awards	~$3.5M
Number of new awards pending adequate proposals of merit	~12 awards
Maximum duration of awards	3 Years
Due date for Step-1 proposals	See Tables 2 and 3 of this ROSES NRA.
Due date for Step-2 proposals	See Tables 2 and 3 of this ROSES NRA.
Planning date for start of investigation	6 months after the Step-2 proposal due date

Page limit for the central Science-Technical-Management section of proposal	15 pp; see also Table 1 of the ROSES *Summary of Solicitation* and the *NASA Guidebook for Proposers*.
Relevance	This program is relevant to the Planetary Science questions and goals in the NASA Science Plan. Proposals that are relevant to this program are, by definition, relevant to NASA.
General information and overview of this solicitation	See the *ROSES Summary of Solicitation*.
Detailed instructions for the preparation and submission of proposals	Please see ROSES *Summary of Solicitation* Section I(g) Order of Precedence, Table 1, and the *NASA Guidebook for Proposers*.
Submission medium	Electronic proposal submission is required; no hard copy is permitted.
Web site for submission of Step-1 and Step-2 proposal via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Web site for submission of Step-1 and Step-2 proposal via Grants.gov	http://grants.gov (help desk available at support@grants.gov or (800) 518-4726)
Funding opportunity number for downloading an application package from Grants.gov	NNH19ZDA001N-PICASSO
Main NASA point of contact concerning this program:	Stephen Rinehart Planetary Science Division Science Mission Directorate National Aeronautics and Space Administration Washington DC 20526-0001 Telephone: 202-358-1884 Email: Stephen.A.Rinehart@nasa.gov
Other NASA points of contact related to this program all of whom share the following postal address: Planetary Science Division National Aeronautics and Space Administration Washington DC 20526-001	Questions concerning Discovery or Astrobiology Program may be addressed to: Mary A. Voytek Senior Scientist for Astrobiology Telephone: 202-358-1577 Email: mary.voytek-1@nasa.gov Questions concerning New Frontiers Program may be addressed to: Curt Niebur New Frontiers Program Discipline Scientist Telephone: 202-358-0390 Email: curt.neibur@nasa.gov

	Questions concerning Mars Exploration Program may be addressed to: Michael A. Meyer Lead Scientist Mars Exploration Program Telephone: 202-358-0307 Email: michael.a.meyer@nasa.gov

C.13 MATURATION OF INSTRUMENTS FOR SOLAR SYSTEM EXPLORATION

NOTICE: NASA does not intend to solicit proposals for this program element in ROSES this year. This program has a two-year cadence, was last solicited in 2018, and it is anticipated that it will be solicited next in ROSES-2020.

1. Scope of Program

The Maturation of Instruments for Solar System Exploration (MatISSE) Program supports the advanced development of spacecraft-based instruments that show promise for use in future planetary missions. The goal of the program is to develop and demonstrate planetary science instruments to the point where they may be proposed in response to future announcements of flight opportunity without additional extensive technology development (approximately technology readiness level [TRL] 6). The proposed instrument must address specific scientific objectives of likely future planetary science missions.

The MatISSE Program seeks proposals for development activities leading to instrument systems in support of the Science Mission Directorate's (SMD) Planetary Science Division. The objectives of the program are to develop new technologies that significantly improve instrument measurement capabilities for planetary science missions (such as Discovery, New Frontiers, Mars Exploration, and other planetary programs, including those flown on commercial spacecraft). It is the responsibility of the proposer to demonstrate how their proposed technology addresses significant scientific questions relevant to stated NASA goals and not for NASA to attempt to infer this.

Only proposals relevant to Planetary Science Division's strategic goals and objectives will be considered for this program element. The MatISSE Program is intended to enable technology infusion into NASA planetary science missions to take place in a timely and efficient manner. As such, the technology readiness level (TRL) that MatISSE supports is TRL 4-6.

It is the responsibility of the proposer to justify the entry and exit level TRL of the proposed technology. Instrument development activities must be planned and initiated so that major technological risk is retired prior to a science solicitation via an Announcement of Opportunity (AO) or Request for Proposal (RFP). This program will permit appropriate funding to be applied at each stage of readiness associated with the development and demonstration of key and enabling technologies, such as breadboarding, brassboarding, and testing of critical components and complete instruments in a relevant environment.

A full description of technology readiness levels (TRLs) 1- 9 appears in Appendix E of NASA Procedural Requirement 7123.1B and is available on the web at *http://nodis3.gsfc.nasa.gov/displayDir.cfm?Internal_ID=N_PR_7123_001B_&page_name=AppendixE*.

Prospective proposers are encouraged to review "Visions and Voyages for Planetary Science in the Decade 2013-2022" (https://solarsystem.nasa.gov/docs/Vision_and_Voyages-FINAL.pdf) for the most recent Decadal Survey) and Science Plan for NASA's Science Mission Directorate 2007-2016 (available at http://science.nasa.gov/about-us/science-strategy/) to learn more about relevant missions.

Proposals not appropriate for MatISSE are feasibility studies, concept formulation, and proof of concept or advanced component development. These proposals should be submitted to the C.12 Planetary Instrument Concepts for the Advancement of Solar System Observations (PICASSO) Program in ROSES. In addition, MatISSE does not support proposals that seek to develop ground-based laboratory instruments; astronomical or astrophysics space observations; auxiliary instrumentation, such as spectrometers for ground based telescopes, mission operation and system software; or any spacecraft technology that does not directly address planetary science instrumentation.

The nature of specific efforts selected for funding will vary, with emphasis given to innovative technologies that improve instrument measurement capabilities. It is anticipated that the science payloads on most future planetary science spacecraft will be limited to small, low mass, and low power consumption instruments.

The Planetary Science Division strongly encourages proposers to investigate current and recent Small Business Innovative Research awards (http://sbir.gsfc.nasa.gov/abstract_archives) as well as NASA programs such as Planetary Instrument Concepts for the Advancement of Solar System Observations (PICASSO), Planetary Instrument Definition and Development Program (PIDDP), Astrobiology Science and Technology for Instrument Development (ASTID), and Game Changing Technologies for possible teaming and leveraging of emerging technologies.

2. Planetary Science Early Career Award

Details of the new Planetary Science Early Career Award (ECA) program are given in program element C.19. The aim of this program is to support research and professional development of outstanding early-career scientists, and to help stimulate research careers in areas supported by the Planetary Sciences Division. This program is an ECA-participating ROSES program element.

3. Point of Contact

Rainee Simons
Planetary Science Division
Science Mission Directorate
National Aeronautics and Space Administration
Washington DC 20526-0001
Telephone: 216-789-0237
Email: rainee.n.simons@nasa.gov

C.14 PLANETARY SCIENCE AND TECHNOLOGY THROUGH ANALOG RESEARCH

This program element continues to use a two-step proposal submission process described in Section 2 of C.1 The Planetary Science Division Research Program Overview.

1. Scope of Program

NASA analog missions research addresses the need for integrated interdisciplinary field experiments as an integral part of preparation for future human and robotic missions. Future planetary research associated with Solar System exploration requires the development of relevant, miniaturized instrumentation capable of extensive operations on lunar, asteroid, and planetary surfaces throughout the Solar System. To this end, and in collaboration with other Directorates at NASA and other agencies, this Planetary Science and Technology Through Analog Research (PSTAR) program solicits proposals for investigations focused on exploring the relevant environments on Earth in order to develop a sound technical and scientific basis to conduct planetary research on other Solar System bodies. The PSTAR program is a science-driven exploration program that is expected to result in new science and operational/technological capabilities to enable the next generation of planetary exploration. Proposals must demonstrate fidelity to at least two of the following three objectives:

1) Science: PSTAR seeks science investigations designed to further planetary research in terrestrial extreme environments that may be analogous to those found on other planets, past or present. Of particular interest are investigations that increase our understanding of the limits of and constraints (or lack thereof) on life in extreme environments and lead to a better understanding of how to seek, identify, and characterize life and life-related chemistry that may exist or have existed on other Solar System bodies. Proposals which claim science fidelity are expected to result in publishable-quality planetary or Earth science results.

2) Science Operations: PSTAR seeks systems-level terrestrial field campaigns that are conducted with complete systems and in a manner that approximates operations during an actual planetary mission, providing an opportunity to understand the performance, capabilities, and efficiencies associated with the tested systems, while enabling human participants to gain operational experience with those systems in the field. Fidelity in this area means that the constraints placed on the execution of science tasks in the field are functionally similar to those of an actual mission, enabling the development, testing, and validation of new concepts of operations that may impact the design of surface infrastructure or ground support. Some examples of science operations elements include:
    a. Decision-making protocols;
    b. Traverse planning;
    c. Sample acquisition, storage, documentation, and high-grading protocols;
    d. Communications and data flow protocols to support science;
    e. Navigation unique to science support;
    f. Crew scheduling for Intra- and Extravehicular activities; and
    g. Science backroom design and support for surface science activities.

Proposals which claim science operations fidelity are expected to describe investigations that rigorously test and evaluate science operations elements, not simply utilize them.

3) Technology: PSTAR seeks the testing and application of technologies that support science investigations, particularly those that enable remote searches for, and identification of, life and life-related chemistry in extreme environments (including lunar and planetary surfaces). These technologies include, but are not limited to:
   a. sample acquisition and handling techniques;
   b. sample manipulation;
   c. the use of mobile science platforms (including planetary rovers and astronauts);
   d. techniques for autonomous operations;
   e. self-contained deployment systems;
   f. intelligent systems and human/robotic interfaces;
   g. communication and navigation systems; and
   h. instrument packages.

PSTAR is not an instrument development program. Science instrument technology proposals should be submitted to C.12 The Planetary Instrument Concepts for the Advancement of Solar System Observations (PICASSO) or C.13 The Maturation of Instruments for Solar System Exploration (MatISSE) Program. Hardware development to ruggedize instruments or otherwise prepare for field trials is acceptable, but is expected to be a minor part of the overall proposed effort.

In summary, PSTAR is expected to lower the risks of planetary exploration through instrument/technology development aimed at or coupled with systems-level field tests in relevant environments that will obtain scientific data and/or develop operational capability.

The high-visibility field campaigns to the Earth's extreme environments that are expected to be supported through this program element should also provide significant opportunities for student involvement in exploration, thereby inspiring a technologically competent next generation of scientists, engineers, explorers, and citizens. Therefore, proposals to PSTAR that provide for graduate or undergraduate science training are encouraged.

In addition, because field activities, particularly those with a high degree of technology fidelity, tend to attract the attention of the public and the media, proposers must include a plan for engaging with the public and media during their field deployment (see section 2.10).

2. Programmatic Information

2.1 General Information

Proposals submitted in response to this call should be for new work that is not currently supported by the Planetary Sciences research and analysis program or for investigations that would extend to their next logical phase those tasks that have been funded, but whose periods of performance expired in this past year or are expiring in the first half of this coming year.

Proposers are strongly advised to read C.1 The Planetary Science Division Research Program Overview, for information on mandatory data management plans.

2.2 Special Requirements for Proposals

Proposals should follow the guidelines set for all ROSES proposals, as given in the *NASA Guidebook for Proposers*.

Proposals should also specify:

- Area(s) of fidelity (Science, Science Operations, and/or Technology, as described in Section 1) that are addressed by the project.
- Specific field activity, site(s), and dates being targeted for their investigation(s), as well as a clear schedule for field preparations, training, and deployment strategy.

Justification for field site selection (see Section 2.4 for restriction on Antarctica).

- If proposed investigation(s) are to be conducted in conjunction with established field campaign(s), proposers must provide evidence of coordination with field campaign leaders.
- Field resource requirements:
    - Duration, timing, and scheduling of investigations
    - Power requirements
    - Communications requirements (bandwidth, type of communications, etc.)
    - Logistics Support Requirements
    - Permits and/or land access/use requirements
- The science objectives and expected science return of the proposed investigation – type and amount of data, validation of science requirements, expected publications, etc.
- Specific deliverables at the conclusion of the field activity.
- Source, type, and amount of external funding already received or expected, if any, for the hardware, software, or operational concepts being tested.
- Risks to the investigation, including weather scrubs, hardware failures, power failures, etc., and a mitigation plan.
- Clear budget, including field deployment costs, logistics support, direct labor, overhead, subcontracts, special equipment, travel, Education and Public Outreach, other costs, General and Administrative Expenses, fees, etc.
- A plan for engaging the public and media during field deployment (see sec 2.10 below).

2.3 Development of Flight Instruments

This solicitation does not request proposals for the development of advanced instrument concepts and technologies as precursors to flight instruments. Such proposals should be submitted to either C.12 Planetary Instrument Concepts for the Advancement of Solar System Observations (PICASSO) or C.13 The Maturation of Instruments for Solar System Exploration (MatISSE) Program.

2.4 Antarctica

The PSTAR program is no longer accepting proposals for work in Antarctica.

2.5 Instrumentation: Construction or Upgrade

Proposers to PSTAR are eligible to request funds for major equipment under the Planetary Major Equipment and Facilities (PMEF) program. See program element C.17 for information on how to append a PMEF request to a regular PSTAR research proposal or submit a stand-alone PMEF proposal to supplement an existing PSTAR award.

2.6 Topical Workshops

The PSTAR program does not accept proposals for topical conferences, workshops, or symposia; such proposals may be submitted in response to program element E.2, "Topical Workshops, Symposia, and Conferences." Proposers should specifically identify the PSTAR program as the relevant SMD program element and refer to the goals and objectives of the PSTAR program in demonstrating relevance.

2.7 Planetary Science Early Career Award

Details of the new Planetary Science Early Career Award (ECA) program are given in program element C.19. The aim of this program is to support research and professional development of outstanding early-career scientists, and to help stimulate research careers in areas supported by the Planetary Sciences Division. This program is an ECA-participating ROSES program element. Proposals from eligible PIs, or Science PIs if applicable, selected from this program in 2019 may become the 'parent award' for future ECA proposals (i.e., in 2020 or later).

2.8 NASA Postdoctoral Program Fellows

Grantees of astrobiology-relevant awards in the program are eligible to serve as mentors to Astrobiology NASA Postdoctoral Program (NPP) Fellows. The tenure of a Fellow must begin before the end of the PSTAR award, but may extend beyond it. Proposals from potential Fellows must be submitted through the standard NPP process. The Astrobiology Program expects to select no more than two Fellows associated with PSTAR research in 2018. More information about the NASA Postdoctoral Program may be found at http://npp.usra.edu/.

2.9 Data Management Plans (DMPs)

Appendix C.1, Section 3.6, discusses the requirements for DMPs in proposals to this program element. Please note that DMPs are mandatory for this program element, and must be placed in a special section no longer than two pages in length, immediately following the References and Citations section for the Scientific/Technical/Management portion of the proposal.

2.10 Plan to engage the Media and Public

Because field activities tend to attract the attention of the public and the media, it is important for teams to be prepared to engage and take advantage of these unique experiences. The description of the plan should be no more than one page and included as an addendum to the 15-page technical proposal immediately following the DMP. Proposals that incorporate public engagement activities, through telepresence capabilities and involvement of professional educators and students nationwide in the fun and challenges of science and technology are particularly encouraged. Proposers should also state in their proposals whether they are willing to host an outside public engagement activity arranged by NASA. Resources budgeted for engagement activities may constitute only a minor component of the proposal.

2.11 Proposal Submission Process

This program element uses a two-step proposal submission process described in Section 2 of Appendix C.1.

Proposers are reminded that Step-1 proposals are mandatory and must be submitted by the proposing organization.

Proposals must follow all formatting requirements that are described in Appendix C.1 and in the *NASA Guidebook for Proposers*. Violation of these rules is sufficient grounds for a proposal to be rejected.

2.12 Duration and Size of Awards

The standard award duration is three years. NASA anticipates that most proposals will seek three years of funding. However, proposals for less than three years are highly encouraged for projects that can be completed on shorter timescales. On rare occasions, four-year projects can be considered, but appropriate justification must be provided. The appropriateness of the proposed funding period will be reviewed and adjustments may be requested. Programmatic balance may limit the opportunities for funding in some areas.

A wide range of award sizes is expected, depending on the nature and scope of the work proposed. We anticipate funding several larger-scope awards (typically $500K-1M per year) and several smaller-scope awards (typically $40-100K per year).

3. Summary of Key Information

Expected program budget for first year of new awards	~$5M
Number of new awards pending adequate proposals of merit	10-12, see Section 2.12
Maximum duration of awards	4 years
Due date for Step-1 proposals	See Tables 2 and 3 of this ROSES NRA.
Due date for Step-2 proposals	See Tables 2 and 3 of this ROSES NRA.
Planning date for start of investigation	8 months after Step-2 proposal due date.
Page limit for the central Science/Technical/Management section of proposal	15 pp; see also Table 1 of the ROSES *Summary of Solicitation* and the *NASA Guidebook for Proposer*
Relevance	This program is relevant to the Planetary Science questions and goals in the NASA Science Plan. Proposals that are relevant to this program are, by definition, relevant to NASA.
General information and overview of this solicitation	See the *ROSES Summary of Solicitation*.

Detailed instructions for the preparation and submission of proposals	Please see ROSES *Summary of Solicitation* Section I(g) Order of Precedence, Table 1, and the *NASA Guidebook for Proposers*.
Submission medium	Electronic proposal submission is required; no hard copy is permitted.
Web site for submission of Step-1 and Step-2 proposals via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Web site for submission of Step-1 and Step-2 proposals via Grants.gov	http://grants.gov (help desk available at support@grants.gov or (800) 518-4726)
Funding opportunity number for downloading an application package from Grants.gov	NNH19ZDA001N-PSTAR
NASA points of contact concerning this program both of whom share this postal address: Planetary Science Division Science Mission Directorate NASA Headquarters Washington, DC 20546-0001	Sarah Noble Telephone: (202) 358-2492 Email: sarah.noble-1@nasa.gov Mary Voytek Telephone: (202) 358-1588 Email: mary.voytek-1@nasa.gov

C.15 PLANETARY PROTECTION RESEARCH

NOTICE: NASA does not intend to solicit proposals for this program element in ROSES this year. [This program was solicited late in ROSES-2018](). It is anticipated that it will be solicited next in ROSES-2020.

1. Scope of Program

Planetary Protection is the practice of protecting solar system bodies from contamination by Earth life and protecting Earth from possible life forms that may be returned from other solar system bodies. Numerous areas of research in astrobiology/exobiology are improving our understanding of the potential for survival of Earth microbes in extraterrestrial environments, relevant to preventing contamination of other bodies by Earth organisms carried on spacecraft. As we continue to bring extraterrestrial samples back to the Earth system for advanced research and analysis, there is an urgent need to understand and prevent biological contamination of the terrestrial environment. Mission-enabling and capability-driven research is required to improve NASA's understanding of the potential for both forward and backward contamination; and improve methods and technologies for accurate, efficient, and effective minimization of biological contamination for outbound spacecraft and return samples. The Planetary Protection Research (PPR) program solicits research in the following areas (in order of programmatic priority):

- Identify and provide proof-of-concept on new or improved methods, designs, technologies, techniques, and procedures to support planetary protection requirements for outbound and return sample missions. Of particular interest are improvements to spacecraft cleaning and sterilization that remain compatible with spacecraft materials and assemblies, prevention of re-contamination and cross-contamination throughout the spacecraft lifecycle, and expansion of materials and commercial-off-the-shelf (COTS) hardware with compatibility to current cleaning and sterilization techniques.
- Develop or adapt modern molecular analytical methods to rapidly detect, classify, and/or enumerate Earth microbes carried by spacecraft (on surfaces and/or in bulk materials, especially at low densities) before, during, and after assembly and launch processing. Of particular interest are methods capable of identifying and verifying the functionality of microbes with high potential for surviving spacecraft flight or planetary environmental conditions (e.g., anaerobes, psychrophiles, radiation-resistant organisms), methods that can validate and support biological modeling as it relates to biological contamination of spacecraft, and comparison to current NASA planetary protection standard assay techniques.
- Model to understand and predict biological and organic contamination sourcing, transport, survival, and burden level of spacecraft. Of particular interest are mission-enabling models that support mission designers, project managers, and life-detecting science teams in the early stages of the mission lifecycle.
- Model space environmental conditions and spacecraft designs that could permit a decrease in biological contamination of spacecraft during the journey to the target destination with emphasis on reduction of organisms currently surviving under

cleanroom conditions. Of particular interest is the radiation environment of deep space and the combined effects of multiple simultaneous stressors, such as a combination of space vacuum and radiation stressors.

- Model planetary environmental conditions and transport processes that could permit mobilization of spacecraft-associated contaminants to locations in which Earth organisms might thrive. Of particular interest are the subsurface environments of icy bodies, such as Europa and Enceladus, and Mars Special Regions.
- Characterize the limits of life in laboratory simulations of relevant planetary environments or in appropriate Earth analogs. Of particular interest are studies on the potential and dynamics of organism survival and reproduction in conditions present on the surface or subsurface of Mars (e.g., gullies and ice-rich environments), or on Europa and other icy satellites – potentially in the presence of a heat source brought from Earth.

It should be noted that the evolving planetary protection requirements of NASA's programs may affect the priorities for funding among these areas.

2. Summary of Key Information

NASA point of contact concerning this program	Becky McCauley Rench Planetary Science Division Science Mission Directorate NASA Headquarters Washington, DC 20546-0001 Telephone: (202) 358- 0530 Email: HQ-PPR@mail.nasa.gov

C.16 LABORATORY ANALYSIS OF RETURNED SAMPLES

NOTICE: Amended April 24, 2019. An IT issue prevented some organizations from accessing the NSPIRES web page yesterday, preventing the preparation and submission of proposals. To allow more time submission from those organizations that were unable to connect to NSPIRES yesterday, the due date for Step-1 proposals for this program element is being delayed by one day to, April 25, 2019. The due date for Step-2 proposals is unchanged.

This program element uses a two-step proposal submission process described in Section 2 of program element C.1.

1. Scope of Program

The goal of the Laboratory Analysis of Returned Samples (LARS) Program is to maximize the science derived from planetary sample-return missions. Activities supported by LARS fall into two categories: (1) development of laboratory instrumentation and/or advanced techniques required for the analysis of returned samples; (2) direct analysis of samples already returned to Earth.

All proposed work must be in support of the overarching goals of the Planetary Science Research Program to help ascertain the content, origin, and evolution of the Solar System and the potential for life elsewhere, consistent with the strategy for Planetary Science Exploration embodied in the *2014 NASA Science Plan.*

1.1 Proposals to Develop Laboratory Instrumentation or Advanced Techniques

Proposals are solicited to develop new analytical instrumentation or combinations of analytical instruments, or new components of analytical instruments, leading to significant improvements in the precision, resolution, or sensitivity of measurements compared to the existing state of the art, and to enable new types of measurements. Also solicited are proposals for the development of new analytical techniques for existing instrumentation that will push the limits of current technology, for example, by the elimination of analytical interferences or contamination problems. In all cases, both the development efforts and the clear relevance to NASA sample-return missions must be documented.

Development proposals may seek to develop instrumentation and techniques that will be used by only a small number of investigators at a single institution, or they may seek to develop facilities to be shared by the entire research community. For shared facilities, proposers must include detailed plans for facility management based on the size of the anticipated user base, including facility oversight, the fraction of time that will be made available to outside users, and the mechanism for allotting such time on a regular basis. In all cases, cost-sharing arrangements in the development of new instrumentation or techniques and evidence of a long-term institutional commitment to the analysis of returned samples will be viewed favorably in the selection process. Collaborations among instrument builders and scientists who understand the samples to be analyzed are encouraged. Ongoing laboratory support (e.g., service contracts) will not be supported.

1.2 Proposals to Analyze Returned Samples

Proposals are solicited to conduct analytical studies of astromaterials already returned by planetary missions (described in Section 2). Samples needed to carry out the work plan do not need to be allocated prior to the submission of a LARS proposal. In such cases, the proposal should address the availability of appropriate samples. Selection and funding of proposals may be contingent upon final allocation of the necessary samples.

1.3 Exclusions

1.3.1 *Lunar samples*

LARS does not support work principally relevant to past lunar sample-return missions:

- Apollo 11, 12, 14, 15, 16, and 17
- Luna 16, 20, and 24

Proposals to work on lunar materials are most likely to be within the scope of the Emerging Worlds (EW, program element C.2) or Solar System Workings (SSW, program element C.3) program elements.

1.3.2 *Space exposed hardware*

LARS does not support work to study returned space-flown hardware that has been exposed to micrometeorite impacts, unless associated with one of the missions listed in Section 2.1. For example, work on micrometeorite impacts on the Long Duration Exposure Facility (LDEF) is not supported by LARS. Proposals to work on micrometeorites are most likely to be within the scope of the EW and SSW programs.

1.3.3 *Terrestrial collections*

LARS does not support research on astromaterials collected on Earth (e.g., meteorites, micrometeorites, cosmic dust) unless these analyses are directly in support of the analysis of mission-returned samples.

1.3.4 *Spacecraft Instrumentation*

LARS does not support efforts to develop instruments for flight on planetary missions. See the instrument development calls for information on this subject (e.g., program elements C.12 PICASSO and C.13 MatISSE).

2. Sample Return Missions

2.1 Completed sample-return missions.

The following completed missions have returned samples, and may be the targets of either Instrument/Method Development or Sample Analysis proposals to LARS:

2.1.1 *Genesis*

This mission was designed to return samples of the solar wind to provide constraints on the chemical and isotopic composition of the primitive solar nebula; it was launched in 2001 and returned samples to Earth in 2004. Further information may be found at http://genesismission.jpl.nasa.gov/. Failure of the parachute system led to a hard landing in the Utah desert, and many of the fragile collectors were shattered on impact and contaminated. Intensive effort is underway to document the chips of collector materials and to measure and remove contamination from the chips. For information on availability of samples, check the Genesis curation website at http://curator.jsc.nasa.gov/genesis/index.cfm.

2.1.2 *Stardust*

This mission returned samples of the coma of comet 81P/Wild (Wild 2); it was launched in 1999, encountered the comet in 2004, and returned samples to Earth in 2006. The dust grains that impacted the silica aerogel collectors during a 6.1 km/sec flyby were all small (<100 µm) and fine-grained. In most cases the particles fragmented on impact and interacted strongly with the aerogel. For example, many particles are coated and sometimes penetrated with compressed or melted aerogel. Many particles impacted on the sample collector frame; work on particle residues in impact craters in the aluminum foils that separated the aerogel cells is also solicited. The aft-facing side of the collector was designed to collect interstellar dust particles, which are expected to be ~0.1 µm in size and to have impacted at more than 20 km/sec. Examination of this interstellar collector is extremely challenging (see http://stardustathome.ssl.berkeley.edu/). In addition to investigations involving direct analysis of Stardust materials, proposals to investigate the details of the capture process are solicited. Further information may be found from the mission homepage at http://stardust.jpl.nasa.gov/ and the Stardust curator's website at http://curator.jsc.nasa.gov/stardust/index.cfm.

2.1.3 *Hayabusa*

This mission, run by the Japan Aerospace Exploration Agency (JAXA), returned samples from the S-type Apollo asteroid, 25143 Itokawa; it was launched in 2003, encountered the asteroid in 2005, and its sample capsule was returned to Earth in 2010. In November 2010, JAXA announced that a large number of small particles, most smaller than 10 micrometers, were present in the capsule, with strong evidence of asteroidal origin for many of them. Most of the particles are curated by JAXA, and a subset that will eventually comprise 10% of the mass is curated at the Astromaterials Curation facility at NASA Johnson Space Center. More information and sample catalogs may be found at http://hayabusaao.isas.jaxa.jp/curation/hayabusa/index.html and http://curator.jsc.nasa.gov/hayabusa/.

2.2 Future sample return missions.

LARS supports Method/Instrumentation Development proposals to prepare for future sample-return missions. Such proposals should focus on gaps in current capabilities of ground-based laboratories, and address both the scientific importance of making such analyses on samples to be returned from these missions, and on the timeliness of initiating the development effort during the proposed performance period. Highest priority will be given to proposals addressing missions already selected for or in flight and to those which can best demonstrate the timeliness of the effort.

2.2.1 *OSIRIS-REx*

This mission launched in September 2016 and encountered 101955 Bennu, a 500-m diameter, B-type Apollo asteroid, in December 2018. It is currently engaged in operations around Bennu. Following observations of the asteroid, a sample of regolith

(<2 cm particles) will be collected. The collected sample, which is expected to have a mass between 60 g and 2 kg, will be returned to Earth in September 2023. The samples will be curated in the Astromaterials Curation facility at NASA Johnson Space Center. The first sample catalog is expected to be published in the spring of 2024. See http://science.nasa.gov/missions/osiris-rex/ for more information.

2.2.2 *Hayabusa2*

JAXA launched the Hayabusa2 mission in December 2014, and encountered asteroid 162173 Ryugu, a ~1-km diameter, C-type, Apollo asteroid, in June 2018. Small samples of surficial material (<1 mm particles) will be collected from up to three locations on Ryugu; the first sampling event was successfully completed in February 2019. Samples are expected to be returned to Earth in December 2020. Samples will be made available for research by JAXA, and a fraction of the returned material will be transferred to NASA for curation at the Astromaterials Curation facility at NASA Johnson Space Center. See http://www.hayabusa2.jaxa.jp/en/ for more information.

2.2.3 *Other missions and potential missions*

Below is a list of some of the missions that may return samples to Earth in the future. Proposals addressing these missions are expected to demonstrate the timeliness of the development effort.

- Mars sample-return missions
- Future New Frontiers comet and lunar sample-return missions
- Future Discovery missions (Discovery >14)
- JAXA's Martian Moons eXploration mission (MMX)
- Emerging lunar sample return opportunities

3. Programmatic information

3.1. Supplemental Funding for Additional Instrumentation

Proposers to LARS are eligible to request funds for Planetary Major Equipment and Facilities (PMEF). See program element C.17 for information on how to append a PMEF request to a regular LARS research proposal or submit a stand-alone PMEF proposal to supplement an existing LARS award.

LARS treats PMEF requests differently from other program elements:

Appended PMEF requests to LARS may only be made for significant off-the-shelf purchases of instrumentation needed to directly perform or enhance the proposed research.

Because LARS directly solicits the development of laboratory instruments, proposers to this program element may not use appended PMEF requests for the purpose of acquiring hardware for instrument development. If the main proposal includes a significant effort to enhance or further develop an off-the-shelf instrument, or to develop analytical methods using such an instrument, then a PMEF appendix is not permitted: the instrument purchase must be part of the main proposal and described within the 15-page limit of the Scientific/Technical/Management portion of the proposal. In these cases, specifications and quotations for significant equipment purchases may be included in the detailed proposal budget.

The rules for stand-alone PMEF requests to LARS are the same as for other program elements, as described in C.17.

3.2 Topical Workshops

The LARS program does not accept proposals for topical conferences, workshops, or symposia; such proposals may be submitted in response to program element E.2 Topical Workshops, Symposia, and Conferences. Proposers should specifically identify the LARS program as the relevant SMD program element and refer to the goals and objectives of the LARS program in demonstrating relevance.

3.3 Planetary Science Early Career Award

Details of the new Planetary Science Early Career Award (ECA) program are given in program element C.19. The aim of this program is to support research and professional development of outstanding early-career scientists, and to help stimulate research careers in areas supported by the Planetary Sciences Division. This program is an ECA-participating ROSES program element. Proposals from eligible PIs, or Science PIs if applicable, selected from this program in 2019 may become the 'parent award' for future ECA proposals (i.e., in 2020 or later).

3.4. Mission data, facilities, and resources

Please refer to ROSES program element C.1, Section 4, for a detailed list of the data and astromaterials resources and facilities available to proposers to this program element, and how to use them.

3.5 Use of mission data

Proposals to this program element must follow the rules for use of mission data given in program element C.1, Section 3.4.

3.6 Statement of Relevance

Proposals to this program element do not require a separate or explicit statement of relevance. As stated in program element C.1, Section 3.5, all proposals, including those submitted to this program element, will be evaluated for relevance to the program element. Consequently, proposers are strongly encouraged to address the question of relevance in the Scientific/Technical/Management portion of the proposal.

3.7 Data Management Plans (DMPs)

Program element C.1, Section 3.6, discusses the requirements for DMPs in proposals to this program element. Please note that DMPs are mandatory for this program element, and must be placed in a special section no longer than two pages in length, immediately following the References and Citations section for the Scientific/Technical/Management portion of the proposal.

4. Proposal Submission Process

Program element C.1, Section 2, outlines the two-step proposal submission process to be used by this program element.

Step-2 (full) proposals must follow all formatting requirements that are described program element C.1 and in the *NASA Guidebook for Proposers*. Proposals that violate the rules may be rejected without review or declined following review if violations are detected during the evaluation process.

5. Summary of Key Information

Expected program budget for first year of new awards	~$2.6M
Number of new awards pending adequate proposals of merit	~ 10
Maximum duration of awards	4 years; shorter-term proposals are encouraged for Development proposals.
Due date for Step-1 proposals	See Tables 2 and 3 of this ROSES NRA.
Due date for Step-2 proposals	See Tables 2 and 3 of this ROSES NRA.
Planning date for start of investigation	~6 months after Step-2 proposal due date
Page limit for the central Science/Technical/Management section of proposal	15 pp; see also Table 1 of the ROSES *Summary of Solicitation* and the *NASA Guidebook for Proposers*.
Relevance	This program is relevant to the Planetary Science questions and goals in the NASA Science Plan. Proposals that are relevant to this program are, by definition, relevant to NASA.
General information and overview of this solicitation	See the *ROSES Summary of Solicitation*.
Detailed instructions for the preparation and submission of proposals	Please see ROSES *Summary of Solicitation, esp.* Table 1 and Section I(g) Order of Precedence, and the *NASA Guidebook for Proposers*.
Submission medium	Electronic proposal submission is required; no hard copy is permitted.
Web site for submission of Step-1 and Step-2 proposals via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Web site for submission of Step-1 and Step-2 proposals via Grants.gov	http://grants.gov (help desk available at support@grants.gov or (800) 518-4726)
Funding opportunity number for downloading an application package from Grants.gov	NNH19ZDA001N-LARS
Point of contact concerning this program	Jeffrey N. Grossman Planetary Science Division Science Mission Directorate NASA Headquarters Washington, DC 20546-0001 Telephone: (202) 358-1218 Email (Preferred): HQ-LARS@mail.nasa.gov

C.17 PLANETARY MAJOR EQUIPMENT AND FACILITIES

NOTICE: March 30, 2020. C.23 Interdisciplinary Consortia for Astrobiology Research has been added to the list of participating programs in Table 1.

Amended October 31, 2019. Stand-alone proposals for planetary Major Equipment and Facilities will not be solicited this year. Schedule and budget constraints delayed the decisions on the 2018 PMEF proposals and, as a result, the 2019 Stand-alone proposals are not solicited. It is anticipated that this program element, including stand-alone proposals will be solicited in ROSES-2020.

Stand-alone proposals submitted to this program element will follow a two-step process, beginning with a required Step-1 proposal. The proposal title, category of instrument (investigator or facility), and the nature of the instrument to be purchased cannot be changed between the Step-1 and Step-2 proposals. Only proposers who are "invited" in response to the Step-1 proposal can submit a Step-2. See Section 3 for details.

Table of Contents

1. Overview

1.1 Scope of Program

The Planetary Major Equipment and Facilities (PMEF) program element allows proposals for the purchase or development of new or upgraded non-flight analytical, computational, telescopic, and other instrumentation to be used in investigations in Planetary Science Division (PSD) research programs.

For a proposal to be relevant to PMEF, the instrument must enable or enhance PSD-funded research in at least one of the "Target" program elements listed in Table 1 of this program element directly below. In addition, PMEF proposals are allowed from NASA Centers to support activities conducted under the Internal Scientist Funding Model (ISFM), provided that the activities are demonstrated to be relevant to one of the non-ISFM program elements shown in Table 1 below.

Table 1. Target program elements, eligible for PMEF funding

Program element	Number	Appended[1]	Stand-alone[2]
Emerging Worlds	C.2	Yes	Yes
Exoplanets Research	E.3	No	Yes
Exobiology	C.5	Yes	Yes
Habitable Worlds	E.4	Yes	Yes
ICAR	C.23	Yes	—
ISFM (NASA centers)	—	No	Yes
LARS	C.16	Yes	Yes
PDART	C.4	Yes	Yes
Planetary Protection Res.	C.15	Yes	Yes
PSTAR	C.14	Yes	Yes
Solar System Obs.	C.6	Yes	Yes
Solar System Workings	C.3	Yes	Yes

[1] Eligible to submit Appended PMEF requests for this ROSES year

[2] May be used as justification for Stand-alone PMEF proposals

1.2 Instrument Categories

There are two types of PMEF instruments that may be proposed: Investigator Instruments and Facility Instruments.

- An "Investigator Instrument" is acquired or developed by the proposer to support the PI's research, where the PI has full authority for its exclusive use, and where there are no commitments to make the instrument available to other investigators.
- A "Facility Instrument" is acquired or developed to support a wide range of planetary science research. Facility Instrument proposals may identify a portion of the instrument time to be reserved for use by the PI, or by an identified group of PSD-supported investigators, but a significant fraction of instrument time must be made available to other knowledgeable researchers conducting investigations in planetary

science. All details of access, announcement of availability, assistance to be provided on its use, and methods of use (whether hands on or by a facility-based operator), charges, and data rights must be documented and agreed to by NASA and the sponsoring institution before NASA support is provided.

1.3 Submission methods and eligibility

1.3.1 *PMEF requests appended to research proposals*

Investigator Instrument PMEF requests may be appended to a normal, full research proposal submitted to an eligible Target Program. Note that not all program elements in Table 1 of this program element allow this type of proposal (e.g., E.3, Exoplanets Research).

In a change from past Planetary Major Equipment (PME) solicitations, Facility Instruments may NOT be proposed as requests appended to research proposals. See Section 1.3.2 for instructions on how to submit proposals for facility instruments.

An Appended PMEF request may either be integral to the research proposal (i.e., required to perform the research) or it may be presented as an enhancement option to the research proposal (see Section 2 for more information on this topic).

The deadline for submission of an Appended PMEF request is the same as that of the Target Program.

1.3.2 Stand-Alone PMEF proposals

Stand-Alone PMEF requests are self-contained, full proposals submitted to enable future PSD-funded research or enhance PSD-funded research in one or more of the Target Programs. Both Investigator Instruments and Facility Instruments may be requested in Stand-Alone PMEF proposals.

In a change from past PME solicitations, there is a single deadline for all Stand-Alone PMEF requests, regardless of Target Program. The deadlines for submission are given in Tables 2 and 3 of ROSES.

Stand-Alone requests for Investigator Instruments and Facility Instruments both begin with submission of a Step-1 proposal, as described in Section 3.1. However, the instructions for preparing Step-2 Stand-Alone proposals differ for the two types of instruments: these are described in Section 3.2 for Investigator Instruments and Section 3.3 for Facility Instruments.

In order to submit a Stand-Alone PMEF proposal for an Investigator Instrument, the following criteria must be met:

1) The Principal Investigator (PI) or the Co-investigator/Science PI of the stand-alone PMEF proposal must either be the PI or Co-investigator/Science PI of an existing, funded (or selected) "parent" award in a Target program (see Table 1 of this program element, above), or funded under ISFM at a NASA center to perform research relevant to one or more of the Target programs. It is also acceptable to justify the PMEF proposal on the basis of multiple parent awards to the same PI in one or more of the Target programs.

2) The parent award or ISFM project of the stand-alone PMEF proposal must not have entered its last funded task year at the time of the Stand-Alone PMEF proposal deadline.
3) The instrument must only be intended to enhance the research in the PI's or Science PI's funded parent award(s).

In a change from past Planetary Major Equipment (PME) solicitations, there are no restrictions on who may be the PI of a Stand-Alone PMEF proposal for a Facility Instrument. The PI of such a proposal does not need to be a funded investigator in one of the Target programs, nor does the proposal need to be tied to a single funded project in one of the Target programs. However, Stand-Alone Facility Instrument proposals do need to include at least one funded investigator from an eligible program (Table 1, "Stand-alone" column) as either the PI, Science PI, or Co-I.

1.4 Allowable PMEF requests

Instrumentation purchases or upgrades that may be requested through the PMEF program are to be of a substantial nature, with hardware costs over $50,000. A PMEF proposal must be for purchase of a single instrument or system, or components of a single instrument or system. If a PI wishes to purchase multiple, unrelated equipment items each of which costs less than $50,000, these are not considered to be major equipment purchases under this program element, even if the combined cost exceeds $50,000.

This program element does not allow for the purchase of personal computers or computer peripherals, unless these are integral parts of an instrumentation package. In addition, it does not support the repair of equipment unless the repair involves significant enhancement of the instrument's basic capabilities. Proposals that seek to design, develop, test, or evaluate new instruments that are intended for commercial sale will be rejected without review.

1.5 Allowable Costs

The PMEF program element allows for either the purchase of instrumentation from a commercial vendor or for the acquisition of components and development of new instrumentation. Funds may also be requested for the installation and check out of instrumentation, either by a vendor or by the investigator(s). No funds may be requested for scientific research, instrument calibration, or development of standards. In addition, no funds may be requested for support contracts, maintenance, or continued operations of any instrument; costs for maintenance and operation beyond the check-out period must be requested in research proposals submitted to appropriate program elements or through ISFM projects. Each relevant cost should be fully explained and substantiated, and a quotation should be provided for any major equipment or components purchased from a commercial vendor. If acquisition or development of an instrument or facility will require more than one year, the proposal should cover the complete project, but make a clear distinction between efforts in each year.

It should be noted that cost sharing between NASA and other federal agencies is encouraged to the extent that NASA's share of the cost will ensure adequate access to the finished instrumentation by NASA investigators; this acquisition/access aspect of any proposed effort involving cost-sharing must be discussed in the proposal. The proposal must document whether any other agency has been approached or has made tentative commitments and provide the name and telephone number of the appropriate officer who can discuss their agency's interest.

It is expected that title to any equipment obtained or developed through this program shall vest with the proposing institution in accordance with the provisions of 2 CFR section 200.313. However, in cases of an equipment upgrade at a facility owned by the U.S. Government, NASA reserves the right to negotiate title of the equipment for the best interests of the user community.

2. Appended PMEF requests for Investigator Instruments

Appended PMEF proposals are always submitted using the process described in ROSES for the eligible Target program element, which may use an NOI followed by a full proposal, or a two-step proposal process. Unless otherwise noted in the Target solicitation, the NOI or Step-1 proposal should mention the anticipated PMEF request, but this is not a requirement: PMEF requests may be appended to proposals in eligible Target program elements regardless of whether the request was mentioned in the Step-1 proposal or NOI.

2.1 Elements of a proposal with a PMEF Appendix

All information about the research to be performed with the equipment associated with an Appended PMEF request should be integrated into the Scientific/Technical/ Management section of the main research proposal. This includes description of any instrument-development efforts associated with the purchase.

In constructing the main research proposal associated with an appended PMEF request, the PI should consider whether and how the main part of the proposal could be executed if the PMEF request were not funded. The Scientific/Technical/ Management section of the main proposal should contain a contingency plan for the non-selection of the PMEF request. This plan might discuss alternative methods of obtaining the required data, the effect that the lack of the instrument would have on the proposed science goals, or tasks that could be descoped from the proposal if the instrument were not available. If the contingency plan has budget implications (either positive or negative), the proposal's budget section should either clearly identify the contingent items, or include a clearly labeled alternate budget table that takes the instrument descope into account. If the proposal could not be executed without the instrument in the appended PMEF request, this should be explicitly stated. If no contingency plan is presented, the PMEF request will be considered as an essential (non-descopable) element of the proposal.

The proposal must contain an appendix entitled, "Planetary Major Equipment and Facilities Request," which should be the last item in the proposal (subsequent to all of the required sections in the main research proposal). This appendix, which does not count toward any page limitations in the main proposal, should include, and is limited to:

- A single cover page specifying:
    i. The title of the PMEF request

ii. The name and institution of the PI
iii. A brief summary/abstract of the PMEF request (which will not be evaluated, and therefore should contain only information covered in the body of the PMEF request)

- A maximum of four (4) pages of description of the instrument request, justifying its purchase. This section should make a convincing case for instrument funding, and should address why the instrument is necessary for the PI's or Science PI's research or how it would enable or enhance that research. It should include a description of the technical capabilities of the instrument and how they relate to the requirements of the proposed research, a discussion of how the instrument relates to other existing instruments that might be used to perform the research, and any cost-sharing arrangements. This section must not be used to describe plans for research to be done with the instrument beyond than that which is outlined in the main body of the proposal.
- A page of instrument specifications
- At least one quote for the instrument or major components

The PMEF appendix itself should not contain a budget section. All costs associated with the Appended PMEF request, including instrument purchase and development, belong in the budget of the main research proposal. When filling out the NSPIRES cover page budget for a proposal with an appended PMEF request, the cost of the equipment must be included as a single number per year on configurable line 10 in Section F, Other Direct Costs and labeled as "Cost of Appended PMEF". In most cases, it is expected that the PMEF costs will be contained within a single budget year.

Appended PMEF requests will be funded only if the main science proposal itself is selected for funding. Conversely, if there is no meritorious descope plan for the PMEF request, or if the PMEF is not descopable, the main science proposal may be declined for funding solely on the basis of the merit of the PMEF request or upon the lack of available funds to select the PMEF request.

2.2. <u>Evaluation of a proposal with a PMEF Appendix</u>

The main science proposal will always be evaluated under the assumption that the equipment proposed in the PMEF request will be selected for funding. However, the proposal may also receive a separate score for intrinsic merit, taking into account any contingency or descope plan that was presented, that would apply if the PMEF request were to be declined. Evaluation criteria for the main proposal will be as described in the program solicitation to which it was submitted.

The appended PMEF request will receive a separate evaluation, with the following factors considered as part of its intrinsic merit:

- The demonstrated value that the equipment will add to the PI's proposed research.
- The demonstrated appropriateness of the instrument for achieving the objectives of the proposed research
- The demonstrated need for the new instrument, given potential alternative methods of achieving the research objectives.

No separate relevance score will be given to appended PMEF proposals. Relevance is determined by the main research proposal.

3. Stand-alone PMEF proposals

Stand-alone proposals submitted to this program element will use a two-step process, beginning with a required Step-1 proposal. Only proposers who are "invited" in response to the Step-1 proposal may submit a full Step-2 proposal.

3.1 Step-1 proposal process for Stand-alone PMEF requests

Step-1 proposals must be submitted electronically by the Step-1 PMEF due date given in Tables 2 and 3 of ROSES. The Step-1 proposal cannot be submitted by the PI alone, it must be submitted by an Authorized Organizational Representative (AOR).

The body of a Step-1 proposal is a single document limited to two pages of text, plus at least one quotation for the instrument or its major components. The text does not need to explain the technical details or specifications of the instrument, and no formal budget information should be submitted. In all cases, the Step-1 proposal must describe the kind of instrument being proposed and how the instrument would be used. If cost sharing is anticipated, the Step-1 proposal should outline how this is being planned, although the plans do not have to be final. For Investigator Instruments, the Step-1 proposal must identify the Parent award or ISFM title, the award number (NASA centers may use the original proposal number), Target program element, and the funded performance period of the award. For Facility Instruments, the Step-1 proposal should explain what parts of the planetary science community, or other communities, would benefit from the instrument and how, as well as which Target programs are expected to benefit from the instrument. Letters of endorsement or other sections beyond the two-page limit plus quotation are not permitted for Step-1 proposals.

Step-1 proposals undergo a programmatic review. The goals of this review are to:

1) confirm that eligibility to submit a stand-alone PMEF proposal was established;
2) enable budget planning to accommodate the cost of anticipated proposals. Proposals that greatly exceed PSD’s present or expected budget requirements may be declined at Step-1;
3) for Facility Instruments, determine whether the proposal plausibly demonstrates a need for the facility, and that there exists an appropriate community of planetary science researchers who might benefit from use of the instrument.

The proposal title, category of instrument, and the nature of the instrument to be purchased may not be changed between the Step-1 and Step-2 proposals. Submission of a Step-1 proposal does not obligate the PI to submit a Step-2 (full) proposal. Quotations from instrument vendors may be updated prior to submitting a Step-2 proposal, but increases in instrument costs of >20% will require permission from the Program Officer prior to submitting the Step-2. Failure to obtain such permission may result in a Step-2 proposal being declined without review.

3.2 Elements of Stand-alone Step-2 PMEF proposals for Investigator Instruments

If a Step-1 proposal for a stand-alone Investigator Instrument is invited, then a Step-2 proposal for an Investigator Instrument can be submitted for review by the PMEF program. These are treated as augmentation proposals for a funded project by the PI or Science PI in one of the Target program elements.

The Scientific/Technical/ Management (STM) section must contain the following components, not exceeding seven total (7) pages:

- Page 1 must be a title page specifying:
    i. The title of the PMEF request
    ii. The name and institution of the PI and, if applicable, the Science PI.
    iii. The name, award number, and period of performance of the Parent award in one of the Target program elements.
    iv. A one-paragraph summary of the equipment request (this will not be evaluated and therefore should contain only information covered in the 5-page body of the PMEF request)

- A maximum of five (5) subsequent pages should describe the instrument request, outlining how the instrument would be used, and justifying its purchase. This section should make a convincing case for instrument funding and must address how the instrument would be used to enhance the PI's or Science PI's funded research. No instrument development tasks may be proposed in Stand-Alone requests for Investigator Instruments. This section may also include a description of the technical capabilities of the instrument and how they relate to the requirements of the proposed research enhancements, a discussion of how the instrument relates to other existing instruments that might be used to perform the research, and any cost-sharing arrangements.

  Note that no information about the Parent award will be provided to reviewers beyond what is written in the Scientific/Technical/ Management of the PMEF request itself, nor will reviewers have access to previous peer-review documents.

  The STM section does not require a statement of relevance if the PI has a parent award in one of the Target program elements. However, if the PI is funded under an ISFM award at a center, a brief statement of how the PI's work is relevant to the Target program element must be provided.

- One page of instrument specifications.

No Data Management Plan (DMP) section is required for a Stand-Alone PMEF Investigator Instrument proposal.

The budget section of the stand-alone PMEF proposal must include at least one quote for the instrument or major components.

No letters of endorsement are allowed for Stand-alone Step-2 proposals for Investigator Instruments. However, letters to confirm cost-sharing arrangements are acceptable.

3.3 Elements of Stand-alone Step-2 PMEF proposals for Facility Instruments

If the Step-1 proposal for a stand-alone Facility Instrument is invited, then a Step-2 proposal for a Facility Instrument may be submitted for review by the PMEF program. If selected, these may either result in augmentations to existing awards or they may result in new awards, depending on the circumstances.

The Scientific/Technical/ Management section must contain the following components, not to exceed twelve (12) total pages:

- Page 1 must be a title page specifying:
    i. The title of the PMEF Facility request
    ii. The name and institution of the PI and, if applicable, the Science PI.
    iii. The proposed location of the Facility Instrument
    iv. The name of the Target program elements to which the request is relevant.
    v. A one-paragraph summary of the equipment request (which will not be evaluated, and therefore should contain only information covered in the body of the PMEF request)
- A maximum of ten (10) pages may be used for the "main body" of the facility request, as further described below.
- One page of instrument specifications.

No data management plan is required for a Stand-Alone PMEF facility proposal.

Letters of affirmation are permitted from community members who are not on the PMEF Facility proposal team. Note that those providing letters will be considered to have a conflict of interest as potential reviewers of the proposal, in the same way as proposal team members.

The budget section must include at least one quote for the instrument or major components.

The main body of the PMEF facility proposal (limited to 10 pages) must describe the instrument request, explain how the instrument would be used, who would use it, how it would be managed, and justify its purchase. If instrument development tasks are proposed, they should be fully described. This section should include:

(a) A description of the technical capabilities of the instrument.
(b) A description of the potential user-community, and how the facility would benefit their research. If the facility is to have an identified portion of time reserved to a particular funded investigator, or group of investigators, their research and the benefits the facility would provide, should be specifically described, as no information about their research awards will be provided to reviewers beyond what is provided here.
(c) A management plan for the instrument that includes, as applicable:
    i. A statement of the percentage of the instrument's time that would be available to various classes of users (e.g., the PI, a specific group of researchers, PSD-funded researchers, or the broader community).
    ii. A statement regarding aspects of user access, such as:
        - time of day when access would be granted,

    - whether access would be "hands on" or only by an operator or collaborator in the proposer's group,
    - any costs to be charged for use,
    - how such costing would be handled,
    - how user access would be solicited, requested (e.g., by personal communication, formal proposal, or other method), and evaluated.

(d) A description of any cost-sharing arrangements.

(e) A demonstration of relevance of the facility to research currently funded in one or more Target program elements.

3.4 <u>Evaluation of Stand-alone Step-2 PMEF proposals.</u>

3.4.1 *Investigator Instruments*

The review of a stand-alone proposal for an Investigator Instrument does not include a re-evaluation of the research in the Parent award, nor will reviewers have access to the original Parent proposal. The evaluation criteria of the stand-alone proposal will include:

- The scientific merit of the newly proposed research enhancements to be enabled by the purchase of the instrument.
- The technical appropriateness of the instrument for achieving the proposed research enhancements.
- The demonstrated need for the new instrument, given potential alternative methods of achieving the research enhancements.

No relevance score will be given to stand-alone PMEF proposals for Investigator Instruments. Relevance was established by the previous funding of the Parent award.

3.4.2 *Facility Instruments*

The following factors may be considered as part of the intrinsic merit of a stand-alone facility instrument proposal:

- The scientific merit of the newly proposed research enhancements to be enabled by the purchase of the instrument for identified, funded investigators in the Target Programs.
- The technical appropriateness of the instrument for achieving proposed research enhancements for identified, funded investigators in the Target Programs.
- The demonstrated value that the equipment will add to research in Planetary Science in general.
- The demonstrated value that the equipment will add to the broader community.
- The quality of the management plan for the facility instrument.
- The demonstrated need for the new facility instrument, given potential alternative methods of achieving the research objectives.

The relevance of a stand-alone PMEF proposal for a facility instrument is determined by whether the proposal demonstrated the need for the instrument to do research that would itself be relevant to one of the Target programs.

4. Funding for PMEF awards

In general, funding for PMEF awards is drawn from a separate PMEF program budget, as noted in Section 5. Some Target programs may also contribute to PMEF awards from their own program budgets, thereby augmenting the amount of PMEF funds available in a given year.

5. Summary of Key Information

Expected annual program budget for new awards	**Not solicited this year [October 31, 2019]**
Number of new awards pending adequate proposals of merit	**Not solicited this year [October 31, 2019]**
Maximum duration of awards	Usually only one year. For stand-alone proposals, the maximum is 3 yrs. For appended proposals, refer to the guidelines of the program element to which the PMEF proposal is submitted.
Due date for proposals	For stand-alone PMEF proposals, Step-1 and Step-2 proposals must be submitted by the PMEF due dates in Tables 2 and 3 of ROSES. For PME proposals appended to new research proposals, no separate Step-1 proposal is required; PMEF requests may be appended to any Step-2 proposal submitted according to the schedule of the eligible program.
Planning date for start of investigation	See the specific science research program element for Appended proposals. Stand-alone proposals should plan on funding that begins approximately 6 months after the Step-2 due date.
Page limit for the describing the instrument request	Variable depending on type of request. See above. • Appended Investigator Instruments, 4 pp • Stand-Alone Investigator Instruments, 5 pp • Stand-Alone Facility Instruments, 10 pp
Relevance	This program is relevant to the Planetary Science questions and goals in the NASA Science Plan. Proposals that are relevant to this program are, by definition, relevant to NASA.
General information and overview of this solicitation	See the *ROSES Summary of Solicitation*.
Detailed instructions for the preparation and submission of proposals	Please see ROSES *Summary of Solicitation, esp.* Table 1 and Section I(g) Order of Precedence, and the *NASA Guidebook for Proposers*.
Submission medium	Electronic proposal submission is required; no hard copy is required or permitted.
Web site for submission of proposals via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376)

Web site for submission of proposals via Grants.gov	http://grants.gov (help desk available at support@grants.gov or (800) 518-4726)
Funding opportunity number for downloading an application package from Grants.gov	**Not solicited this year [October 31, 2019]**
Point of contact concerning this program	Jeffrey N. Grossman Planetary Science Division Science Mission Directorate NASA Headquarters Washington, DC 20546-0001 Telephone: (202) 358-1218 Email: HQ-PME@mail.nasa.gov

C.18 EARLY CAREER FELLOWSHIP START-UP PROGRAM FOR NAMED FELLOWS

NOTICE: September 20, 2019. Email address corrected.

Updated April 19, 2019. The text has been modified slightly and the point of contact updated. New text is in bold.

This program element is only for those who have already been named Early Career Fellows to submit proposals for start-up funds. For information on how to apply for the new early career award see program element C.19, The NASA Planetary Science Early Career Award Program. Data management plans are not required for this program element.

1. Scope of Program

The Early Career Fellowship (ECF) program supports the development of individual research programs of outstanding scientists early in their careers and stimulates research careers in the areas supported by the Planetary Sciences Division. This Program is based on the idea that supporting key individuals is a critical mechanism for achieving high impact science that will lead the field forward with new concepts, technologies, and methods.

This program element solicits seven-page proposals for $100K in start-up funds from those who have previously been named an "Early Career Fellow" and have obtained a permanent track position, defined in Section 3.3. See Section 2 for eligibility to apply for start-up funds. **To apply for the new Planetary Science Early Career Award program, please refer to program element C.19. [Added April 19, 2019]**

Please also refer to the Frequently Asked Questions PDF, which may be downloaded from the NSPIRES web page for this program element.

2. Fellowship Start-up Funds

The application for start-up funds is the second component of this program, i.e., those who respond to this program element must have been already named an "Early Career Fellow" in response to a proposal previously submitted to ROSES. The request for up to $100K of start-up funds, for those who meet the eligibility requirements in Section 2.1, takes the form of a proposal submitted in response to this program element at any time during the open period for ROSES (i.e., there is no single fixed due date).

2.1 Eligibility for Start-up Funds

To be eligible for start-up funds, the PI must have previously been named an Early Career Fellow.

Proposals for start-up funds must be submitted in response to this program element within ten calendar years of the year in which the PI received their Ph.D. (or equivalent degree). However, see also Section 3.2.

To be eligible for start-up funds, the PI may not already be in a permanent position at the time of submission of their proposal for start-up funds. To be eligible for start-up funds, the PI must be in a "permanent track" position at the time of submission of their proposal for start-up funds. The definition of "permanent" position is provided at the end of this program element in Section 3.3.

Fellows (or organizations) applying for start-up funds are strongly encouraged to communicate with the point of contact listed below to verify that the position that has been offered to the Fellow satisfies the requirement for award of start-up funds.

2.2 Procedure to Propose for Start-up Funds

The process for submitting proposals for start-up funds is as follows:

1. Receive an award letter explicitly stating that you have been named an ECF;
2. Gain a "permanent track position";
3. Meet the eligibility requirements in Section 2.1; and
4. Submit a proposal to this program element via the organization where you have the permanent track position.

Eligible PIs may submit proposals for up to $100K in start-up funds in response to this program element at any time during the eligibility period, via the organization through which they have the permanent track position. The start-up package is intended to aid Fellows in establishing a research group or laboratory in their new permanent track position. This funding is not guaranteed simply based on having been named a Fellow. Rather, it depends on the proposal submitted to this program element passing peer review.

The proposal must clearly describe how the funds will be used to establish their research program and how the proposed research is relevant to the Planetary Science Division (e.g., the Planetary Science questions and goals in the NASA Science Plan). In addition to the immediate use of the start-up funds, the proposal must contain a strategy describing the Fellow’s plans for the research program over the long term.

A detailed budget with a narrative justification is required as part of the proposal.

The proposal must provide evidence that the appointment meets the requirements for a "permanent track" position provided in Section 3.3.

Proposals for start-up funds must adhere strictly to the rules for ROSES in general, and this program element in particular. For example, the technical management section of a proposal to this program element is limited to seven pages.

2.3 Evaluation Criteria for Start-Up Proposals

Proposals for start-up funds will be evaluated vs. the three standard criteria given in ROSES: merit, relevance, and cost reasonableness. The evaluation of start-up proposals vs. these criteria will be completely independent of any prior evaluation of the original application to be an ECF.

3. Programmatic Information

3.1 Role of Fellow on Proposal vs. Organizational rules

Some institutions do not allow researchers in certain kinds of positions (e.g., not tenure track) to independently apply for NASA grants, which might prevent potential PIs from proposing to this program. However, the proposal may list the Early Career researcher as the Co-I/Science PI and include an organizationally approved individual as the PI to allow the application to be submitted by the Authorized Organizational Representative (AOR).

3.2 Time Since Degree

Potential proposers who took a leave of absence for family leave, military service, or serious health problems may request a waiver to the chronological eligibility restrictions outlined in Sections 2.1. These applicants should write to the ECF point of contact given in Section 5 prior to proposal submission.

3.3. Definition of a Permanent and Permanent Track Position

A permanent position is one in which the organization substantially compensates the PI for his or her salary, without making it conditional on outside funding, nor limiting the term of employment. Examples of permanent positions include, but are not limited to, tenured faculty and permanent civil service appointments.

A permanent track position is one with a clearly defined process and schedule that can lead to a permanent position. Examples of permanent track equivalent positions include, but are not limited to, tenure track faculty and certain term civil service appointments.

4. Summary of Key Information

Expected program budget for first year of new awards	N/A; all funds are distributed by the corresponding research program element
Number of Fellow appointments pending adequate proposals of merit	1 to 3 per planetary research program element
Maximum duration of awards	3 years for start-up funds
Due date for Notice of Intent to propose (NOI)	No Notices of Intent are requested for this program element.
Due date for proposals	Proposals from Fellows selected in prior years for start-up funds may be submitted at any time until 11:59 pm Eastern time on March 27, 2020.
Planning date for start of investigation	6 months after proposal receipt
Page limit for the central Science/Technical/Management section of proposal	7 pp, for proposals from current Fellows for start-up funds; see also Table 1 of the ROSES *Summary of Solicitation* and the *NASA Guidebook for Proposers*
Relevance	Proposals must be relevant to the Planetary Science Division. See also Section 2.2.
General information and overview of this solicitation	See the *ROSES Summary of Solicitation*.
Detailed instructions for the preparation and submission of proposals	Please see ROSES *Summary of Solicitation* Table 1, Section I(g) Order of Precedence, and the *NASA Guidebook for Proposers*.
For Additional Information	See the Frequently Asked Questions.

Submission medium	Electronic proposal submission is required; no hard copy is permitted.
Web site for submission of proposal via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Web site for submission of proposal via Grants.gov	http://grants.gov (help desk available at support@grants.gov or (800) 518-4726)
Funding opportunity number for downloading an application package from Grants.gov	NNH19ZDA001N-ECF (only for current Fellow applications for start-up funds; otherwise please see C.19)
Point of contact concerning this program	**Shoshana Weider** **[Email address corrected September 20, 2019]** Planetary Science Division Science Mission Directorate NASA Headquarters Washington, DC 20546-0001 Email: **shoshana.z.weider@nasa.gov**

C.19 PLANETARY SCIENCE EARLY CAREER AWARD

NOTICE: Corrected April 19, 2019. A reference in 2.f to the wrong section number has been corrected. New text is in bold, deleted text is struck through.

1. Scope of Program

The Planetary Science Early Career Award (ECA) program supports the research and professional development of outstanding early-career scientists, and serves to stimulate research careers in areas supported by the Planetary Sciences Division (PSD). The support of this program will allow promising individuals to play an increasing and meaningful role in the planetary science community. PSD intends to fund approximately five (5) Early Career Awards per year (one-time award of up to $200K).

2. Eligibility for the Early Career Award (ECA)

To be eligible to propose to the ECA program in ROSES-2019, all of the following criteria must be met:

a. The applicant must be the Principal Investigator (PI), or a co-investigator designated as the Science-PI, on an award (referred to below as the "parent award") from a participating program element solicited in ROSES-2017 or ROSES-2018 (see Table 1 of this program element, below). See Section 5.1 (role of PIs and Science-PIs) and Section 2.1 (ECA-participating programs) for more information.
b. The applicant must have received their Ph.D. (or equivalent degree) no earlier than January 1, 2009. See Section 5.2 for more information on this time criterion.
c. The applicant must be affiliated with a U.S. institution.
d. The parent award cannot previously have been used as the basis for a proposal to the ECA program.
e. The applicant may only submit one proposal to the ECA program per ROSES year.
f. The applicant cannot be the recipient of a previous ECA or of NASA Early Career Fellowship funds (see Section 5.**4** ~~5~~ for more details). **[Corrected April 19, 2019]**

2.1 Participating ROSES Program Elements for the Early Career Award

ROSES-2019 ECA proposals can be made on the basis of parent awards from participating ROSES-2017 and ROSES-2018 programs, as listed in Table 1 of this program element, below. Proposals selected through participating ROSES-2017, ROSES-2018, and ROSES-2019 programs will be suitable as parent awards for ECA proposals starting in ROSES-2020, i.e., thereafter there will be a rolling three-year window of eligibility (subject to programmatic factors).

ECA-participating ROSES-2019 elements are identified in Tables 2 and 3 of the ROSES solicitation by a "[3]" after the program title.

Table 1. ECA-participating program elements from ROSES-2017 and ROSES-2018. 'Parent awards' from these programs may be used as the basis for a proposal to this year's (ROSES-2019) ECA program.

ROSES-2017	ROSES-2018
Emerging Worlds	Emerging Worlds
Solar System Workings	Solar System Workings
Habitable Worlds	Habitable Worlds
Exobiology	Exobiology
Solar System Observations	Solar System Observations
Planetary Data Archiving, Restoration and Tools	Planetary Data Archiving, Restoration and Tools
Lunar Data Analysis Program	Lunar Data Analysis Program
Mars Data Analysis Program	Mars Data Analysis Program
Cassini Data Analysis Program	Cassini Data Analysis Program
Discovery Data Analysis Program	Discovery Data Analysis Program
Planetary Instrument Concepts for the Advancement of Solar System Observations	Planetary Instrument Concepts for the Advancement of Solar System Observations
Planetary Science and Technology Through Analog Research	Maturation of Instruments for Solar System Exploration
Planetary Protection Research	Planetary Science and Technology Through Analog Research
Laboratory Analysis of Returned Samples	Planetary Protection Research
New Frontiers Data Analysis	Laboratory Analysis of Returned Samples
Rosetta Data Analysis	New Frontiers Data Analysis
Small Innovative Missions for Planetary Exploration	Rosetta Data Analysis
OSIRIS-REx Participating Scientist	Development and Advancement of Lunar Instrumentation
Instruments for Gondola for High-Altitude Planetary Science	Instrument Concepts for Europa Exploration 2
InSight Participating Scientist	Apollo Next Generation Sample Analysis Program
Exoplanets Research	Scientific Exploration Subsurface Access Mechanism for Europa Technology Development
Juno Participating Scientist	Mars 2020 Participating Scientist
	Lunar Surface Instrument and Technology Payloads
	Astrodynamics in Support of Ice Worlds Missions

	Planetary Mission Concept Studies
	Korea Pathfinder Lunar Orbiter Participating Scientist
	Exoplanets Research
	Second Exoplanets Research

3. <u>ECA Proposal Submission Process</u>

Proposals to this program should be made in the form of the ECA Application Package (see Section 3.1), and must be submitted via NSPIRES or Grants.gov. Formatting rules laid out in program element C.1 (Section 2.4) apply to this program, unless superseded by information in Section 3.1 of this element.

3.1 <u>ECA Application Package</u>

The full ECA application package consists of: (1) parent proposal information; (2) a personal statement; (3) a curriculum vitae (CV); (4) publication history; (5) outline of intended use of funds; and (6) one to three letters of support.

Parent Award Information

Information about the eligible ROSES-2017 or ROSES-2018 'parent award', i.e., the basis of the ECA proposal must be provided. This must include:

- Parent award program
- Parent award ROSES year
- Parent award title
- ECA applicant role on parent award (PI or Science PI)
- Parent award number
- Parent award start date

Personal Statement

The personal statement (maximum two pages) should include the following:

- A description of the applicant's scientific focus and future aims;
- How the applicant would use the ECA to support career-advancing activities;
- How the applicant's past, current, and planned activities support, and are relevant to, the goals of the Planetary Sciences Division (see Section 4.1 for more information regarding relevance). For cross-divisional programs, the specific relevance of the parent award to the Planetary Sciences Division should also be described; and
- How the applicant's past, current, and planned activities support the planetary science community (this could, for example, include service activities, dedication to diversity and inclusion, mentorship, science communication, and collaborative work).

Curriculum Vitae (CV)

The CV (maximum two pages) should include details of collaborative activities (e.g., involvement on large scientific teams, including mission teams), awards, service, and any other relevant information.

Publication History

A publication history (separate to the CV), with no page limit, should be included in the application package.

Intended Use of Funds

The outline of the intended use of funds (maximum one page), should be a brief plan for use of the ECA funds, with an explanation of how the funds will support the activities described in the personal statement. ECA funds must be used within five years of the start of the award. Successful ECA applicants will be required to submit a full, complete budget before the Award will be distributed.

Letters of Support

At least one, but no more than three letters of support (maximum 3 pages each) are required. These letters should substantiate the application and address the ECA evaluation criteria (see Section 4).

4. ECA Evaluation Criteria and Selection

Proposals to the ECA program will be evaluated independently of the parent research proposals (which will not be available to reviewers). ECA awards will be selected based upon evaluation of the ECA application package (see Section 3.1). The following factors will be considered:

- relevance to the ECA program;
- the applicant's potential for scientific impact, leadership, and community involvement; and
- the potential impact of the proposed use of ECA funds.

4.1 Relevance

Applications are relevant to the ECA program if the scientific focus of the parent award and the proposed use of ECA funds are relevant to the scope of PSD (see program element C.1). The evaluation of relevance for the ECA may therefore differ from that of the parent research program. For example, proposals to cross-divisional ROSES program elements (Appendix E) that are partly run and funded by PSD may not be relevant to PSD goals. ECA applications that are deemed to be out of the scope of PSD will not be considered.

4.2 Potential for Scientific Impact and Leadership

The ECA applicant's scientific success to-date will be assessed, as will their future scientific vision and goals. In addition, the applicant's potential for future leadership in the scientific community—based on their engagement in their field—will be evaluated. Information of interest includes, but may not be limited to: invited and/or public lectures, awards received, participation on scientific program committees, conference or workshop organization, professional society activities, special international or industrial partnerships, review or editor activities, as well as significant education and public outreach activities (especially activities aimed at broadening participation and inclusion of under-represented groups in planetary science).

4.3 Proposed use of funds

The full ECA application package (see Section 3.1), particularly the personal statement and intended use of funds outline, will be used to assess the likely impact of the proposed use of ECA funds.

5. Programmatic Information

5.1 Role of Early Career Applicant on Proposal vs. Organizational rules

Some institutions do not allow non-tenured researchers to independently apply for NASA grants, which might prevent early-career researchers from proposing to this program. At either stage of the ECA process (i.e., either for the parent research proposal or for the full ECA application package) the proposal may therefore list the early-career researcher as the "Co-I/Science PI", and include an organizationally approved individual as the "PI" to allow the application to be submitted by the Authorized Organizational Representative.

5.2 Time Since Degree

To be eligible for the ECA program, applicants must have received their Ph.D. (or equivalent degree) no earlier than January 1, 2009. Time taken away from career activities for family (e.g., for the birth or adoption of a child, or for the care of a dependent) or health reasons, or for military service will not be counted against this time limit for eligibility. Applicants who received their Ph.D. before January 1, 2009, but who may therefore still be eligible for the ECA should email the Program Officer for this program (see Section 6), before submitting their proposal, to request a waiver for eligibility.

5.3 Duration of Awards

The ECA will be granted one time. ECA funds must be used within five years of the start of the award.

5.4 Relation to the Previous Early Career Fellowship program

The older PSD Early Career Fellowship (ECF) program (C.18 in ROSES-2019) was not solicited in ROSES-2017 and -2018, while the program was evaluated and reformulated. The following information is relevant to the change of programs (see also Section 5.2):

- The period of eligibility for the new ECA program has been expanded, from seven to ten years post-Ph.D., to allow PIs who 'aged out' of eligibility during the hiatus to apply for the new ECA.
- Unlike the old ECF program, the new ECA program places no restriction on the type of position held by the ECA applicant. To be eligible for the ECA, applicants do not need to hold a "permanent" position. However, awards must be made to a U.S. institution with which the applicant is affiliated.
- Previously named ECF awardees are eligible to propose to the ECA program, provided they (1) meet all other eligibility requirements and (2) have not yet received ECF funding. Previously named Early Career Fellows who apply for both ECF and ECA funding can only receive an award in one of the programs,

i.e., either the ECA or the ECF award must be declined. ECF awardees who have received ECF funding are not eligible to propose to the ECA program.

5.5 Data Management Plan

Data management plans (DMPs) are not required as part of the ECA Application Package (see Section 3.1). Nonetheless, a DMP (see C.1 for more information) will be required for all relevant, selected ECA proposals (i.e., for work that will produce data). In these cases, the satisfactory DMP must be submitted before the Award will be distributed.

5.6 Future feedback from awardees

For the purposes of evaluating the impact of the ECA program, please note that successful ECA applicants may be asked, going forward, to provide PSD with general feedback regarding the award and their career development.

6. Summary of Key Information

Expected program budget for first year of new awards	~$1M.
Award size	$200K each.
Number of awards	About five per year.
Maximum duration of awards	Five years
Due date for Notice of Intent to propose (NOI)	Notices of Intent are not requested for this program element.
Due date for proposals	December 2, 2019 (to be considered for an ECA in ROSES-2019).
Planning date for start of use of ECA funds	Six months after ECA proposal submission.
Page limit for proposal	See Section 3. Parent proposal information: no page limit. Personal statement: maximum 2 pages. CV: maximum 2 pages. Publication history: no page limit. Use of funds outline: maximum 1 page. Letters of support: 3 pages each (up to three letters are permitted).
Relevance	Parent award proposals and proposed use of ECA funds must be relevant to the Planetary Sciences Division. See also Section 4.1.
General information and overview of this solicitation	See the *ROSES Summary of Solicitation*.
Detailed instructions for the preparation and submission of proposals	See the *NASA Guidebook for Proposers* at http://www.hq.nasa.gov/office/procurement/nraguidebook/.
Submission medium	Electronic proposal submission is required; no hard copy is permitted.
Web site for submission of proposal via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376).

Web site for submission of proposal via Grants.gov	http://grants.gov (help desk available at support@grants.gov or (800) 518-4726).
Funding opportunity number for downloading an application package from Grants.gov	NNH19ZDA001N-ECA
Point of contact concerning this program	Shoshana Weider Planetary Science Division Science Mission Directorate NASA Headquarters Washington, DC 20546-0001 Telephone: (202) 358-1667 Email: shoshana.z.weider@nasa.gov

C.20 DEVELOPMENT AND ADVANCEMENT OF LUNAR INSTRUMENTATION PROGRAM

NOTICE: March 18, 2019. To the end of Section 2.1 has been added reference to an optional TRL Assessment spread sheet that may be uploaded as an additional appendix along with the Step-2 proposal. New text is in bold. The proposal due dates remain unchanged.

Instruments advancing lunar science suitable for small landers, including those of commercial providers, should be submitted to the DALI program, whereas those with a broader scope should be proposed to C.13 MatISSE, when that program is next solicited. Proposers considering submissions to both programs are strongly encouraged to review the prohibition on duplicate proposals guidance in Section 3.1 of C.1 Planetary Science Research Program Overview. No data management plan is requested for this program element.

This program element uses a two-step proposal submission process described in Section 2 of Appendix C.1.

This program element includes a special emphasis on lunar science instruments, including, but not limited to, flight hardware for small commercial lunar landers.

Unlike most program elements in Appendix C, this program element may result in contracts, depending on the nature of the work.

1. Scope of Program

The Development and Advancement of Lunar Instrumentation (DALI) Program supports the advanced development of spacecraft-based instruments that show promise for use in future lunar missions including expected commercial ventures. The goal of the program is to develop and demonstrate lunar science instruments to the point where they may be proposed in response to future announcements of flight opportunity without additional extensive technology development (approximately technology readiness level [TRL] 6). The proposed instrument must address specific scientific objectives of likely future lunar science missions.

The DALI Program seeks proposals for development activities leading to instrument systems in support of the Science Mission Directorate's (SMD) Planetary Science Division. The objectives of the program are to develop new technologies that significantly improve instrument measurement capabilities for lunar science missions (such as Discovery, New Frontiers, and other planetary programs, including those flown on commercial spacecraft). It is the responsibility of the proposer to demonstrate how their proposed technology addresses significant scientific questions relevant to stated NASA goals and not for NASA to attempt to infer this.

Only proposals relevant to Planetary Science Division's strategic goals and objectives will be considered for this program element. The DALI Program is intended to enable technology infusion into NASA planetary science missions to take place in a timely and efficient manner. As such, the technology readiness levels (TRLs) that DALI supports are TRL 4-6.

This program seeks to mature lunar science instruments that support NASA's broader lunar exploration goals, including human exploration and *in situ* resource utilization (ISRU), as well as lunar science. While all lunar instrument types, including rover-based and orbital, will be considered, instruments for small stationary landers are especially of interest. For this DALI solicitation, we are most interested in technologies that will reach at least TRL 6 by the end of the grant period, and ideally would be ready to build flight hardware for a lander with flight opportunities as early as ~2021.

It is the responsibility of the proposer to justify the entry and exit level TRL of the proposed technology. Instrument development activities must be planned and initiated so that major technological risk is retired prior to a lunar mission solicitation via an Announcement of Opportunity (AO) or Request for Proposal (RFP). This program will permit appropriate funding to be applied at each stage of readiness associated with the development and demonstration of key and enabling technologies, such as breadboarding, brassboarding, and testing of critical components and complete instruments in a relevant environment.

A full description of technology readiness levels (TRLs) 1- 9 appears in Appendix E of NASA Procedural Requirement 7123.1B and is available on the web at *http://nodis3.gsfc.nasa.gov/displayDir.cfm?Internal_ID=N_PR_7123_001B_&page_name=AppendixE*.
Prospective proposers are encouraged to review "Visions and Voyages for Planetary Science in the Decade 2013-2022" (https://solarsystem.nasa.gov/docs/Vision_and_Voyages-FINAL.pdf) for the most recent Decadal Survey) and Science Plan for NASA's Science Mission Directorate 2014 (https://science.nasa.gov/about-us/science-strategy) to learn more about relevant missions. Proposers are encouraged to review the Scientific Context for the Exploration of the Moon (https://www.nap.edu/catalog/11954/the-scientific-context-for-exploration-of-the-moon), the recent LEAG Special Action Team reports, NEXT SAT and ASM SAT (https://www.lpi.usra.edu/leag/reports.shtml), the Lunar Human Exploration Strategic Knowledge Gaps (https://www.nasa.gov/exploration/library/skg.html), and the specifics of planned commercial missions supported by NASA (https://www.nasa.gov/feature/nasa-extends-agreements-to-advance-commercial-lunar-landers).

Proposals not appropriate for DALI are feasibility studies, concept formulation, and proof of concept or advanced component development. These proposals should be submitted to the C.12 Planetary Instrument Concepts for the Advancement of Solar System Observations (PICASSO) Program in ROSES. In addition, DALI does not support proposals that seek to develop ground-based laboratory instruments; astronomical or astrophysics space observations; auxiliary instrumentation, such as spectrometers for ground based telescopes, mission operation and system software; or any spacecraft technology that does not directly address planetary science instrumentation.

The nature of specific efforts selected for funding will vary, with emphasis given to innovative technologies that improve instrument measurement capabilities. It is anticipated that the science payloads on most future planetary science spacecraft will be limited to small, low mass, and low power consumption instruments.

The Planetary Science Division strongly encourages proposers to investigate current and recent Small Business Innovative Research awards (http://sbir.gsfc.nasa.gov/abstract_archives) as well as NASA programs such as Planetary Instrument Concepts for the Advancement of Solar System Observations (PICASSO), Planetary Instrument Definition and Development Program (PIDDP), Astrobiology Science and Technology for Instrument Development (ASTID), and Game Changing Technologies for possible teaming and leveraging of emerging technologies.

2. Programmatic Considerations

2.1 Special Requirements for Proposals

Proposals are solicited under this program element for instrument development only for the mission focus areas described in Decadal Survey or the Science Plan. All Step-2 proposals submitted to this program element must specify:

- The mission focus area for which the proposed instrument is applicable. Instruments that are applicable to more than one mission will be given priority.
- The relationship between the science objectives and the instrumental capabilities must be clearly demonstrated. For those instruments that are applicable to more than one mission or capable of meeting multiple science objectives, examples of science objectives for the proposed mission or missions must be given.
- A detailed description and justification for the entry technology readiness level and a detailed plan for raising the instrument to the proposed exit technology readiness level. The plan must include descriptions of planned tests or demonstrations and milestones, as well as discussions of how those tests or demonstrations will advance the technology readiness level of the instrument.
- Technological advances are to be pursued as an inherent element of achieving the science objectives. Proposers must identify potential mechanisms that could facilitate transfer of these technologies to other users, including the private sector, for possible application beyond the immediate one of meeting mission science objectives.
- The technical, schedule, and cost risks to the proposed project and risk mitigation strategies shall be addressed in the proposal work plan.
- Because of the anticipated greater degree of complexity, the Scientific/Technical/Management section of proposals for these investigations may be 25 pages long, instead of the default 15 pages specified in the *NASA Guidebook for Proposers*.
- An entry level Summary Chart, not counted in the page limit, shall be submitted as a separately uploaded appendix PDF file to the Step-2 Proposal. A template for the entry level summary chart is available from the SARA web page at https://science.nasa.gov/researchers/templates-planetary-science-division-appendix-c-roses-proposals. The Summary Chart shall contain the following information:
  - Title, Principal Investigator (PI) Name and Institution
  - Target (Moon)
  - Bulleted list of science that will be enabled by a new instrument
  - Bulleted list of major objectives of proposed work
  - Co-Investigators (Co-Is) Names and Institutions

- A figure illustrating and clarifying the proposed concept
- Top level Milestones
- Entry and exit technology readiness levels (TRL)

- **An optional TRL Assessment spread sheet is available from the SARA web page indicated above. This optional spreadsheet, not counted in the page limit, may be submitted as a separately uploaded appendix PDF file to the Step-2 Proposal to help justify the TRL case.**

2.2 Additional Evaluation Considerations

In addition to the criteria specified in Section VI.(a) *ROSES Summary of Solicitation* and (by reference) the *NASA Guidebook for Proposers,* the following will also be considered when evaluating the relevance, merit, and cost reasonableness, and when formulating DALI selection recommendations.

The extent to which the proposed instrument is applicable to multiple lunar science missions;

The extent to which the instrument addresses a priority science goal of the above lunar mission or missions.

2.3 Award Duration and Types

It is expected that most proposals will request awards with durations of three years, but proposals may be submitted for projects of duration from one to four years. For proposals that request an award of four years in duration, a detailed justification is required and will be used in determining the duration of any award, should the proposal be selected. While in most cases awards will be in the form of grants, when appropriate fixed price contracts will be issued.

2.4 Technical Reporting Requirements

Once awarded, all Progress Reporting deliverables applicable to this solicitation shall be submitted to the web-based Planetary Electronic Reporting System (ERS). A user account on ERS will be provided to the PI upon award. Due to NASA IT security requirements, all Principal Investigators (PIs) must register with the Identity Management and Account Exchange (IdMAX) system before a user account on ERS will be established. To create an IdMAX account, some personal information will be required. All submissions shall be made in PDF format.

The following deliverables shall be required of institutions that win awards. In cases where subcontract arrangements exist, consolidated project reports are the responsibility of the Principal Investigator (PI). The proposed budget should provide for these reporting requirements. In this context, "Annual" refers to a twelve-month task effort that commences at award.

2.4.1 *Initial Plans and Reports*

Within 15 days of award, the PI shall provide an updated project plan and budget. The updated project plan and budget is only required if the selected proposal has been de-scoped. The project plan (if applicable) shall be E-mailed to the NASA Program Officer for this program.

2.4.2 *Quarterly Technical Reports*

The quarterly technical report shall focus on the preceding three month's efforts. Each report shall address:

1. <u>Technical status:</u> The PI shall summarize accomplishments for the preceding three months, including technical accomplishments (trade study results, requirements analysis, design, etc.), technology development results, and results of tests and/or demonstrations.
2. <u>Schedule status:</u> The PI shall quantitatively address the status of major tasks and the variance from planned versus actual schedule, including tasks completed, tasks in process, tasks expected to complete later than planned, and tasks that are delayed in starting, with rationale for each and recovery plans, as appropriate.

Quarterly Technical Reports shall be uploaded to the ERS system starting on the third-month anniversary date of the signing of the award vehicle. All awardees will receive a user name and password after selections have been made.

In months for which the PI is providing an Annual Review, the requirement for a quarterly report is superseded by the review requirements discussed in the next two sections.

Reports shall be submitted in PDF, Microsoft Word, or Microsoft PowerPoint compatible file formats by the required due date, or by close of business of the first workday following the due date, if the due date falls on a weekend or a holiday. A teleconference or brief meeting may be conducted between the NASA Program Officer and the PI to review and discuss each report.

2.4.3 *Annual Progress Report Deliverable*

The PI shall provide an Annual Review at the end of the first twelve-month calendar period commencing from the date of award and at twelve-month intervals thereafter. The PI must conduct an oral presentation summarizing the work accomplished and results leading up to this Annual Review and must:

1. Describe the primary findings, technology development results, and technical status, e.g., status of design, construction of breadboards or prototype implementations, results of tests and/or proof-of-concept demonstrations, etc.;
2. Describe the work planned for the remainder of the project and critical issues that need to be resolved to successfully complete the remaining planned work;
3. Summarize the cost and schedule status of the project, including any schedule slippage/acceleration. A schedule milestone chart of all major task activities shall be created and maintained and shown at all reviews. A cost data sheet shall be created and maintained, showing total project costs committed, obligated, and costed, along with a graphical representation of the project cost profile to completion;
4. Provide a summary of accomplishments and anticipated results at the end of the task;
5. Report any educational and outreach components of the project, e.g., graduate degrees, educational activities; technology infusion or patents applied for or

granted; journal or conference publications; presentations at professional conferences, seminars, and symposia; demonstrations; media exposure; and, other activities that contributed to the overall success of the research project;

6. The Annual Review should be comprehensive and should include a discussion of the planned content of the written report.

The NASA Program Officer will conduct the Annual Review at the PI's facility or via teleconference. If the review is conducted at the PI's facility, or a mutually agreed to location, the PI may also provide a laboratory demonstration, if appropriate, to show technical results and status. The presentation slides (Power Point) shall be uploaded to the ERS system at least two working days prior to the review.

Following the review, the presentation shall be updated in accordance with comments and discussion resulting from the review; this will constitute the Annual Review. The presentation, updated in accordance with comments and discussion resulting from the review, together with the separate written Annual Report, shall constitute the Annual Progress Report deliverable. A copy of each report shall be uploaded to the ERS system and, for grants, E-mailed to the NASA Shared Services Center (NSSC) at NSSC-Grant-Report@mail.nasa.gov. For grants, the Annual Review may be scheduled as early as 60-days before the grant start date anniversary. The release of the annual budget allocation is contingent on the timely submission of the Annual Progress Report deliverables.

2.4.4 *Final Review and Final Report*

The PI shall provide a comprehensive Final Review at the completion of the activity. The Final Review is similar to the Annual Reviews and includes all of the products required at an Annual Review with the following exceptions:

1. The Final Review must provide conclusions of the work performed and make recommendations for follow-on activities that should be pursued, with estimates of the cost and schedule to achieve TRL 7.
2. As this is the Final Review, there is no need to present future work plans or a cost profile.

The written Final Report shall include the following:

1. Background of the project, including the science rationale for conducting this technology development;
2. Results of all analyses, element, subsystem, or system designs, breadboards, and/or prototyping implementations and designs;
3. Performance analysis results of tests and/or demonstrations; estimation of reduction(s) in size, mass, power, volume, and/or cost; improved performance; description of newly enabled capability; and documentation of technology dependencies;
4. Tables, graphs, diagrams, curves, sketches, photographs, and drawings in sufficient detail to comprehensively explain the results achieved;
5. An updated TRL assessment, including a rough order of magnitude cost and a description and estimate of the duration of the follow-on activities necessary to achieve TRL 7;

6. At the end of the period of performance, the PI shall provide a final Accomplishments Chart which contains the following information
    - Upper Left: "Description and Objectives."
    - Middle: "Accomplishments."
    - Upper Right: A visual, graphic, or other pertinent information.
    - Bottom: "Co-Is" (name and affiliation), "Entry TRL," and "Exit TRL."

The written Final Report, Accomplishments Chart, and updated TRL assessment shall be uploaded to the ERS system within ten days of the final review. In addition, for grantees, a copy of the written report shall be emailed to the NSSC.

2.5 Planetary Science Early Career Award

Details of the new Planetary Science Early Career Award (ECA) program are given in program element C.19. The aim of this program is to support research and professional development of outstanding early-career scientists, and to help stimulate research careers in areas supported by the Planetary Sciences Division. This program is an ECA-participating ROSES program element. Proposals from eligible PIs, or Science PIs if applicable, selected from this program in 2019 may become the 'parent award' for future ECA proposals (i.e., in 2020 or later).

2.6 NASA Postdoctoral Program Fellows

Grantees in the program are eligible to serve as mentors to NASA Postdoctoral Program (NPP) Fellows. The tenure of a Fellow must begin before the end of the award but may extend beyond it. Proposals from potential Fellows must be submitted through the standard NPP process. The DALI Program expects to select no more than two Fellows associated with Planetary Science or Astrobiology Instrument Development. More information about the NASA Postdoctoral Program may be found at http://npp.usra.edu/.

3. Resources: Information, Data, and Facilities

3.1 Limits on Use of Mission Data

Proposals to this program element must follow the rules for use of mission data given in Appendix C.1, Section 3.4. If the data to be analyzed have issues that might represent an obstacle to analysis, the proposers must demonstrate clearly and satisfactorily how such potential difficulties will be overcome.

3.2 Facilities and Data Sources Available to Proposers

Proposers are advised to read Section 4 of Appendix C.1, The Planetary Science Division Research Program Overview, for information on facilities and data sources that are available to supported investigators. If their use is anticipated, this should be discussed and justified in the submitted proposals (especially note the provision for such discussion in the proposal section entitled Facilities and Equipment). Also note that, per the directions in Section 2.3 of the *NASA Guidebook for Proposers*, a letter of support may be required from any facility required for the proposed effort.

4. Proposal Submission Process

This program element uses a two-step proposal submission process described in Appendix C.1, Section 2.

Proposers are reminded that Step-1 proposals are mandatory and must be submitted by the proposing organization.

Proposals must follow all formatting requirements that are described in Appendix C.1 and the *NASA Guidebook for Proposers*. Violation of these rules is sufficient ground for a proposal to be rejected.

5. Summary of Key Information

Expected program budget for first year of new awards	~ $1.0M per year per award
Number of new awards pending adequate proposals of merit,	~ 5
Maximum duration of awards	3-4 Years, (See Section 2.3)
Due date for Step-1 proposals	See Tables 2 and 3 of this ROSES NRA.
Due date for Step-2 proposals	See Tables 2 and 3 of this ROSES NRA.
Planning date for start of investigation	Six months after the Step-2 proposal due date
Page limit for the central Science/Technical/Management section of proposal	25 pp; see also Table 1 of the *ROSES Summary of Solicitation* and the *NASA Guidebook for Proposers.*
Relevance	This program is relevant to the Planetary Science questions and goals in the NASA Science Plan. Proposals that are relevant to this program are, by definition, relevant to NASA.
General information and overview of this solicitation	See the *ROSES Summary of Solicitation*.
Detailed instructions for the preparation and submission of proposals	See the *NASA Guidebook for Proposers* at http://www.hq.nasa.gov/office/procurement/nraguidebook/.
Submission medium	Electronic proposal submission is required; no hard copy is permitted.
Web site for submission of Step-1 and Step-2 proposal via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Web site for submission of Step-1 and Step-2 proposal via Grants.gov	http://grants.gov (help desk available at support@grants.gov or (800) 518-4726)
Funding opportunity number for downloading an application package from Grants.gov	NNH19ZDA001N-DALI

Main point of contact concerning this program	Rainee Simons Planetary Science Division Science Mission Directorate National Aeronautics and Space Administration Washington DC 20526-0001 Telephone: 216-789-0237 Email: rainee.n.simons@nasa.gov
Other points of contact for related programs	Questions concerning Discovery Program may be addressed to: Michael H. New Lead Discovery Program Scientist Planetary Science Division National Aeronautics and Space Administration Washington DC 20526-001 Telephone: 202-358-1766 Email: michael.n.new@nasa.gov Questions concerning New Frontiers Program may be addressed to: Curt Niebur New Frontiers Program Scientist National Aeronautics and Space Administration Washington DC 20526-001 Telephone: 202-358-0390 Email: curt.neibur@nasa.gov The Lunar Science Point of Contact is: Sarah Noble Planetary Science Division Science Mission Directorate NASA Headquarters Washington, DC 20546-0001 Telephone: (202) 358-2492 Email: sarah.noble-1@nasa.gov

C.21 LUNATECH PROGRAM

NOTICE: Amended, July 1, 2019. The Planetary Science Division will not solicit proposals through this program element. The Space Technology Mission Directorate will be managing solicitations for potential opportunities for spacecraft platform technology development for lunar applications. For more information please see https://www.nasa.gov/directorates/spacetech/solicitations.

~~**The Planetary Science Division intends to solicit proposals for this program in ROSES-2019. It is expected that the final text of this element will be published as an amendment to ROSES with a Step-2 proposal due date no fewer than 90 days after the release of the text.**~~

Scope of Program

This program element will not be solicited.

~~The Lunar spacecraft technology program (LunaTech) supports the development and maturation of spacecraft technologies for Lunar science and exploration. The overall goal of the program is to develop and reduce the technical risk of spacecraft technologies so that these technologies can ultimately be infused into future flight missions. Note that the LunaTech program does not solicit technologies or hardware for a specific flight opportunity.~~

Point of contact

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C.22 BEPICOLOMBO PARTICIPATING SCIENTIST PROGRAM

NOTICE: Amended May 14, 2019. This program element will not be solicited. It has been superceded by a joint ESA and JAXA Announcement of Opportunity for Interdisciplinary Scientists and Guest Investigators in the BepiColombo mission for Interdisciplinary Scientists (IDSs) and Guest Investigators (GIs). Proposals from investigators at US organizations will require letters of endorsement. For NASA letters of endorsement please email the point of contact given below.

~~The Planetary Science Division may solicit proposals for this program in ROSES-2019. If so, the text of this element will be published as an amendment to ROSES with a Step-2 proposal due date no fewer than 90 days after the release of the text~~.

Scope of Program

On the release of ROSES-2019 a placeholder for this program element indicated that the Planetary Science Division might solicit proposals for BepiColombo participating scientists. This program element will not be solicited. It has been superceded by a joint ESA and JAXA Announcement of Opportunity for Interdisciplinary Scientists and Guest Investigators in the BepiColombo mission that invites proposals for Interdisciplinary Scientists (IDSs) and Guest Investigators (GIs) to increase the scientific return of the BepiColombo Mercury mission.

At the time of the release of this amendment to ROSES ESA/JAXA solicitation is requiring a mandatory letter of intent is by June 13, 2019 at 12:00pm (noon) CEST and proposals are due by July 15, 2019 at 12:00pm (noon) CEST. Please check the solicitation linked above for the latest information.

BepiColombo is a joint mission of ESA and JAXA for the exploration of the planet Mercury. The mission consists of two satellites launched together: the Mercury Planetary Orbiter (MPO) and the Mercury Magnetospheric Orbiter (MMO). BepiColombo will use two Venus gravitational assists to optimize its trajectory to Mercury. These Venus fly-bys will take place on October 16, 2020 and August 11, 2021. BepiColombo is due to arrive at Mercury and begin its science exploitation phase in December 2025 (MPO) and April 2026 (MMO), respectively. The duration of the nominal science operations is one year.

Successful candidates will be appointed for a first period of three years (renewable). For more information please refer to the ESA Announcement of Opportunity available at https://cosmos.esa.int/web/bepicolombo-ids-gi-2019.

Proposals from investigators at US organizations will require letters of endorsement. For NASA letters of endorsement please email the point of contact given below.

~~The objective of the BepiColombo Participating Scientist Program (PSP) is to enhance the scientific return of the BepiColombo mission to Mercury, a joint mission of the~~

~~European Space Agency and the Japan Aerospace Exploration Agency. The goals of the program are to enhance the scientific return from the mission by broadening participation, and to augment the existing science team by including new members conducting investigations that broaden and/or complement the current team's investigations~~.

Point of contact

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C.23 INTERDISCIPLINARY CONSORTIA FOR ASTROBIOLOGY RESEARCH

NOTICE: Amended on March 30, 2020. This amendment delays the Step-2 proposal due date for this program element to May 15, 2020

~~**Amended on March 17, 2020. This amendment delays the Step-2 proposal due date for this program element to April 17, 2020**~~

Amended November 25, 2019. This amendment releases final text for this program element.

This program element uses a two-step proposal submission process, described in Section 2 of C.1 The Planetary Science Division Research Program Overview.

Participants on awards selected via this program element will become members of the newly established Astrobiology Program Research Coordination Networks that are relevant to their selected research. For more information about these networks, see Section 2.12 of this program element.

This program element differs from the default in ROSES and/or C.1 The Planetary Science Research Program Overview in a number of ways. Please See Section 2 for a list of program specific requirements.

1. Introduction and Scope of Program

The goal of the NASA's Astrobiology program is the study of the origins, evolution, and distribution of life in the Universe. It is central to NASA's continued exploration of our Solar System and beyond. Research is centered on the origin and early evolution of life, the potential of life to adapt to different environments, and the implications for life elsewhere. NASA, together with the science community, has developed the 2015 Astrobiology Strategy that describes the scientific goals and objectives of NASA's Astrobiology Program (see https://astrobiology.nasa.gov/research/astrobiology-at-nasa/astrobiology-strategy/).

A wide array of NASA Science Mission Directorate (SMD) flight missions incorporate astrobiology goals and objectives. For this reason, with this program element NASA is seeking proposals responding to both the long-term goals and objectives identified in the Astrobiology Strategy and focused on ensuring that the NASA Astrobiology community is prepared to respond to the challenge of planning and implementing these missions. Accordingly, proposals that place emphasis on research that will help prepare for current or future flight programs directed at astrobiological targets are encouraged.

Proposals for Interdisciplinary Consortia for Astrobiology Research (ICAR) must describe an interdisciplinary approach to a single compelling question in astrobiology, and address at least one aspect of the 2015 Science Strategy. Team size and resources requested should be appropriate to the scale of the proposed research. There is no ideal size of an ICAR Team. Because this is an opportunity for larger teams and for five years of support, the scope of the research, and subsequently the resources needed, should exceed those typically considered in a Research Opportunities in Space and Earth Sciences (ROSES) program element (e.g., Exobiology, Habitable Worlds).

NASA's Astrobiology Program (see http://astrobiology.nasa.gov/) is managed within the Science Mission Directorate (SMD) at NASA Headquarters (HQ) and supports awards for individual investigator research, instrument and technology development and testing. More information on the strategic priorities and research/technology investments of the SMD can be found in the 2014 Science Plan for NASA's Science Mission Directorate, available at http://science.nasa.gov/about-us/science-strategy/.

NASA recognizes and supports the benefits of having diverse and inclusive scientific, engineering, and technology communities and fully expects that such values will be reflected in the composition of all panels and teams including peer review panels (science, engineering, and technology), proposal teams, science definition teams, and mission and instrument teams. Critical steps must be taken to broaden the participation of underrepresented groups and institutions serving minority students in NASA activities. The following web page from the Office of Civil Rights, U.S. Department of Education links to lists of institutions of higher education enrolling populations with significant percentages of undergraduate minority students, or that serve certain populations of minority students:

https://www2.ed.gov/about/offices/list/ocr/edlite-minorityinst.html

The Astrobiology Program is committed to increasing the participation of underrepresented groups in its activities, and it strongly encourages their participation as Lead or Co-Institutions.

1.1 Research Coordination Networks

The areas of research emphasis in this program element are linked to three of the five astrobiology research coordination networks (RCN) and are as follows:

- Habitability and Detection of Life on Exoplanets

Research in this area seeks to accelerate the discovery and characterization of other potentially life-bearing worlds in the galaxy, using a systems science approach. Topics of interest include the investigation of the diversity of exoplanets including how their history, geology, dynamical processes, stellar radiation, and climate interact to create the conditions for life. Investigations that study Earth and/or other planetary bodies in our Solar System as coupled atmosphere-hydrosphere-cryosphere-geosphere-biosphere (Earth) systems, that study the properties of the Sun (and other stars) and how they interact with the magnetic fields, affect atmospheric chemistry and climates of their orbiting planets, or that seek to understand the underlining planetary processes that are responsible for the fidelity, resilience or detectability of biosignatures are encouraged. Research aimed exclusively at collecting data that reveals the diversity of planets in the galaxy and the properties of their host stars should be submitted to the Exoplanet Research Program (E.3). Proposals aimed exclusively at the identification and characterization of radio signals from extrasolar planets that may harbor intelligent life are not solicited at this time. Research focused on defining, understanding or characterizing "technosignatures" as specific types of biosignatures indicative of intelligent life are included in this area; however, proposals to search for technosignatures are not included.

- Prebiotic Chemistry in Early Earth Environments

Research in this area seeks to delineate the planetary and molecular processes that set the physical and chemical conditions within which living systems may have arisen. Topics of interest include the formation of complex organic molecules in space and their delivery to planetary surfaces; models of early environments in which organic chemical synthesis could occur; the forms in which prebiotic organic matter has been preserved in planetary materials; determining what chemical systems could have served as precursors of metabolic and replicating systems on Earth and elsewhere, including alternatives to the current DNA-RNA-protein basis for life; and the range of planetary environments amenable to life. Emphasis is placed on studies that constrain or extend concepts of possible chemical evolution relevant to the origin, evolution, and distribution of life. Studies of sites thought to be analogues to the early Earth or other planetary environments that might potentially harbor life will be considered as part of NASA's broader interest in the search for life in the Universe. Laboratory and theoretical studies, as well as related data-analysis, will be considered.

- Primitive Cells to Multicellularity

The goal of research into the early evolution of life is to determine the nature of the most primitive organisms, the environment in which they evolved, evolution of the earliest metabolism, and the origin of advanced life. Target investigations include but are not limited to: i) determining when and in what setting life first appeared and the characteristics of the first successful living organisms; ii) understanding the phylogeny and physiology of microorganisms, including extremophiles, whose characteristics may reflect the nature of primitive environments; iii) determining the original nature of biological energy transduction, membrane function, and information processing, including the construction of artificial chemical systems to test hypotheses regarding the original nature of key biological processes; iv) investigating the development of key biological processes and their environmental impact; v) examining the response of Earth's biosphere to extraterrestrial events; vi) investigating the evolution of genes, pathways, and microbial species subject to long-term environmental change relevant to the origin of life on Earth and the search for life elsewhere; vii) studying the coevolution of microbial communities, and the interactions within such communities, that drive major geochemical cycles, including the processes through which new species are added to extant communities; and viii) studying the origin and early evolution of those biological factors that are essential to multicellular life, such as developmental programs, intercellular signaling, programmed cell death, the cytoskeleton, and cellular adhesion control and differentiation, in the context of the origin of advanced life.

Acknowledging the potential overlap between the topics listed above and those in other program elements (e.g. XRP, or Exobiology), it is necessary that proposers use the relevance statement (see Section 2.5) to explain why the topic and/or scope would not be appropriate for any other ROSES element.

2. <u>Programmatic Information</u>

Proposals are sought for new projects within the scope of the Astrobiology program. Proposals submitted in response to this program element must be for work that is not currently supported or for investigations that would extend to their next logical phase those tasks that have been funded in the Astrobiology program, but with periods of performance that expired in the last year or are expiring in the next half-year.

Although there is a place in the program for exploration of novel and relevant environments, selection preference will be given to hypothesis-driven research projects.

This program element differs from the default in ROSES and or [C.1 The Planetary Science Research Program Overview] in a number of ways. Proposers should be aware that:

- There is a required Relevance Statement collected on the NSPIRES cover page (see Section 2.5)
- The ban on adding team members between Step-1 and Step-2 is more restrictive than the default rules in C.1 (see Sections 4.1 & 4.3)
- The constituent parts of the proposal and their page limits differ from the ROSES default (see Table 1 in Section 4.3) and
- The evaluation criteria differ from the default (see Section 5).

2.1 Program Exclusions

The following restrictions apply to proposals submitted to this program element:

- Research aimed exclusively at collecting data that reveals the diversity of planets in the galaxy and the properties of their host stars should be submitted to the Exoplanet Research Program (E.3).
- Proposals aimed exclusively at the identification and characterization of radio signals from extrasolar planets that may harbor intelligent life are not solicited at this time.
- This program does not accept proposals for work in Antarctica.
- This program element does not request proposals for the development of advanced instrument concepts and technologies as precursors to astrobiology flight instruments. Such proposals should be submitted to the Planetary Instrument Concepts for the Advancement of Solar System Observations (PICASSO; see program element C.12) Program (for technology readiness levels [TRLs] 1-3+) or the Maturation of Instruments for Solar System Exploration (MatISSE; see program element C.13) Program (for TRLs 4-6).
- Proposals for science-driven field campaigns that are expected to produce new science results, as well as new operational or technological capabilities, should be submitted to the Planetary Science and Technology from Analog Research (PSTAR) program (see program element C.14).
- The ICAR program does not accept proposals for topical conferences, workshops, or symposia; such proposals may be submitted in response to program element E.2 Topical Workshops, Symposia, and Conferences. Proposers should specifically identify the ICAR program as the relevant SMD program element and refer to the goals and objectives of the ICAR program in demonstrating relevance.

2.2 Additional Funding for Relevant Instrumentation Construction or Upgrade

Proposers to ICAR are eligible to request funds for major equipment under the Planetary Major Equipment and Facilities (PMEF) program. See program element C.17

for information on how to append a PMEF request to a regular ICAR research proposal or submit a stand-alone PMEF proposal to supplement an existing ICAR award.

2.3 NASA Postdoctoral Program Fellows

PIs and Co-Is on awards from this program are eligible to serve as mentors to NASA Postdoctoral Program (NPP) Fellows. The tenure of a Fellow must begin no later than two years before the end of the ICAR award but may extend beyond it. Proposals from potential Fellows must be submitted through the standard NPP process. The Astrobiology Program expects to select no more than three Fellows associated with ICAR research this year. More information about the NASA Postdoctoral Program may be found at http://npp.usra.edu/.

2.4 Planetary Science Division Early Career Award Program

Details of the new Planetary Science Early Career Award (ECA) program are given in program element C.19. The aim of this program is to support research and professional development of outstanding early-career scientists, and to help stimulate research careers in areas supported by the Planetary Sciences Division. This program is an ECA-participating ROSES program element. Proposals from eligible PIs, or Science PIs if applicable, selected from this program in 2020 may become the 'parent award' for future ECA proposals (i.e., in 2021 or later).

2.5 Relevance Statement Requirement

Proposals must discuss relevance to this program element in a (4000-character max) text box on the cover pages via the NSPIRES web interface for this program element. This statement is outside of the 25-page Research Plan and the relocation of the relevance discussion does not decrease that 25-page limit. This requirement supersedes the *NASA Guidebook for Proposers* and the *ROSES Summary of Solicitation*, and the omission of this statement is sufficient reason for a proposal to be returned without review.

The relevance discussion must explicitly refer to the section of this program element to which the proposal is responsive. The relevance discussion must identify the RCN(s) to which the proposed research is most closely related and include how the proposed research will contribute to the goals of that RCN. If the proposed work is close in scope to research covered by any other program element, this discussion must also justify why it is more relevant to this program element than that other program element. This discussion may not be used to address the proposal's intrinsic merit, budget justification, or any other factor that remains in the 25-page main body, or any other section, of the proposal.

2.6 Research Coordination Networks (RCNs)

PIs of proposals selected for funding from this program element that cover a research topic related to the newly established Research Coordination Networks will become members of the Steering Committees of these RCNs (For more information, see: https://astrobiology.nasa.gov/news/astrobiology-program-faqs/). Relevance to an RCN is an evaluation criterion for proposals to this program element, and eligibility for participation in an RCN does not indicate that additional research funding will be provided. However, PIs will be expected to attend one in person steering committee meeting a year and a PI meeting for all RCN PIs. The proposal should include a request for funding to cover this travel. The currently active RCNs are:

- NExSS (Nexus for Exoplanet System Science): a research coordination network that brings together scientists from many disciplines to investigate the diversity of exoplanets and to learn how their history, geology, and climate interact to create the conditions for life. (For more information see https://nexss.info/.)
- PCE3 (Prebiotic Chemistry and Early Earth Environments): a research coordination network that brings together those interested in how to investigate the delivery, synthesis, and fate of small molecules under the conditions of the Early Earth, and the subsequent formation of proto-biological molecules and pathways that lead to systems harboring the potential for life. (For more information see http://prebioticchem.info/)
- FECM (From Early Cells to Multicellularity): members of this RCN will investigate the earliest biological processes and the evolution of life on Earth into more complex organisms up to the advent of multicellularity.

Information about the additional RCNs that are being established can be found here: https://astrobiology.nasa.gov/news/how-many-astrobiology-research-coordination-networks-will-be-established/

2.7 Award Type and Funding Information

Proposals to ICAR will have a nominal five-year period of performance and are expected to start in the third quarter of calendar year 2020. It is anticipated that $5-7M will be available for this selection in the first award year, leading to five to ten awards, each of five years duration. If the appropriated funds available are less than anticipated, then fewer awards may be made. It is also anticipated that the same amount of funding as the first year will be available in the subsequent award years. Annual funding allotments after the first award year will be provided only after the submission of an acceptable progress report (see Section 6.3). Note that all funding awards are contingent upon the availability of appropriated funds.

3. Resources: Information, Data, and Facilities

3.1 Limits on Use of Mission Data

Proposals to this program element must follow the rules for use of mission data given in section 3.4 of C.1, the Planetary Science Research Program Overview. If the data to be analyzed have issues that might represent an obstacle to analysis, the proposers must demonstrate clearly and satisfactorily how such potential difficulties will be overcome.

3.2 Facilities and Data Sources Available to Proposers

Refer to section 4 of C.1, the Planetary Science Research Program Overview, for a detailed list of the data and astromaterials resources, and facilities available to proposers to this program element, and how to use them. If their use is anticipated, this should be discussed and justified in the submitted proposals (especially note the provision for such discussion in the proposal section entitled Facilities and Equipment). Also note that, per the directions in the *NASA Guidebook for Proposers*, a letter of support may be required from any facility required for the proposed effort.

3.3 Data Management Plans (DMPs)

Proposals submitted to this program element must include a Data Management Plan (see C.1, Section 3.6), and since samples are an important component of ICAR Research, please discuss both data and sample management as part of the Data Management Plan. This must be placed in a special section, not to exceed two pages in length, immediately following the References and Citations section for the Scientific/Technical/Management portion of the proposal. These two pages are not considered part of the 25-page limit for the Research Plan portion of the proposal.

3.3.1 *Other research material sharing, registration and curation*

Sharing of valuable sample material is highly encouraged. Investigators are expected to share with other researchers, at no more than incidental cost and within a reasonable time, samples, physical collections, and other supporting materials created or gathered in the course of work under NASA agreements. Teams are expected to encourage and facilitate such sharing.

Nonbiological samples collected during the conduct of research funded by NASA will be registered in SESAR, the System for Earth Sample Registration, as a first step towards sample curation and sharing.

SESAR operates the registry that distributes the International Geo Sample Number IGSN. SESAR catalogs and preserves sample metadata profiles, and provides access to the sample catalog via the Global Sample Search. For more information see http://www.geosamples.org/.

3.3.2 *Biological Samples*

Academic, private, and community facilities have traditionally been sites where biological materials are curated. Not all material can (or should) be accommodated in these facilities. PIs should archive voucher and type specimens as dictated by community standards and practices, as required by journals for publication, and as appropriate to support research results.

3.4 Geologic Maps

Proposers who plan investigations involving geologic mapping should consult C.1, Section 3.8, for guidance on submission and requirements for publication of U.S. Geological Survey (USGS) maps. The scientific goal of such a geologic map product should be clearly explained and justified.

4. Proposal Submission and Content

4.1 Two-Step Submission Process

This program element will use a two-step proposal submission process. A 5-page Step-1 proposal is required and must be submitted electronically by the Step-1 due date in Tables 2 and 3. The Step-1 proposal must be submitted by the organization's Authorized Organizational Representative (AOR). Only proposers who submit a Step-1 proposal are eligible to submit a full Step-2 proposal. 25-page Step-2 proposals must contain the same title, scientific goals and Principal Investigator as those in the Step-1 proposal. No team members may be added between Step-1 and Step-2. Format and compliance evaluation criteria are described below. Submission of the Step-1 proposal does not obligate the offerors to submit a Step-2 proposal.

4.2 Step-1 Proposal Content

The content of Step-1 proposal must be uploaded as a PDF file in NSPIRES. In addition to the Principal Investigator, proposers are reminded that the must have the team assembled with the proposal at Step-1 (if you are not familiar with this process in NSPIRES please refer to the walkthrough from the SARA web page). The Step-1 proposal shall contain a scientific and technical section, not to exceed 5 pages, that begins with the title of the proposed investigation and describes:

a. A compelling question in astrobiology that will be the focus of the proposed research program;
b. A description of the importance of the research program and its relevance to the goals of the Astrobiology Program as contained in the 2015 Astrobiology Strategy https://astrobiology.nasa.gov/research/astrobiology-at-nasa/astrobiology-strategy/;
c. A description of the research approach, including a discussion of how each investigation in the proposed research is necessary and how it will be integrated into an interdisciplinary investigation; and
d. A description of how the proposed research complements the research goals covered by one or more of the RCNs described in Section 2.6.

Please note that the NSPIRES system for proposal submission requires a very brief summary to be entered into the Proposal Summary field and a Proposal Attachment, which should be a single PDF file of the science and technical section of the Step-1 proposal. Evaluation criteria for Step-1 proposals can be found in Section 5.1.

4.3 Step-2 Proposal Submission and Content

A budget and other specified information is required. The Step-2 proposal title, scientific goals and Principal Investigator must be the same as those in the Step-1 proposal. No team members may be added between Step-1 and Step-2.

All Step-2 proposals must include the following materials in the following order and using the titles as given. Details for each item are given in Section 7.

Content for Step-2 (full) proposals are specified in this document and supercede default instructions in the *ROSES Summary of Solicitation* and the Planetary Science Research Program Overview.

Table 1 Constituent Parts of the Proposal

	PAGE LIMITS
Step-2 Proposal *Cover Page*/*Proposal Summary*	As per NSPIRES
Step-2 Proposal Title Page (optional)	1
Table of Contents	1
Executive Summary	3
Summary of Personnel and Commitments	As needed
Research Plan	25*
Science Management Plan	4

Data Management Plan		2
References		As needed
Facilities and Equipment (as appropriate)		5
Curriculum Vitae	For the PI:	3
	For each Co-I:	1
Current and Pending Support		As needed
Statement(s) of Commitment from Co-Is and/or Collaborators		As needed
Budget Summary and Details		As needed
Total Budget File (separate PDF)		As needed
HEC request form (optional separate PDF)		As per RMS system

* Including illustrations, tables, figures, and foldouts.

5. Evaluation Criteria

5.1 Step-1 Evaluation Process and Criteria

Step-1 proposals will not be peer reviewed. They will be evaluated by the Astrobiology Senior Scientist, the Astrobiology Deputy Program Scientist, and the Lead of the Planetary Science Research and Analysis Program. Feedback will be provided to the proposers via NSPIRES.

The four criteria for evaluation of Step-1 proposals are:

1. The compelling nature of the focus of the proposed research program and the appropriateness of its scope.
2. The relevance of the proposed research program to the goals of the Astrobiology Program, as contained in the 2015 Astrobiology Strategy.
3. The degree of interdisciplinarity of the proposed research program.
4. The extent to which the proposed research program addresses the research goals of the RCNs identified above.

Based on evaluations of the Step-1 proposals, Step-2 proposals will be categorized as either Encouraged or Discouraged and the proposer will be notified electronically via NSPIRES. Step-2 proposals may still be submitted even if Discouraged.

5.2 Step-2 Evaluation Process and Criteria

Step-2 proposals shall be evaluated by a peer review panel.

The five criteria for evaluation of Step-2 proposals are:

1. Merit of the Research Plan
2. Merit of the Science Management Plan
3. Merit of the Data and Sample Management Plan
4. Relevance to ICAR
5. Cost Reasonableness

Successful proposals must score highly on the first four evaluation criteria to be a high priority for Selection. Selection is expected to be highly competitive.

5.2.1 *Scientific/Technical Merit of the Proposed Research*

This criterion addresses the scientific and technical merit of the proposed astrobiology research program with respect to the goals and objectives in the 2015 Astrobiology Strategy. Particular emphasis will be placed upon innovative and interdisciplinary approaches to fulfilling research objectives.

Specifically, this criterion addresses the:

- Expected significance of the proposed research – its potential impact to astrobiology and the broader scientific community,
- Extent to which the research is innovative, asking new questions and proposing new ways to answer them,
- Extent to which the entire proposal is integrated towards answering a unifying and compelling question in astrobiology,
- Degree to which the proposal is interdisciplinary – that is, the degree to which it includes and credibly applies the perspectives, skills, tools, and approaches of multiple disciplines toward addressing the question,
- Detail and soundness of the technical approach and methodology to be employed in conducting the proposed research, and
- Quality of scientific staff.

Prior relevant accomplishments will be considered positive evidence of the likelihood that the proposed research plan can be carried out successfully.

To score highly on Merit of the Research Plan, proposals should include interdisciplinary investigations of the highest quality, on a focused, compelling question that addresses at least one aspect of the 2015 Astrobiology Strategy. A proposal will be considered responsive to this program element whether its compelling question addresses a single Strategy goal or multiple Strategy goals, provided that the proposal provides an interdisciplinary approach to conducting the research.

5.2.2 *Merit of the Science Management Plan*

Each proposal must include a separate plan that describes how the staff, facilities, and other resources identified in the proposal will be managed to achieve the research objectives.

This plan must include:

- A structure for administering personnel, with particular emphasis on how the activities of researchers from different science disciplines will be integrated in implementing the proposed research program,
- A definition of the roles and responsibilities of each participant, noting the proportion of each individual's time to be devoted to the proposed research activity,
- A specific plan, when multiple institutions are involved in the proposal, for bringing separate elements together into a well-functioning and interdisciplinary unit. (If a consortium of institutions is proposed, letters verifying cooperation, coordination, and commitments of resources from administrative officials of the consortium members must be included as an appendix to the proposal.),

- An outline of the general plan of work, including anticipated key milestones for accomplishments, and
- A plan for maintaining communication among team members (e.g., weekly tag-ups, videoconferencing, annual meetings).

5.2.3 *Merit of the Data and Sample Management Plan*

The data management plan should ensure that results are fit for contemporary use and available for discovery and reuse.

Management plans must include:

- Types and volume of data, samples, and other materials to be produced in the course of the project.
- Standards to be used for data and metadata format and content.
- Policies for providing access and enabling sharing.
- Provisions for reuse, redistribution, and the production of derivatives.
- Plans for archiving and preserving access to data and materials.

Data should be made openly available as soon as possible, but no later than two (2) years after the data were collected. This period may be extended under exceptional circumstances, but only by agreement between the Principal Investigator and NASA.

5.2.4 *Relevance to ICAR*

Proposals will be evaluated on their relevance to the astrobiology program goals and relevance to an RCN. To be of high relevance, proposals must articulate and demonstrate an understanding of how the proposed research relates to and will influence the field of astrobiology as well as ongoing and planned research activities and flight missions of NASA, if applicable. Proposals will also be evaluated on how well they draw specific connections to, and describe how the results of the work will have strategic impact on, NASA's space flight programs, its broader science activities (e.g., in astronomy, astrophysics and Earth sciences), and/or its role as one of a suite of a Federal Research and Development (R&D) agencies supporting scientific research.

Relevance would be demonstrated by, but is not limited to, the following:

- Support of current or future space missions directed at astrobiological targets,
- Technology or instrument development related to the astrobiological exploration of these targets,
- Fundamental research having clear and critical but longer-term implications for acquiring or interpreting data from these targets,
- Synergistic collaboration with other funding agencies, or between the Astrobiology Program and other NASA science programs, for example, the Earth Science, Heliophysics, and Astrophysics Programs**.**

5.2.5 *Cost Reasonableness*

The resources requested must be appropriate and well justified for the period of performance. An assessment of cost, in the context of the proposed scope of work, will be performed by peer review, but not factored into the evaluation score. NASA

Astrobiology Program personnel will evaluate cost compared to funds available through this program element.

6. Summary of Key Information

Expected program budget for first year of new awards	~$5-7M
Number of new awards pending adequate proposals of merit	~5-10
Maximum duration of awards	5 years.
Due date for Step-1 proposals	See Tables 2 and 3 of this ROSES NRA.
Due date for Step-2 proposals	See Tables 2 and 3 of this ROSES NRA.
Planning date for start of investigation	6 months after proposal due date.
Page limit for the Research Plan section of proposal	25 pp; see below.
Relevance	This program is relevant to the Planetary Science questions and goals in the NASA Science Plan. Proposals that are relevant to this program are, by definition, relevant to NASA.
General information and overview of this solicitation	See the *ROSES Summary of Solicitation*.
Detailed instructions for the preparation and submission of proposals	Please see *ROSES Summary of Solicitation* Section I(g) Order of Precedence and the *NASA Guidebook for Proposers*.
Submission medium	Electronic proposal submission is required; no hard copy is permitted.
Web site for submission of Step-1 and -2 proposals via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Web site for submission of Step-1 and -2 proposals via Grants.gov	http://grants.gov (help desk available at support@grants.gov or (800) 518-4726)
Funding opportunity number for downloading an application package from Grants.gov	NNH19ZDA001N-ICAR
Point of contact concerning this program	Mary Voytek Planetary Science Division Science Mission Directorate NASA Headquarters Washington, DC 20546-0001 Telephone: 202-358-1577 Email: Mary.A.Voytek@nasa.gov

7. Details of Proposal Contents

Proposals to ICAR have the same basic requirements as submissions to other ROSES calls, with a few notable exceptions. Veteran ROSES proposers may refer to Section 2, above for a bullet list of the ways in which this program element differs from the default. However, in the interest of facilitating proposals from a broad community, including many who may be unfamiliar with ROSES, we include below thorough guidelines, repeating some things that appear in the *ROSES-2019 Summary of Solicitation*.

All Step-2 proposals in response to this element should include the following parts in the order listed (note that some are optional). Proposals that omit any required parts will be returned without review.

- NSPIRES Proposal Cover Page/Proposal Summary

The NSPIRES Proposal Cover Page contains the following:

Proposal Information: PI information, proposal title, proposed start and end dates, submitting institution information, certification and authorization.

Certifications, Assurances, and Representations: The Authorized Organizational Representative's (AOR) signature on the Proposal Cover Page automatically certifies that the proposing organization has read and is in compliance with these certifications. No additional form is necessary. Go to NSPIRES for the updated list.

Team Members*:* Names, institution and contact information. All team members must register themselves in NSPIRES and provide all required data. Each team member must establish an organizational relationship, i.e., identify the organization or other auspices through which the person is participating in the proposal. A proposal cannot be submitted if an organizational relationship within NSPIRES is missing from any team member. The online confirmation for team members satisfies the requirement for a "statement of commitment" unless contributions are provided. In such a case, a "letter" validating the contribution is additionally required.

Proposal Summary: (max. 4000 characters, Section 2.3.3 of the *NASA Guidebook for Proposers):* Brief description of the project, including objectives, targeted audience, partners, method of approach, relevance to NASA themes, use of NASA content, and outcomes. For Step-2 proposals, NSPIRES will initially populate this section with the proposal summary input for Step-1, which can be edited as necessary. Please note that if your proposal is selected this summary will be released so it should not contain any propriety information and must not contain any ITAR information.

NSPIRES Budget: Include figures for all years (up to 5 years for this program element) of the proposed project in the spaces provided, describing total budget, including any subawards. All labor costs, including civil servant labor, shall be provided in this part of the cover page; labor figures will automatically be redacted by NSPIRES for presentation to the peer reviewers (see Section IV(b)iii of the *ROSES Summary of Solicitation* and the SARA web page the walkthrough on this subject for more information on labor redaction).

Program Specific Data: Proposers should answer all questions asked in this section of the cover page.

Note: To improve proposal reviewability, only one PDF file for the full proposal can be submitted through NSPIRES. This file begins with the Proposal Title Page (the Table of Contents if no Title Page is used) and includes all of the contents described below. An advantage of submitting the proposal as one PDF document is that it is easier for the offeror to create a table of contents that will be correct. See below for further instructions on creation and submission of an additional PDF file – the "total budget" file.

- Proposal Title Page

The Proposal Title Page is optional, and its design is at the discretion of the proposer. If one is included, at a minimum it must include the full title of the proposal, the name of the Principal Investigator, the name and address of the proposing institution, and a list of any other institutions participating in the proposed investigation. The ITAR notice, if there is one, should be included on this page.

- Table of Contents

A *Table of Contents* shall identify each of the key parts of the proposal, including subsections of the proposal's central Research Plan. To facilitate developing and assembling the proposal, a proposer may individually number each principal section.

- Executive Summary

The Executive Summary should clearly describe the proposed program: its rationale, innovations, distinguishing features, unifying intellectual focus, proposed research, and training plans; and its approach to management of its participating personnel and institutions. In addition, this Summary should briefly address the commitment to implementing the collaborative and networking concepts of the NASA Astrobiology RCNs.

- Summary of Personnel and Commitments

The proposal must contain a one page summary list, in simple tabular form of the proposer's own choosing, that gives the names and/or titles of all personnel (including postdoctoral fellows and graduate students) and intended work commitment (both compensated and uncompensated) for the proposed investigation in time (rounded to the nearest 0.01 of a Work Year) for each year of the proposed period of performance.

- Research Plan

The proposal should contain sufficient detail to fully describe the proposed effort in order to enable a reviewer to make informed judgments about the overall merit of the proposed research and about the probability that the investigators will be able to accomplish their stated objectives. In addition, the proposal should indicate clearly the interdisciplinary nature of the research, and what innovative approaches are being applied to achieve the objectives.

This section is the main body of a proposal and should cover the following topics in the order given, all within the specified limit of 25 pages:

- The objectives and expected significance of the proposed research, including a complete description of any instruments or hardware proposed to be built in order to carry out the research (Note: see also the Facilities and Equipment section below for the description of critical equipment needed for carrying out the proposed research).
- How the proposed work is expected to build on and otherwise extend the state of knowledge in the field.
- The technical approach and methodology to be employed in conducting the proposed research, including any special facilities of the proposing institution(s) and/or capabilities of the proposer(s) for carrying out the work.

- Science Management Plan

The Science Management Plan should include each of those items indicated in Section 5 in sufficient detail to allow the reviewer to assess the likelihood of success of the proposed objectives.

- Data and Sample Management Plan

The Data and Sample Management Plan should demonstrate appropriate standards for data, metadata, and sample sharing and provide adequate details for reviewers to assess feasibility and accessibility of data and sample sharing with respect to the criteria listed in section 5.2.3.

The costs required to implement the proposed Data and Sample Management Plan must be included within the overall proposed budget.

Other research material sharing, registration and curation:

Sharing of valuable sample material is highly encouraged. Investigators are expected to share with other researchers, at no more than incidental cost and within a reasonable time, samples, physical collections, and other supporting materials created or gathered in the course of work under NASA agreements. Teams are expected to encourage and facilitate such sharing.

Nonbiological Samples collected during the conduct of research funded by NASA will be registered in SESAR, the System for Earth Sample Registration**,** as a first step towards sample curation and sharing.

SESAR operates the registry that distributes the International Geo Sample Number IGSN. SESAR catalogs and preserves sample metadata profiles, and provides access to the sample catalog via the Global Sample Search. For more information see http://www.geosamples.org/.

Biological Samples

Academic, private, and community facilities have traditionally been sites where biological materials are curated. Not all material can (or should) be accommodated in these facilities. PIs should archive voucher and type specimens as dictated by community standards and practices, as required by journals for publication, and as appropriate to support research results.

- References

All citations given in the *Research Plan* must be included in full in a list of references, without page limits. It is highly desirable that references use the full title of the paper or article being referenced. In all cases, standard and easily understood abbreviations for journals must be used.

- Relevance

Proposals must discuss relevance to this program element in a (4000-character max) text box on the cover pages via the NSPIRES web interface for this program element. Proposers are asked to explicitly address the relevance of their program to ICAR (see Sections 2.5 and 5.2.4). Proposals must demonstrate specific relevance. For example, relevance to missions should, when possible, describe specific missions and how the proposed work will contribute. Relevance to other NASA science programs should describe the specific program and the resulting synergy that is expected. Collaborations with other funding partners should describe the individual organizations and the nature of the partnership. Major impact to astrobiological science objectives should describe the particular significance of the work and its impact on the field.

- Facilities and Equipment

As appropriate, this section should describe any facilities (including any U.S. Government owned facilities) and/or major equipment critical for carrying out the proposed project that are already available or would need to be purchased in order to carry out the proposed investigation. In the latter case, these costs should be entered in the required proposal Budget Summary and described in accompanying budget details.

- Curriculum Vitae

The PI must submit a *Curriculum Vitae* (not to exceed three pages) that includes a history of his/her professional training and positions and a bibliography of publications relevant to the proposal. The proposal must also include a one page *Vitae* for each Co-I. A Co-I who serves as an Institutional PI may submit a *Vitae* using the same page limit as for the PI.

- Current and Pending Support

Information must be provided for all ongoing and pending projects and proposals that involve the proposing PI and any Co-Is who are expected to perform a significant share of the proposed work (e.g., an Institutional PI), whether or not their contributions are specific costs in the proposal's budget. Information is required for each of two categories of support awards that exist at the time of the proposal submission deadline, namely:

a) Current Support (for any of the period that overlaps with the proposal being submitted to this program element), and
b) Pending Support (including the proposal to this program element).

For each of these categories, provide the following information for each such key individual on the proposal team as noted above:

- Title of award or project;
- Program name (if appropriate) and sponsoring agency or institution (including point of contact with telephone number);
- Proposed period of performance and budget; and
- Commitment in fractions of a full time Work Year (WY = 2080 hours).

In addition, provide the name of any other institution, including an individual point of contact with their telephone number, to which the proposal submitted to this program element, or any part thereof, has been or will be submitted for consideration of funding. For such pending research, the PI must notify the Program Officer immediately of any successful proposals that are awarded any time after the proposal submission date until the time of selections.

- Statement(s) of Commitment from Co-I's and/or Collaborators

Every PI, Co-I, and Collaborator identified as a participant on the proposal's cover page and/or in the proposal's Research Plan must acknowledge his/her intended participation in the proposed effort. The NSPIRES proposal management system allows for participants named on the Proposal Cover Page to acknowledge a statement of commitment electronically.

- *Budget Summary and Details*

The required NSPIRES *Proposal Cover Page* contains a section in tabular form for the submission of budget figures, including all labor, for each year of the proposed effort, as well as for the total period of performance.

In addition to the budget summary information provided in the NSPIRES Cover Page forms, all proposers are required to include more detailed budgets including total FTE commitment for a task whether or not compensation is requested. NASA also requires budget justifications, including detailed subcontract/subaward budgets in the Budget Justification. For this program element, this additional budget must be divided into three parts, the "Budget Justification: Narrative" and the "Budget Justification: Details", both as described in the *NASA Guidebook for Proposers*, and the separately uploaded "Total Budget" a requirement specific to this solicitation. Proposers to this solicitation must provide the Total Budget in a file called "totalbudget.pdf" uploaded as a separate attachment in NSPIRES.

The first two parts the "Budget Justification: Narrative" and the "Budget Justification: Details" are within the proposal and available for peer review. The Budget Justification: Narrative includes the rationale and basis of estimate for all components of cost including procurements, travel, publication costs, and all subawards/subcontracts. The Budget Justification: Details must include the detailed proposed budget including all of the Other Direct Costs (see list below) and Other Applicable Costs as specified in the NASA Guidebook for Proposers. For this solicitation, the Budget Justification: Narrative and the Budget Justification: Details must not specify the Total Estimated Cost, or the cost of Labor, fringe or over head for any personnel.

The Total Budget file which is not seen by the peer reviewers must specify the complete set of cost components including all costs discussed in the Budget Narrative and Budget Details, as well as the Total Estimated Cost, cost of Direct Labor (including civil servant labor), and Administrative Costs (overhead). The Total Budget document will not be provided to the peer review, but will used by NASA in the evaluation of total cost and comparison of the proposed cost to available funds.

The required Budget Justification: Narrative and Details sections of the proposal must be incorporated into the single PDF proposal document as these will be provided to the peer review.

Note that failure to provide sufficient budget justification and data in the Budget Narrative (including the Table of Personnel and Work Effort) and the Budget Details, recognizing that the peer review will not have access to the Total Estimated Cost, the cost of Direct Labor, and Administrative Costs (e.g., overhead), will prevent the peer review from appropriately evaluating the cost reasonableness of the proposed effort. A finding by the peer review of “insufficient information to properly evaluate cost reasonableness” will be considered a weakness of the proposal. Inconsistent budget information between these budget descriptions will also be considered a weakness of the proposal.

Instructions for presenting the proposed budget are provided below. Note that the discussion below references items that should be in the “*total budget*” file; proposers should follow the guidance provided above for determining where each item described below should be presented.

1) Provide a complete Budget Summary for the total, as well as each individual year of the, proposed period of performance. The proposed costs are to be summarized according to the following general categories, which are consistent with the budget section of the *Proposal Cover Page*:
    - Direct Labor (salaries, wages, and fringe benefits)
    - Other Direct Costs:
        - Subcontracts
        - Consultant Services
        - Equipment
        - Materials and Supplies
        - Travel
        - Other
    - Indirect Costs (Facilities and Administrative Costs)
    - Total Estimated Costs

2) Provide detailed computations of all estimates in each cost category with narratives as required to fully explain each proposed cost as follows.
    - Direct Labor (salaries, wages, and fringe benefits): list the number and titles of personnel, amounts of time to be devoted to the grant, and rates of pay.
    - Other Direct Costs:
        a. Subcontracts: describe the work to be subcontracted, estimated amount, recipient (if known), and the reason for subcontracting.
        b. Consultants: identify consultants to be used, why they are necessary, the time they will spend on the project, and rates of pay (not to exceed the equivalent of the daily rate for Level IV of the Executive Schedule, exclusive of expenses and indirect costs).

c. Equipment: list separately. Explain the need for items costing more than $5,000.

   Describe basis for estimated cost. General purpose equipment is not allowable as a direct cost unless specifically approved by the NASA Grant Officer. Any equipment purchase requested to be made as a direct charge under this award must include the equipment description, how it will be used in the conduct of the basic research proposed, and why it cannot be purchased with indirect funds.
d. Supplies: provide general categories of needed supplies, the method of acquisition, and the estimated cost.
e. Travel: describe the purpose of the proposed travel in relation to the grant and provide the basis of estimate, including information on destination and number of travelers, where known.
f. Other: enter the total of direct costs not covered by above. Include an itemized list explaining the need for each item and the basis for the estimate.
g. Proposed Cost Sharing (if any): Any proposed cost sharing should be reflected within the amounts entered in the *Budget Summary* forms and the value of such cost sharing and the nature of it should be described in the narrative. There is no ability to demonstrate cost sharing as a negative number within the *Budget Summary* forms.

- Facilities and Administrative (F&A) Costs: Identify F&A cost rate(s) and base(s) as approved by the cognizant Federal agency, including the effective period of the rate. Provide the name, address, and telephone number of the Federal agency official having cognizance.
- Subtotal-Estimated Costs: Enter the sum of all items listed above.
- Other Applicable Costs: Enter total explaining the need for each item.
- Total Estimated Costs: Note that this amount must match the amount presented on the *Proposal Cover Page.*

- Note also the following important considerations when completing the proposed budget*:*

   (i) If a proposal is selected for award, failure to adequately address the provisions of the Instructions for Equipment will require that NASA contact the proposing institution for the required information. Such activity may delay the award until the purchase is either justified as a direct charge for general-purpose equipment or budgeted as an indirect expense.

   (ii) If a PI from a non-Government institution proposes to team with a Co-I from a U.S. Government institution (for this purpose, JPL is considered a NASA Center), then the institutional budget for that Government Co-I is to be included in the proposal's budget details, and the cost for this Government Co-I is to be listed under Other Applicable Costs of the Budget Summary and no institutional overhead should be applied to these costs. If the proposal is selected, NASA will execute an inter- or intra-agency funds transfer, as appropriate, to cover the cost of the Government Co-I. Conversely, if a Government PI institution teams with a private sector Co-I institution, that Government institution is expected to cover such Co-I costs through a subcontract that they execute. Therefore, such private sector Co-I costs should be entered under Subcontracts on the Budget Summary.

(iii) The proposing (PI) institution must subcontract the funding of all proposal Co-I's who reside at other institutions (except for a Government Co-I for a private sector PI as noted above); that is, NASA will not separately make awards to Co-Is at distributed institutions regardless of the cost impact to the PI proposal for the management of such subcontracts. (Note: Under exceptional circumstances, this provision can be waived)

(iv) Personnel from NASA Centers must propose budgets based on Full Cost Accounting (FCA). Non-NASA U.S. Government organizations should propose based on FCA unless no such standards are in effect; in that case such proposers should follow the Managerial Cost Accounting Standards for the Federal Government as recommended by the Federal Accounting Standards Advisory Board (for further information, see http://www.hq.nasa.gov/fullcost).

Electronic Submission through the NASA Solicitation and Proposal Integrated Review and Evaluation System (NSPIRES)

All proposals submitted in response to this solicitation must be submitted in electronic form. Hard copies will not be accepted. Electronic proposals must be submitted by the Authorized Organization Representative (AOR) at the proposer's institution. Electronic submission by the AOR serves as the required original signature by an authorized official of the proposing institution.

Proposers may opt to submit their Step-1 proposals in response to this solicitation via either of two different electronic proposal submission systems: either via the NASA Solicitation and Proposal Integrated Review and Evaluation System (NSPIRES) at http://nspires.nasaprs.com or via Grants.gov at http://www.grants.gov.

Step-2 proposals must be submitted via NSPIRES, regardless of which system was used for Step-1. NASA plans to use the NSPIRES system to facilitate the review process.

Note carefully the following requirements for submission of an electronic proposal to NSPIRES:

- Every organization that intends to submit a proposal to NASA electronically must be registered in NSPIRES. (this requirement applies even for Step-1 proposals submitted via Grants.gov)

- Organizations must obtain a Data Universal Numbering System (DUNS) number. Note that an organization must also be registered in the System for Award Management (SAM) and obtain a CAGE Code before receipt of any Federal award. The SAM approval process can take several days (at minimum). SAM registration should be performed by an organization's electronic business primary point-of-contact. Organizations new to NSPIRES or any offeror new to the NASA process should visit and register in the SAM system (sam.gov) early in the proposal preparation process.
- Any partner institution requesting NASA funds through the proposed project must be listed on the Proposal Cover Page. NASA will not fund institutions that do not appear on the Proposal Cover Page.
- In addition, every individual named on the proposal's electronic Proposal Cover Page form as a proposing team member in any role, including Co-Is and collaborators, must be registered in NSPIRES, even if the Step-1 proposal is submitted via Grants.gov. Such individuals must perform this registration themselves; no one may register a second party, even the PI of a proposal in which that person is committed to participate. This data site is secure and all information entered is strictly for NASA's use only.
- Each individual team member named on the proposal's cover page must specify an institutional relationship. The institutional relationship specified must be the institution through which the team member is participating in the proposed project. A proposal cannot be submitted if an organizational relationship is missing for any team member. If the individual has multiple institutional relationships, then this institution may be different from the individual's primary employer or preferred mailing address.

Submission of electronic proposals via NSPIRES requires several coordinated actions within the proposing institution. In particular, when the PI has completed entry of the data requested in the required electronic forms and attachment of the allowed PDF attachments, including the project description section, an official at the PI's institution who is authorized to make such a submission (referred to as the AOR) must submit the electronic proposal (forms plus attachments). Coordination between the PI and his/her AOR on the final editing and submission of the proposal materials is facilitated through their respective accounts in NSPIRES. Note that if one individual is acting in both the PI and AOR roles, he/she must ensure that all steps in the process are taken, including submitting the proposal from the institution.

Only appendices/attachments that are specifically requested in either this program element or in the *NASA Guidebook for Proposers* will be permitted. Proposals containing additional appendices/attachments may be declared noncompliant and returned without peer review. In the event the information in this program element is different from or contradicts the information in the *NASA Guidebook for Proposers*, the information in this program element takes precedence.

Important note on creating PDF files for upload: It is essential that all PDF files generated and submitted meet the NASA requirements below. This will ensure that the submitted files can be transferred into NSPIRES. At a minimum, it is the responsibility of the offeror to: (1) ensure that all PDF files are unlocked and searchable and that edit permission is enabled, to ensure that all submitted files can be ingested by NSPIRES; and (2) ensure that all fonts are embedded in the PDF file and that only Type 1 or TrueType fonts are used. In addition, any offeror who creates files using TeX or LaTeX is required to first create a DVI file and then convert the DVI file to Postscript and then to PDF. See http://nspires.nasaprs.com/tutorials/index.html for more information on submitting PDF documents into NSPIRES. PDF files that do not meet the NASA requirements cannot be transferred into the NSPIRES system; such files may be declared noncompliant and not submitted to peer review for evaluation.

NSPIRES will provide a list of all elements that make up an electronic proposal, and the system will conduct an element check to identify any item(s) that is (are) apparently missing or incomplete. The element check may produce warnings and/or identify errors. Warnings can be ignored if the proposer has verified that the apparently incomplete information is not inconsistent with the requirements of the solicitation. Warnings do not preclude proposal submission; however, an error in the element check will preclude submission.

Offerors are encouraged to begin their submission process early. Tutorials and other NSPIRES help topics may be accessed through the NSPIRES online help site at http://nspires.nasaprs.com/external/help.do. For any questions that cannot be resolved with the available on-line help menus, requests for assistance may be directed by E-mail to nspires- help@nasaprs.com or by telephone to (202) 479-9376, Monday through Friday, 8:00 a.m. to 6:00 p.m. Eastern Time (excluding Federal holidays).

C.24 GRAVITY/RADIO SCIENCE TEAM FOR THE EUROPA CLIPPER MISSION

NOTICE: Amended December 10, 2019. Proposals for Co-Investigators are now due January 24, 2020. This delay allows NASA time to select and announce the Lead Scientist for the Gravity/Radio Science team prior to the proposal deadline. New text is in bold and deleted text is struck through.

October 2, 2019. This amendment adds this new program element to ROSES-2019. A Notice of Intent (NOI) is mandatory for all proposers. Mandatory NOIs are due by October 21, 2019. Proposals to be Lead Scientist are due November 6, 2019 and proposals to be a team member are due ~~December 13, 2019~~.

1. Scope of the Program

The objectives of the Europa Clipper Gravity/Radio Science Team (Clipper G/RS) Program are to 1) add new members to the Europa Clipper science team with expertise in gravity, radio science, and/or similar investigations to the Europa Clipper science team; and 2) expand science community participation on the existing Europa Clipper science team. The program will select a Lead Scientist and Co-Investigators (Co-Is) to populate the Clipper G/RS team.

1.1. Eligibility

In order to meet the Clipper G/RS Program objective to expand science community participation on the Europa Clipper science team, current Co-Is on the Europa Clipper science team may not be the PI or Science PI of a proposal to this program element.

1.2. Background Information

The goal of the Europa Clipper mission is to explore Europa to investigate its habitability. The science objectives are:

- Characterize the ice shell and any subsurface water, including their heterogeneity, ocean properties, and the nature of the surface-ice ocean exchange;
- Understand the habitability of Europa’s ocean through composition and chemistry; and
- Understand the formation of surface features, including sites of recent or current activity; identify and characterize high science interest localities.

The spacecraft hosts nine science instruments, including cameras, an ultraviolet spectrograph, a mass spectrometer, a dust analyzer, a thermal imager, a magnetometer, an infrared spectrometer, an ice penetrating radar, and a plasma instrument. The Europa Clipper mission will conduct dozens of flybys of Europa at various latitudes and altitudes. While gravity/radio science investigations are not explicitly part of the Europa Clipper science objectives or Level 1 requirements, during flybys the mission shall collect a data set, on a best effort basis, conducive to performing Doppler radio science near Europa.

1.3. <u>Solicited Work</u>

1.3.1. General Information

Three types of proposals are permitted under this program element: 1) proposals to serve as the Lead Scientist for the G/RS team that describe the offeror's leadership abilities; 2) proposals to serve as a Co-I on the G/RS team that describe a science investigation; and 3) proposals to serve as a Co-I on the G/RS team focused on leading the data archiving effort for the G/RS team.

Eligible individuals may submit separate proposals for any or all of these three roles. NASA will first solicit proposals and select a Lead Scientist, followed by the submission of proposals and selection of proposals to place Co-Is on the G/RS team operating under the leadership of the Lead Scientist. This allows individuals not selected as the Lead Scientist to subsequently submit a proposal to serve as a Co-I on the G/RS team. Proposers need only submit a single Notice of Intent (NOI), regardless of how many proposals they may ultimately end up submitting. There is a NOI question where proposers may indicate the likely type of proposal(s) to be submitted.

1.3.2. Lead Scientist

The Lead Scientist will be responsible for managing and overseeing the quality and success of the Gravity/Radio Science investigations. More specifically, the Lead Scientist will:

- Oversee the selected Co-Is on the G/RS team, ensuring they are making appropriate progress on their investigations, verifying they possess the resources and data needed, and are abiding by Europa Clipper science team policies;
- Coordinate efforts among the Co-Is on the G/RS team, including publication of research papers, sharing research data and results among Co-Is on the G/RS team, and fostering collaboration among the Co-Is and the broader Europa Clipper science team;
- Represent the G/RS team to project leadership and the broader Europa Clipper science team.

The Lead Scientist will not manage awards for the Co-Is on the G/RS team. The Lead Scientist may choose to conduct their own research investigation as well.

1.3.3. Co-Investigator conducting research investigation

Co-Is on the G/RS team will be responsible for conducting their proposed and selected science investigation. Proposals submitted for this role should describe a science investigation utilizing the data provided by the spacecraft's telecommunications system to pursue research related to the science objectives listed above. Co-Is conducting a research investigation will fall under the leadership of the Lead Scientist.

1.3.4. Co-Investigator leading archiving activities

The Co-I on the G/RS team leading archiving activities for the G/RS, if selected, will be responsible for coordinating the archival of gravity and radio science data in the Planetary Data System, including archiving higher order data products produced by other G/RS team members. Such work must be submitted as a standalone proposal and not as part of a proposal describing a scientific investigation. The Co-I leading archiving activities will fall under the leadership of the Lead Scientist.

2. Programmatic Information

The Principal Investigator of selected proposals will join the Europa Clipper science team as Co-Is (or as the Lead Scientist) on the G/RS team for the remainder of the mission. These individuals will have the same rights and responsibilities as current Co-Is on the Europa Clipper science team. The G/RS Lead Scientist and Co-Is must follow the Rules of the Road, Code of Conduct, and Science Management Plan policies. Failure to do so will result in removal from the science team.

As stated above, the mission will collect radio science data during flybys on a best effort basis. Changes to the spacecraft design are not possible, and proposers should use the technical information posted with this program element on the NSPIRES web page to constrain their investigations. While the final tour is not yet finalized, proposers should use tour information provided with this program element when crafting their investigation. Investigations requiring mission support beyond that described in the information provided with this program element may be downgraded. Questions on the mission capabilities to support G/RS investigations should be sent to the point of contact listed in Section 4.

Only individuals employed at U.S. institutions are eligible to propose as Lead Scientist. Individuals at any institution, U.S. or non-U.S., may propose for a Co-I position on the G/RS team.

This solicitation is intended to select individuals as Co-Is (or Lead Scientist) for the G/RS team. Proposal teams shall consist of a single PI (or Science PI) with no collaborators, Co-investigators, or other team members listed in the proposal or on the cover page. Proposals violating this will be deemed noncompliant and returned without review. Support for unnamed undergraduate students, graduate students, and/or postdoctoral researchers is permissible.

This program element is an exception to the Appendix C default that external awards from are issued as grants. It is anticipated that the external awards that derive from proposals to this element will be as contracts from the project office at JPL.

2.1. Proposals from Non-U.S. Institutions

Proposals from non-U.S. institutions are acceptable and will only be considered on a no-exchange-of-funds basis. The expected program budget listed in section 4 excludes contributions from foreign organizations. All proposals will be reviewed by NASA to the same standards. All selections will be made by NASA. Proposers from non-U.S. institutions should read the Foreign PI Affiliation instructions document, which is downloadable as a PDF file from the NSPIRES web page for this program element. Non-U.S. proposers must include a letter of commitment promising financial support for all proposed activities. Even though no funds are to be requested from NASA, all non-U.S. proposals must contain all of the required sections outlined in the NASA Guidebook for Proposers, including complete budget information and the required table of time commitments for all proposal team members.

2.2. Sources of Information and Data Used in Proposal

All information used in the proposal pertaining to Europa Clipper or other missions must be available in the public domain (which includes the information available through NSPIRES), or the proposal will not be considered for selection, and may be returned without review. This includes any planetary spacecraft mission data. All data must be available in the Planetary Data System (PDS) or an equivalent, publicly accessible archive at least 30 days prior to the full proposal submission deadline. These restrictions are to prevent those who currently have access to data that are not yet public from having an unfair advantage by presenting these data in the proposal. Selected Co-Is on the G/RS team will have access to Europa Clipper data that are not yet public once they become members of the team; proposed access to and use of such data must be consistent with the *Europa Clipper Rules of the Road* and *Science Management Plan*.

2.3. Start Dates, Duration, and Selections

NASA expects to make selections for this program starting in FY 2020, with investigations running for the duration of the Europa Clipper mission. The budget for the program is expected to support the selection of one Lead Scientist and approximately five Co-Is on the G/RS team, excluding any selections from non-U.S. institutions.

Proposals should specify start dates of ~~February 1~~**April**, 2020.

2.4. Data Management Plans

Proposals submitted to this program element must include a Data Management Plan (DMP) consistent with the requirements outlined in program element C.1. This must be placed in a special section, not to exceed two pages in length, immediately following the References and Citations section for the Scientific/Technical/Management portion of the proposal. The DMP does not need to cover archiving of spacecraft data returned by the mission, which is already controlled by the mission-level DMP; however, it must cover new data and software products that would be generated under the proposal, including those derived from spacecraft data.

2.5. Program-Specific Proposal Content

Due to the extended nature of the mission, proposers should include a work plan and budget representing three mission phases: development, cruise, and prime operations plus mission closeout. This can be provided as a simple three-year plan and budget with one year representing each mission phase. The work plan and budget during development and cruise should be focused on supporting the project to execute the Europa Clipper mission. For these two periods, work plans and budgets should support attendance at two Europa Clipper science team meetings per year, participating in teleconferences, conducting analyses needed by the project, and attending G/RS team meetings. Proposers may consider approximately 10 weeks of effort per year during development and approximately 6 weeks of effort per year during cruise as reasonable estimates to guide crafting work plans and budgets. Proposals for the Lead Scientist role should include some additional support for the extra duties associated with the position. Work plans and budgets during prime operations should be driven by the needs of the proposed investigation.

Proposals must describe any roles the proposer currently holds on the Europa Clipper project and/or science team (e.g., Collaborator on an instrument).

The Science/Technical/Management (STM) section must contain a clear statement of how the proposed work can be accommodated by the Europa Clipper spacecraft and mission planned activities as well as how it advances achievement of the science objectives.

In addition to elements of a standard proposal, individuals interested in serving as the Lead Scientist of the G/RS team should include the following:

- Brief description as a standalone special section of the proposal not exceeding two pages describing the proposer's interest in serving as the Lead that emphasizes the proposer's key experience and skills relevant to the position and describes the proposer's leadership experience and philosophy; and
- (if proposer chooses to propose a science investigation) Brief description as part of the STM section describing the proposer's research investigation (note page limit on STM section in Section 4 below).

In addition to elements of a standard proposal, individuals interested in serving as a Co-I conducting research on the G/RS team must include the following:

- Brief description as part of the STM section describing the proposer's research investigation (note page limit on STM section in Section 4 below).

In addition to elements of a standard proposal, individuals interested in serving as a Co-I leading archiving activities on the G/RS team must include the following:

- Brief description comprising the STM section describing the proposer's interest in serving as the archiving lead that emphasizes the proposer's key experience and skills relevant to the position, describes past experience working with the PDS on archiving issues, and presents a general plan for working with the G/RS team, Europa Clipper project, and PDS to archive G/RS data and higher order data products (note page limit on STM section in Section 4 below).

For all proposals, there is a 6-page limit for STM Section. As stated above, Leads should include an additional section not exceeding two pages for their leadership description.

3. Proposal Preparation, Submission, and Evaluation

3.1 One Step Proposals

This program element does not use the two-step proposal submission process. For this program element, the submission of a NOI is mandatory. Proposals that are not preceded by the mandatory NOI may be returned without review.

3.2 Proposal Formatting and Content

Proposals must follow all formatting and content requirements described in C.1 the Planetary Science Research Program Overview and Section IV(b)ii of the ROSES Summary of Solicitation. Violation of these rules is sufficient grounds for a proposal to be rejected. Although proposers are expected to follow all of the rules outlined above, they should be especially aware of these common errors:

- Do not add an extra page containing your abstract prior to the main body of the proposal. The abstract is limited to the cover pages generated by NSPIRES.
- Do not add a table of symbols or abbreviations as an extra page beyond the page-limited Science/Technical/Management (STM) section. Such definitions must fit within the page limit.
- Do not set your figure captions in a smaller typeface than the minimum permitted for the body text.

Also, we recommend, but do not require, the following practices for clarity in writing proposals:

- Please do not use numbered callouts to bibliographic references in the STM section. Use the author name(s) and year.
- There is no need to present budgets broken down by federal fiscal years. Budgets should be organized by mission phase (see Section 2.5).
- Place clear titles on all subsections of your budget.

3.3 Modular Proposals

NASA has the option of funding only part of a proposal, if that part of the proposal receives a significantly better evaluation on intrinsic merit, relevance, or cost, or if only part of the overall project fits within the program budget. In order to be considered for this type of descoping, a proposal must be modular, with clearly identified (numbered), separable "tasks." A descopable task is a self-contained sub-project, which in and of itself is relevant to Clipper G/RS Program and of high scientific merit. Proposals that do not enumerate modular tasks will not generally be considered for descoped funding. Note that a proposal containing identified tasks does not require presentation of a separate budget for each task.

3.4 Evaluation and Selection of Proposals

All proposals with be evaluated for Intrinsic Merit, Cost, and Relevance, as defined in Appendix D of the NASA Guidebook for Proposers and consistent with Section VI(a) of the ROSES *Summary of Solicitation*. In addition, the extent to which the proposed work complements or augments Europa Clipper planned activities, would enhance the scientific return of the mission, or would reduce risk on the mission, may be considered a major component of the Intrinsic Merit score.

Programmatic factors that may affect selection of proposals include the degree to which the new work broadens participation in the mission and the ability of the mission to accommodate the proposed work in light of spacecraft and instrument capabilities, schedule, and resources. In addition, NASA will additionally consider the following criteria when selecting the Lead Scientist:

- Expertise in the area of gravity science, radio science, and/or other relevant field;
- Ability to lead and engage a diverse group of colleagues in a respectful, constructive, and positive manner; and
- Commitment to Europa Clipper mission and its science team.

4. Summary of Key Information

Expected program budget for first year of new awards	~$325K
Number of new awards pending adequate proposals of merit	One Lead Scientist and approximately five NASA-funded Co-Is on the G/RS team
Maximum duration of awards	Duration of Europa Clipper mission
Due date for mandatory Notice of Intent (NOI) for al proposals	October 23, 2019; See Tables 2 and 3 of this ROSES NRA.
Due date for proposals for Lead Scientist role	November 6, 2019; See Tables 2 and 3 of this ROSES NRA.
Due date for proposals for Co-I role (research and archiving) on the G/RS team	~~December 13, 2019~~ **January 24, 2020**; See Tables 2 and 3 of this ROSES NRA.
Planning date for start of investigation	~~February~~ **April** 1, 2020
Page limit for the central Science/Technical/Management section of proposals	6 pages. Two extra 2 pages are permitted for the leadership section.
Relevance	This program is relevant to the Planetary Science questions and goals in the NASA Science Plan. Proposals that are relevant to this program are, by definition, relevant to NASA.
General information and overview of this solicitation	See the *ROSES Summary of Solicitation.*
General requirements for content of proposals	See Section 3 of the *NASA Guidebook for Proposers* and Section IV and Table 1 of *the ROSES Summary of Solicitation*.
Detailed instructions for the submission of proposals	See https://nspires.nasaprs.com/tutorials/ Sections 3.22-4.4 of the *NASA Guidebook for Proposers* and Section IV(b) of *the ROSES Summary of Solicitation*.
Submission medium	Electronic proposal submission is required; no hard copy is required.
Web site for submission of proposals via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Web site for submission of proposals via Grants.gov	Not applicable. Awards will be contracts from the project office at JPL

Point of contact concerning this program	Curt Niebur Planetary Science Division Science Mission Directorate NASA Headquarters Washington, DC 20546-0001 Telephone: (202) 358-0390 Email: curt.niebur@nasa.gov

C.25 AKATSUKI PARTICIPATING SCIENTIST PROGRAM

NOTICE: Amended October 15, 2019. This amendment adds this new program element to ROSES-2019. Mandatory Notices of Intent are required by November 22, 2019 and proposals are due January 31, 2020. Proposals that are not preceded by a Notice of Intent will be returned without review.

1. Scope of Program

The objectives of the Akatsuki Participating Scientist Program (PSP) are to aid in data archiving and enhance and supplement Venus science being performed by the Akatsuki Venus Climate Orbiter. This call for proposals is for approximately four Participating Scientists (PSs) from U.S. institutions, and may include the selection of one Akatsuki Participating Scientist in residence (PSiR) at JAXA.

1.1 Overview

The Akatsuki PSP program seeks to support and enhance the Akatsuki mission science objectives, such as a better understanding of Venus' atmospheric circulation using global mapping with Akatsuki's five cameras (from ultraviolet to infrared wavelengths) and measurements of the atmospheric vertical structure with radio occultation techniques. The regular and continuous observations by Akatsuki should provide a complete dataset of the Venusian atmospheric dynamics that complements the observations by Venus Express and prior missions to Venus.

1.2 Participating Scientist Program

This program is intended to support the Akatsuki Mission. Selected Participating Scientists will become members of the Akatsuki science team and be required to fulfill responsibilities similar to those of current science team members, yet with the expectation that the scientific goals proposed enhance – not duplicate – those of the mission team. The selected PSs shall coordinate their activities and analyses with the present Principal Investigators (PIs) and Co-Investigators (Co-Is) on Akatsuki to achieve the essential scientific objectives of the investigation within the scope and resources of the project, and ensure dissemination of the investigation and results to the scientific community and the general public.

This opportunity includes the selection of one Akatsuki PSiR at JAXA, with full financial support. It is not required, but desirable, that the Akatsuki PSiR have knowledge of the Japanese language. The PSiR will reside in Japan (at the Institute of Space and Astronautical Science, ISAS) and work with the Akatsuki Science Team to reduce and help archive the data. Please see Section 1.4 regarding the PSiR.

Each PS will:

- Plan and advocate for the proposed PS scientific investigation as a Science Team Member,
- Participate in Akatsuki science team meetings,
- Perform initial data analysis to support operations and carry out subsequent analysis necessary to complete the proposed scientific investigation,

- Prepare, validate and deliver data products, documentation, and other pertinent investigation information for which they are responsible to the Planetary Data System (PDS) in PDS format, including participating in the Akatsuki Data Archive Working Group,
- Publish the results in peer-reviewed journals in accordance with NASA and Akatsuki project data release and publication policies, and
- Support the education and public outreach efforts of the Akatsuki's E/PO team.

1.3 Science Priorities for this Program Element

To be eligible, proposals must include a science investigation that addresses one or more of the Akatsuki mission-level science objectives listed below. Selected investigators will be expected to work in a collaborative manner with other Akatsuki science team members after selection. All team members will be bound by the Akatsuki Project "Rules of the Road" document that describes the data access rights, data-sharing responsibilities, and data release policies of the Akatsuki science team. This document will be available on the NSPIRES page for this program element. In the course of carrying out their scientific investigation, if a PS generates higher-level instrument products that an instrument PI is not already planning to produce and archive, the Participating Scientist must archive those products in the PDS. If such higher-level products are planned this must be indicated in the proposal and archiving described in the Data Management Plan.

Participating Scientists may propose any investigation of Venus that addresses one or more of the Akatsuki mission-level science objectives listed here:

- Structure of the Venusian atmosphere, cloud layers, and minor constituents near the cloud-top level,
- Better correction for navigation inaccuracies based on knowledge about cloud structure,
- Assimilation studies using Akatsuki data,
- Regional meteorology modeling,
- Better understanding of the local-time variations and long-term variability of the Venusian atmosphere,
- Synergistic research using Akatsuki data with observations from ground-based and/or earth-orbiting telescopes.

Although NASA is open to considering any outstanding proposals that meet these criteria, there are a few types of investigations that are particularly desired through this solicitation:

- Cloud microphysics and chemistry,
- Atmospheric dynamics and data assimilation, including modeling, radiative transfer and heat budget,
- Venus weather and long-term variability, including regional meteorology,
- Synergistic studies with ground and other space-based telescopes.

1.4 Participating Scientist in Residence (PSiR)

To be considered a PSiR, one must check the box on the NSPIRES web interface "cover page" affirming the intention to be a PSiR and provide a clear statement explaining how the PI meets the required qualifications. The PSiR statement is to follow the main 15-page Science/Technical/Management Section of the proposal but preceed the References and Citations. The PSiR statement must not exceed one page in length (with the normal formatting rules that apply to proposals).

In addition to the significant scientific contribution of the proposed project, desired qualifications for PSiR include, but are not limited to, the following:

- Desire to live in Japan for at least 50% of the calendar year(s) to work at ISAS (Sagamihara).
- Demonstrated expertise with PDS archival process. If the proposer has no PDS experience, they have to state a willingness to be trained.
- Proven experience as a team player. Significant interaction with all members of the Akatsuki mission team and their stakeholders will be required.
- Good communication skills. The PSiR will communicate with the team and other PSP PIs regarding mission development and updates.
- Knowledge of the Japanese language (desired).

Those applying to be PSiR must address expected expenses for their stay in Japan, including lodging, food, travel, etc., in the budget and the corresponding budget narrative.

1.5 Data Management Plans (DMPs)

Proposals submitted to this program element must include a Data Management Plan (see program element C.1). This must be placed in a special section, not to exceed two pages in length, immediately following the References and Citations section for the Scientific/Technical/Management portion of the proposal.

2. Proposal Submission

Please check Tables 2 and 3 of the ROSES-2019 solicitation for the most up to date information and links to amendments or clarifications. We anticipate selections approximately 8 weeks after proposals are received.

2.1 Proposal Guidelines

Only the PIs from each PSP proposal selected through this program will be designated as a Participating Scientist on the Akatsuki mission; any Co-Is or collaborators on the PSP proposal will be designated as Akatsuki science team Co-Is or collaborators according to Akatsuki's "Rules of the Road". Proposals may include funded Co-Is and/or unfunded collaborators to complete the proposed science investigation. The participation of graduate students and postdoctoral researchers is encouraged. However, they should be working under direct supervision of an Akatsuki Participating Scientist. Collaborators may be affiliated to any institution and their participation would provide focused contributions to specific tasks that are essential, but not critical, to the proposed work.

All proposals should contain the elements described in Section 2 of the *NASA Guidebook for Proposers*. Proposals should identify scientific ideas, including knowledge of terrestrial analogs (if appropriate), and unique theoretical and analytical capabilities that best meet the scientific objectives of the Akatsuki mission as described in this solicitation. Key projected milestones, accomplishments, and deliverables during each year of the proposed investigation should be identified.

2.2 Mandatory NOI

This program element uses a mandatory Notice of Intent (NOI). No budget is required for the NOI. Only proposers who submit an NOI by the due date given in Tables 2 and 3 of ROSES may submit a proposal. Proposals that are not preceded by a NOI will be returned without review. Mandatory NOIs are being used to allow assembly of the review panel in advance of the receipt of proposals so, please provide in the NOIs names of all participants you plan to include on your proposal. See Section IV(b)vi of the *ROSES Summary of Solicitation* for background on the mandatory NOI. Grants.gov does not provide NOI capability so, even if your organization plans to submit the proposal via Grants.gov, make sure that NOI is submitted on time via NSPIRES.

3. Programmatic Information

3.1 Eligibility to Propose

Any U.S. institution may propose to this solicitation, including current Akatsuki PSP PIs, Co-Is and Collaborators, with the exception of current Akatsuki team members (i.e., Akatsuki's PIs and Co-Is).

3.2 Type, Size, Number and Duration of Awards

All selected proposals will result in the award of grants, cooperative agreements, or intra- or inter-Government transfers, as appropriate. The Summary Table of Key Information in Section 4 gives the anticipated budget and number of awards. Selected investigators are expected to be funded for the period of May 2020 through April 2023.

3.3 Budget Information

Proposers must provide a detailed budget covering the entire time period from May 2020 through April 2023. The budget must follow the guidelines described in Section IV(b)iii of the ROSES Summary of Solicitation.

The budget must include funds to travel to one Akatsuki science team meeting in FY 2020, two in FY 2021, two in FY 2022, and one in FY 2023. Participating Scientists closely tied to a particular instrument are also encouraged, but not required, to include travel funds in their budget to visit that instrument PI's institution for one to two visits or instrument team meetings per year. Proposers should assume that the operations training sessions and Akatsuki science team meetings would take place in Japan and USA, although the actual location may be different. Science team meeting participation could also be done via teleconference.

Budgets must include all expenses for the PSP including all page charges for publication, attendance at conferences, travel, and other necessary expenses.

Funding of multiyear projects is contingent upon availability of funds, annual assessment of performance, and relevance of the research effort to the Akatsuki mission and program requirements.

3.4 Proposal Evaluation

The three main evaluation criteria are intrinsic merit, relevance, and cost. Compliant proposals will be evaluated vs. these criteria as given Section IV(a) of the *ROSES Summary of Solicitation*. In addition to the definition given in Appendix D of the *NASA Guidebook for Proposers*, intrinsic merit specifically includes the following factors:

- The material contribution of the investigator's proposed presence and involvement in mission planning and mission operations to obtaining data to support the investigation,
- The value added to the science mission planned by the existing Akatsuki science team, and the extent that the proposed investigation complements the currently planned science investigations, and
- The role of the investigator in improving existing and planned Akatsuki data products.

Proposals may not include bilateral participation with the People's Republic of China, see Section III(c) of the *ROSES Summary of Solicitation* for more information.

3.5 Progress Reports and Deliverables

After selection, each Participating Scientist shall provide to the Akatsuki Project Scientist, an Implementation Plan with a schedule for deliverables (including, but not limited to, software, data products, reports, and publication plans), and details regarding plans for data analysis, computing facilities, ground data system support, software development, support of instrument calibration, data archiving, and participation in E/PO activities. The Participating Scientists shall provide semiannual reports to the Akatsuki Project Scientist and the NASA Headquarters Program Officer that include: accomplishments over the past year, plans for the next year period, issues and concerns, schedule performance, financial performance, recovery plans, and status of publications and other deliverables.

4. Summary of Key Information

Average per year budget	~ $1M
Number of new awards pending adequate proposals of merit,	~ 4: ~three PSPs and one PSiR.
Maximum duration of awards	Typical awards are 3 years. Up to 4 years permitted.
Due date for Mandatory NOIs	See Tables 2 and 3 of this ROSES NRA.
Due date for proposals	See Tables 2 and 3 of this ROSES NRA.
Planning date for start of investigation	May 2020
Page limit for the central Science/Technical/Management section of proposal	15 pp; see also Table 1 of the *ROSES Summary of Solicitation* and the *NASA Guidebook for Proposers.*
Relevance	This program is relevant to the Planetary Science questions and goals in the NASA Science Plan. Proposals that are relevant to this program are, by definition, relevant to NASA.

General information and overview of this solicitation	See the *ROSES Summary of Solicitation*.
General requirements for content of proposals	See Section 3 of the *NASA Guidebook for Proposers* and Section IV and Table 1 of *the ROSES Summary of Solicitation*.
Detailed instructions for the submission of proposals	See https://nspires.nasaprs.com/tutorials/ Sections 3.22-4.4 of the *NASA Guidebook for Proposers* and Section IV(b) of *the ROSES Summary of Solicitation*.
Submission medium	Electronic proposal submission is required; no hard copy is permitted.
Web site for submission of mandatory NOI and proposal via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Web site for submission of proposals via Grants.gov	http://grants.gov (help desk available at support@grants.gov or (800) 518-4726)
Funding opportunity number for downloading an application package from Grants.gov	NNH19ZDA001N-ATSKIPSP
Points of contact, both of whom share the following postal address: Planetary Science Division Science Mission Directorate NASA Headquarters Washington, DC 20546-0001	Adriana C. Ocampo Telephone: (202) 358-2152 Email: aco@nasa.gov Lucas Paganini Telephone: (202) 358-3911 Email: lucas.paganini@nasa.gov

C.26 MARS 2020 PARTICIPATING SCIENTIST PROGRAM

NOTICE: Amended January 13, 2020. A FAQ, Helicopter Proposal Information Package, and Mars 2020 Science Team Guidelines have been added to the NSPIRES page for this program element, under "Other Documents". The due date for mandatory NOIs is now January 27, 2020. The due date for proposals remains unchanged.

December 13, 2019. This program requires a Notice of Intent (NOI). Proposals that are not preceded by the mandatory NOI will be returned without review. No feedback will be provided in response to the NOI. Data management plans will not be collected via the NSPIRES cover page, they are to be included in the uploaded proposal, see Section 2.6.

1. Scope of Program

1.1 Introduction and Background

The Mars 2020 rover mission is expected to launch in July/August 2020, with the objectives to assess the geological history of the Jezero crater landing site, determine the habitability and astrobiological potential of the landing site by seeking signs of ancient life in the rock record, collect a carefully selected and documented, returnable cache of martian surficial materials, and prepare for the eventual human exploration of Mars. The mission will use a variety of scientific instruments and technology demonstrations carried on the rover that will operate using its own power and telemetry, and that is expected to carry out its mission over the course of at least one Mars year.

This program element is for investigations in the Mars 2020 Participating Scientist Program (Mars 2020 PSP) to enhance the scientific return from the mission by broadening participation in the mission, augmenting the existing Mars 2020 science team to include new investigations that broaden and/or complement the funded Principal Investigator (PI)-led investigations, thus maximizing the contribution of Mars 2020 to the future exploration and scientific understanding of Mars. The second important goal of this opportunity is to increase the number of scientists supporting daily mission operations.

The timing of this solicitation is designed to permit selection and training of participating scientists (PSs) in time to contribute fully to both pre-landing activities such as landing site analysis and to science operations immediately upon arrival at Mars. Selected participating scientists will become members of the Mars 2020 science team and be required to fulfill responsibilities similar to those of current science team members. The PSs will be assigned to the Project and Program Scientists, rather than to an instrument PI. The Mars 2020 science investigators are intended to function primarily as an integrated team during operations. However, instrument teams will still exist and the PSs will be invited to attend instrument team meetings relevant to their investigation. Participation of PSs in the Science Theme Groups is particularly important, as discussed in the PS Program Proposal Information Package (PIP), which may be found under "Other Documents" on the NSPIRES page of this program element. The selected PSs will coordinate their activities and analyses with the Mars 2020 science team to achieve the essential scientific objectives of their PS investigation, within the scope and resources of the Mars 2020 project while following the "Rules of the Road", and ensure dissemination of the results of the investigation to the scientific community and the general public.

Before the Mars 2020 rover lands on Mars, each PS will:

- Become thoroughly familiar with the rover, its instruments, and its investigations;
- Participate in mars 2020 science team meetings;
- Participate as appropriate in mars 2020 science team working groups or instrument team meetings;
- Prepare to analyze data, developing techniques or algorithms if necessary;
- Prepare to archive any data products that will be generated by the ps investigation which are not currently in the mars 2020 data;
- Participate in operations training exercises and receive training for one or more operational roles;
- Work with the mars 2020 project to secure any needed clearances for jpl physical access, jpl computer access, jpl software licenses, etc.; and
- Support education and public outreach efforts of the Mars 2020 mission.

During the landed mission, each PS will:

- Actively and regularly participate in daily tactical operations, including serving in at least one operational role;
- Plan and advocate for the proposed ps scientific investigation as a science theme group member;
- Participate in mars 2020 science team, working group, and instrument team meetings;
- Freely share data with other team members
- Work with other members of the science team and rover engineering teams to define the long-term science operations strategy;
- Perform initial data analysis to support operations and carry out subsequent analysis necessary to complete the proposed scientific investigation;
- Prepare, validate, and deliver data products, documentation, and other pertinent investigation information for which each ps is responsible to the planetary data system, in accordance with the mars exploration program data management plan and the mars 2020 data plan archive generation, validation, and transfer plan,
- Publish the results in peer-reviewed journals in accordance with nasa, mars exploration program, and mars 2020 project data release and publication policies; and
- Support education and public outreach efforts of the Mars 2020 Mission.

This program element is soliciting investigations primarily involving the seven instruments that comprise the Mars 2020 payload. Investigations involving data from outside the seven instruments, including science investigations based on data from any of the engineering systems or technology demonstrations present on the rover (such as the helicopter), may be considered, but there is little ability to affect the capability and calibration of other mission hardware. In addition, there is limited information the project can provide about the actual capability and calibration of other mission hardware at this time, beyond what is in the Proposal Information Package.

To be compliant Proposals must include a science investigation that addresses one or more of the Mars 2020 science objectives listed below. Selected investigators will become members of the Mars 2020 science team and be encouraged to work in a collaborative manner with other Mars 2020 science team members after selection. All team members will be bound by the Mars 2020 Project "Rules of the Road" document that describes the data access rights, data-sharing responsibilities, and data release policies of the science team. The current version of this document is available in the Proposal Information Package on the NSPIRES index page for this program element. In the course of carrying out his or her scientific investigation, if a PS has to generate higher-level instrument products that an instrument PI is not already planning to produce and archive, the Participating Scientist proposal must indicate that the PS will archive those products in the PDS.

Participating Scientists may propose any investigation that addresses the goals of NASA and the Mars Exploration Program, although emphasis will be placed on investigations addressing one or more of the Mars 2020 science objectives, which are listed here:

A. Characterize the processes that formed and modified the geologic record within a field exploration area on Mars selected for evidence of an astrobiologically-relevant ancient environment and geologic diversity.

B. Perform the following astrobiologically relevant investigations on the geologic materials at the landing site:

   1) Determine the habitability of an ancient environment.
   2) For ancient environments interpreted to have been habitable, search for materials with high biosignature preservation potential.
   3) Search for potential evidence of past life using the observations regarding habitability and preservation as a guide.

C. Assemble rigorously documented and returnable cached samples for possible future return to Earth.

   1) Obtain samples that are scientifically selected, for which the field context is documented, that contain the most promising samples identified in Objective B and that represent the geologic diversity of the field site.
   2) Ensure compliance with future needs in the areas of planetary protection and engineering so that the cached samples could be returned in the future if NASA chooses to do so.

In addition to its scientific objectives, the Mars 2020 Project will conduct the following mission operations and technology validation experiments in order to support feed-forward to future Mars exploration missions:

D. Contribute to the preparation for human exploration of Mars by making significant progress towards filling at least one major Strategic Knowledge Gap (SKG). The highest priority SKG measurements that are synergistic with Mars 2020 science objectives and compatible with the mission concept are:

1) Demonstration of In-Situ Resource Utilization (ISRU) technologies to enable propellant and consumable oxygen production from the Martian atmosphere for future exploration missions,
2) Characterization of atmospheric dust size and morphology to understands its effects on the operation of surface systems and human health, and
3) Surface weather measurements to validate global atmospheric models.

Although NASA is open to considering any outstanding proposals that meet these criteria, we especially encourage those with expertise in astrobiology (as it related to investigating the potential for past life on Mars and searching for biosignatures, in line with the mission objectives), deciphering Mars' ancient climate from the rock record, and sedimentology/stratigraphy.

Because the intention of this program is to enhance and broaden the scientific return of the Mars 2020 mission, proposals submitted by Mars 2020 Instrument PIs, Deputy PIs, Instrument Co-Investigators (Co-Is), or anyone with a funded role on the mission will not be considered. In addition, anyone previously selected as a Returned Sample Science Participating Scientist is ineligible to apply to this solicitation.

NASA encourages proposals from people who have not previously participated in Mars missions or Mars research, but who have expertise in relevant scientific areas.

1.2 Proposal Information Package

The Proposal Information Package (PIP) for the Mars 2020 PS Program provides more details about the spacecraft, its payload and other useful information about the Mars 2020 mission and the science team. The Mars 2020 PIP is available on the NSPIRES index page for this program element under "Other Documents". At this time, the project can provide no information about the actual capability and calibration of other mission hardware beyond what is in the Proposal Information Package. Any additional information or responses to questions will be provided by updating and/or adding documents, such as Frequently Asked Questions, to the NSPIRES index page for this program element.

2. Proposal Submission

A Notice of Intent (NOI) is mandatory for this program element. NOIs must be submitted by the deadline, and late NOIs will not be accepted. Any proposal that is not preceded by an NOI will be returned without review. Note that no changes in title, scope, or PI are permitted from NOI to proposal. Also, this program element will not collect a data management plan on the NSPIRES cover pages, since data archiving is required of all members of the Mars 2020 science team and proposers will be held to the same requirements as those of the Mars 2020 project. In addition, some aspects of data management must be included in the body of the text and will be evaluated as part of merit (see Section 2.6). Moreover, if peer reviewed publications result from these awards, the data behind figures and tables must be available electronically at the time of publication, ideally in supplementary material with the article. See also Section II (c) of the *ROSES Summary of Solicitation.*

2.1. Proposal Guidelines

All proposals must contain the elements described in Table 1 of the *ROSES Summary of Solicitation* and Section 3 of the *NASA Guidebook for Proposers.* Where ROSES differs from the Guidebook, ROSES takes precedence (see Section I(g) of the ROSES Summary of Solicitation).

Only the principal investigator of each proposal selected through this program will be designated as a Participating Scientist on the Mars 2020 mission; any Co-Investigators (Co-Is) or collaborators on the proposal will be designated as Mars 2020 Science Team collaborators according to the Mars 2020 *Rules of the Road*. The Participating Scientist principal investigator is expected to be the primary, if not sole, individual contributing to the proposed science and all proposals should indicate a commitment level of an average of at least 18% time per month by the principal investigator alone, in each of the fiscal years FY20-FY23. Although not encouraged, proposals may include funded Co-Investigators at the same institution as the PI (and/or unfunded collaborators from any institution) only if they are critical to the proposed science investigation and justified in the proposal; however, participation of graduate students and postdoctoral researchers is encouraged in all proposals. Students and postdoctoral researchers should be working under the supervision of the PI during the mission; roles and responsibilities of students and postdocs should be clearly defined. Co-Is and collaborators should also indicate their commitment level in each of the award years AY 2020 through AY 2023, and provide focused contributions to specific tasks.

Proposals must identify scientific ideas and theoretical, field, and analytical capabilities that best meet the scientific objectives of the Mars 2020 mission, as described in this program element. Key projected milestones, accomplishments, and deliverables during each year of the proposed investigation should be identified.

2.2 Operational Roles

Because proposers will be participating in operations roles, they should be prepared to obtain the necessary training for operational positions (including participation in Operational Readiness Tests, which must be included in the travel budget; see Section 3.2) and they should be prepared to staff operational roles on a regular basis. If selected, the Project will assist in determining the operations roles that are most suitable and recommended location(s) for training. See also Section 3.2 and the Proposal Information Package for additional information regarding participation in other mission activities.

2.3 Sources of Information and Data Used in the Proposal

All information and data used in the proposal pertaining to the Mars 2020 mission, the Mars 2020 instruments (or testbeds or engineering models belonging to the Mars 2020 instrument teams), and Mars 2020 science data (from instruments, testbeds, or engineering models belonging to the Mars 2020 instrument teams) must be available and publicly available at least 30 days prior to the due date. If data are not available, then the proposal will not be considered for selection. By "publicly available," we mean information that can be found in the published literature, at the Mars 2020 website (http://mars.jpl.nasa.gov/m2020/), in the PDS, or through the NSPIRES web site or other established public archives and such information should be referenced in the proposal accordingly. For details on the mission and instrument capabilities, proposers should refer to the Proposal Information Package (PIP), which may be downloaded from the NSPIRES page for this program element.

2.4 Proposals from Non-U.S. institutions

Proposals from non-U.S. institutions are acceptable but will only be considered on a no-exchange-of-funds basis. The expected program budget listed in Section 4 excludes contributions from foreign organizations. Non-U.S. proposals will be reviewed to the same standards as proposals from U.S. institutions and selected solely by NASA. Proposers from non-U.S. institutions should read the Foreign PI Affiliation instructions document, which is downloadable as a PDF file from the NSPIRES web page for this program element. Non-U.S. proposers should include a letter of commitment demonstrating financial support for all proposed activities. Even though no funds are to be requested from NASA, all non-U.S. proposals must contain all of the required sections outlined in the *NASA Guidebook for Proposers*, including complete budget information and the required table of time commitments for all proposal team members. It is anticipated that more time will be needed to satisfy the requirements of Export Control Laws prior to making foreign persons members of the teams. Selected foreign investigators will work with JPL to secure access to JPL facilities.

2.5 Termination of Award

Any alteration of the Mars 2020 mission, or any of its instruments, engineering systems, mission priorities, or technology demonstrations, that renders the Participating Scientist unable to accomplish all of the proposed science tasks (*e.g.,* spacecraft or instrument failure) may be cause for award termination. In such a case, NASA reserves the right to terminate the award after a suitable closeout period is negotiated with the PI. NASA may alternatively choose to engage the PI to conduct a modified or altered research program, for all or part of the remainder of the award period.

2.6 Data Management Plan

Proposals must include a data management plan (DMP) that describes proposed involvement in improving planned data products. Proposers are strongly encouraged to use the PSD DMP template, that may be downloaded as a Word document, or a LaTeX template in the form of a .txt file, from the SARA web page at: https://science.nasa.gov/templates-planetary-science-division-appendix-c-roses-proposals.

DMPs must be placed in a special 2-page section of the proposal, entitled "Data Management Plan" immediately following the references and citations for the S/T/M portion of the proposal. The two-page DMP section does not count against the 15-page limit of the S/T/M section. Formatting requirements for DMPs are the same as for the S/T/M section.

3. Programmatic Information

3.1 Award Duration and Funding

Participation is expected to begin in July/August of 2020 and extend through the end of the prime mission (currently June 2023) plus a 3-month wrap up period. The start date is contingent on funding availability. For purposes of this proposal the end date should be considered 30 September 2023.

Proposers should be prepared (and should budget for) a commitment of a minimum of 18% time through this three-and-a-half-year period.

3.2 Budget Information

The budget must follow the guidelines described in the *NASA Guidebook for Proposers*, and the budget must include funding for any training and data analysis to support the proposed science investigation. Budgets should include salary, all page charges for publication and reprints, attendance at conferences, all travel, and other necessary expenses.

Proposers should include adequate funds for the PI to travel to Pasadena, CA to participate in one Operations Readiness Test (ORT) during Phase E (after launch but before landing on Mars, July 2020-February 2021), and science team meetings (one week per calendar year from 2020-2023). In addition, proposers should budget travel for 60 days of a 90-day period of Science Team co-location in Pasadena, CA post-landing during calendar year 2021. After those first 3 months, participation in operations will be done by the science team remotely from scientists' home institutions. Landing will be 18 February 2021; proposers should use that date for planning their budgets and work.

The expected program budget for the first year of award and number of awards are indicated in Section 4 (Summary of Key Information).

3.3 Evaluation Criteria

As stated in Section VI.(a) of the *ROSES-2019 Summary of Solicitation* and the *NASA Guidebook for Proposers*, the evaluation criteria are intrinsic merit, relevance, and cost reasonableness. In addition to the factors for each criterion given in the Proposers Guidebook, this program specifically includes the following factors:

• Intrinsic merit will additionally include:
  - Technical consideration of the capability of the rover and the Mars 2020 payload and other hardware to reasonably accomplish the proposed investigation.
  - Technical consideration of the capabilities of the Mars 2020 spacecraft to reasonably accomplish the proposed investigation.
  - Merit of proposed involvement in working groups.
  - Merit of proposed involvement in improving planned data products, as described in the data management plan.
  - Proposed involvement in science mission operations

- The value added to the science mission and the extent to which the proposed investigation complements, expands on, or enhances the currently planned science investigations.

• Relevance will include evaluation of the extent to which the proposal contributes to the goals and the applicable mission-level science objectives of the Mars 2020 Mission.

• Cost reasonableness will additionally include budget analysis to ensure that participation in daily operations is sufficiently supported.

Programmatic factors that may affect selection of proposals will also include the degree to which the proposed work broadens participation and expertise in the mission and the ability of the mission to accommodate the proposed work in light of spacecraft and instrument capabilities, schedule, mission priorities, and resources.

3.4 Progress Reports and Deliverables

The Participating Scientist shall provide annual reports to the Mars 2020 Project Scientist and the NASA Headquarters Mars 2020 Program Scientist that include: accomplishments over the past year, plans for the next year, issues, concerns, schedule performance, financial performance, recovery plans, and status of publications and other deliverables. PSs selected through this program element will be funded directly from NASA Headquarters; extramural awards will be grants and not contracts.

4. Summary of Key Information

Expected program budget for first year of new awards	~$1.5-2M
Number of new awards to US PIs pending adequate proposal of merit	~10
Maximum duration of awards	3.5-4 years (see text)
Due date for mandatory NOI	See Tables 2 and 3 of this ROSES NRA.
Due date for proposals	See Tables 2 and 3 of this ROSES NRA.
Planning date for start of investigation	July/August 2020
Page limit for the central Science-Technical-Management section of proposal	15 pp; see also Table 1 of the *ROSES-2019 Summary of Solicitation* and Section 3 of the *NASA Guidebook for Proposers*.
Relevance	This program is relevant to the Planetary Science questions and goals in the NASA Science Plan. Proposals that are relevant to this program are, by definition, relevant to NASA.
General information and overview of this solicitation	See the *ROSES-2019 Summary of Solicitation*
Detailed instructions for the preparation and submission of proposals	See Table 1 and Section I(g) of the *ROSES-2019 Summary of Solicitation* and the *NASA Guidebook for Proposers*

Submission medium	Electronic proposal submission is required; no hard copy is required or permitted.
Web site for submission of proposal via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376)
We site for submission of proposal via Grants.gov	http://grants.gov (help desk available at support@grants.gov of (800) 518-4726)
Funding opportunity number for downloading an application package from Grants.gov	NNH19ZDA001N-M2020PSP
Point of contact concerning this program	Mitch Schulte Mars 2020 Program Scientist Planetary Science Division Science Mission Directorate NASA Headquarters Washington, DC 20546-0001 Telephone: (202) 358-2127 Email: Mitchell.D.Schulte@nasa.gov

APPENDIX D. ASTROPHYSICS RESEARCH PROGRAM

D.1 ASTROPHYSICS RESEARCH PROGRAM OVERVIEW

1. Introduction

The objectives of research solicited in program elements described in program elements D.2 through D.12 of this NASA Research Announcement (NRA) are focused on achieving the goals of the Science Mission Directorate's Astrophysics Research Program, as defined in the *NASA Science Plan* (available at http://science.nasa.gov/about-us/science-strategy). Proposers to the elements described in Appendix D are encouraged to read this *NASA Science Plan* to gauge the relevance of their research to the Astrophysics Research Program.

The *NASA Guidebook for Proposers* and the *ROSES Summary of Solicitation* (Section IV) provide clear and specific requirements for the format of proposals submitted in response to this solicitation: page limits, acceptable font sizes, line spacing, margins, etc. See also Table 1 of the *ROSES Summary of Solicitation.* Some of the program elements listed below also include formatting requirements. These requirements have been developed to ensure a level playing field for all proposers. The Astrophysics Division takes these requirements seriously, and proposals found to violate them will be penalized, even to the extent of not being evaluated or considered for funding. It is the responsibility of the proposer to ensure that a submission complies with all formatting requirements.

Most proposals to ROSES will require a data management plan (DMP) or an explanation of why one is not necessary given the nature of the work proposed (e.g., instrument development proposals, see Sections 3, 6, and 7, below). This requirement will be satisfied by responding to the compulsory NSPIRES cover page question about the DMP. It is expected that the majority of proposals will simply state that the proposer will meet the mandatory minimum requirement by making the data behind figures and tables available electronically at the time of publication, ideally in supplementary material with the article. More information on the data management plan is available in the SARA DMP FAQs.

Proposers are reminded that it is the PDF version of their proposal in NSPIRES that will be judged for compliance. In rare cases, cross-platform translation of PDF documents can alter the formatting of a document. To ensure that they still conform to all formatting requirements, proposers are strongly urged to download copies of all documents after upload to NSPIRES.

Unless otherwise noted in the individual program elements, NASA does not anticipate awarding contracts in response to proposals submitted to most program elements in Appendix D, because it would not be appropriate for the nature of the work solicited. Contracts may be awarded in response to proposals to D.3 APRA and D.8 SAT, as appropriate.

The program elements included as of the release date of this ROSES NRA are described below. Abstracts of previously selected investigations may be found online at http://nspires.nasaprs.com/ by choosing "Solicitations" followed by "Closed/Past

Selected", searching on the name or abbreviation of the program (e.g., ADAP), and downloading the selections PDF file from the home page of that program element.

2. Astrophysics Data Analysis

PLEASE NOTE that because of the partial government shutdown and subsequent delay in the release of ROSES-2019, the ADAP solicitation for calendar year 2019 was solicited via a late amendment to ROSES-2018 so that its historically early due dates could be maintained. The Astrophysics Data Analysis Program (ADAP; program element D.2) supports research with a primary emphasis on the analysis of archival data from current and past NASA space astrophysics missions. The magnitude and scope of the archival data from those missions enables science that transcends traditional wavelength regimes and allows researchers to answer questions that would be difficult, if not impossible, to address through an individual observing program. The program now also supports the analysis of publicly available data from the Neutron star Interior Composition Explorer (NICER) and some approved Guest Observer (GO) programs using Spitzer, even if those observations have yet to be executed, or the data are still within their proprietary period.

3. Astrophysics Research and Analysis

The Astrophysics Research and Analysis program (APRA; program element D.3) supports suborbital and suborbital-class investigations, development of detectors and supporting technology, and laboratory astrophysics. Basic research proposals in these areas are solicited for investigations that are relevant to NASA's programs in astronomy and astrophysics, including the entire range of photons, gravitational waves, and particle astrophysics. The emphasis of this solicitation is on technologies and investigations that advance NASA astrophysics missions and goals. Projects devoted to technology development efforts (Detector Development and Supporting Technology categories) that do not generate scientific data need not provide a data management plan and proposers may simply cite this statement in response to the NSPIRES cover page question in lieu of presenting a plan.

4. Astrophysics Theory

The Astrophysics Theory Program (ATP; program element D.4) supports theoretical investigations or modeling of the astrophysical phenomena targeted by past, current, or future NASA astrophysics space missions. Laboratory work related to NASA strategic goals in gravitation and fundamental physics is now supported in the Astrophysics Research and Analysis program (APRA; program element D.3). Theoretical work pertaining to atomic and molecular astrophysics and other topics directly related to Laboratory Astrophysics should also be proposed to APRA. Beginning in ROSES-2017, the Astrophysics Theory Program (ATP) element of ROSES converted to soliciting proposals on a biennial basis. Thus, NASA did not solicit ATP proposals as part of ROSES-2018, but is soliciting ATP proposals in ROSES-2019.

5. Astrophysics Guest Investigators

Six program elements support science investigations that require and/or support new data obtained with currently operating NASA astrophysics space missions. Guest investigator programs are included for the Neil Gehrels Swift Observatory gamma-ray burst explorer (program element D.5), the Fermi Gamma-ray Space Telescope (program element D.6), the nuclear spectroscopic telescope NuSTAR (program element D.9), the Transiting Exoplanet Survey Satellite (TESS, program element D.10), and the Neutron star Interior Composition Explorer (NICER, program element D.11). Guest investigator programs for the Hubble Space Telescope (http://www.stsci.edu/hst/), the Chandra X-ray Observatory (http://cxc.harvard.edu/), Stratospheric Observatory for Infrared Astronomy (SOFIA) (https://www.sofia.usra.edu/), and the Spitzer Space Telescope (http://www.spitzer.caltech.edu/) are solicited separately by the respective science centers of those missions.

6. Strategic Astrophysics Technology

The Strategic Astrophysics Technology program (SAT; program element D.7) supports focused development efforts for key technologies to the point at which they are ready to feed into major missions in the three science themes of the Astrophysics Division: Exoplanet Exploration, Cosmic Origins, and the Physics of the Cosmos. This program is specifically designed to address middle technology readiness level (TRL) "gaps" between levels 3 and 6: the maturation of technologies that have been established as feasible, but which are not yet sufficiently mature to incorporate into flight missions without introducing an unacceptable level of risk. NASA does not require a data management plan for proposals to SAT.

7. Nancy Grace Roman Technology Fellowship Program

The goals of the Nancy Grace Roman Technology Fellowship (RTF) program in Astrophysics are to provide early-career researchers the opportunity to develop the skills necessary to lead astrophysics flight instrument development projects, including suborbital investigations, in preparation to become principal investigators (PIs) of future astrophysics missions; to develop innovative technologies for space astrophysics that have the potential to enable major scientific breakthroughs; and to foster new talent by putting early-career instrument builders on a trajectory towards long-term positions.

The RTF program, as described in program element D.8, now consists of two components with two different submission procedures. The first component is a one-page application from an eligible early-career individual to be named a Roman Technology Fellow. The application is submitted as part of a proposal submitted to the Astrophysics Research and Analysis (APRA) Program described in program element D.3 of this ROSES solicitation. The second component is the subsequent submission of a proposal for Fellowship Funding by a previously selected Roman Technology Fellow once that individual obtains a permanent or permanent-track position, in order to start a laboratory or develop a research group at the Fellow’s institution.

8. Exoplanet Research Program (XRP)

PLEASE NOTE that because of the partial government shutdown and subsequent delay in the release of ROSES-2019, the XRP solicitation for calendar year 2019 was solicited via a late amendment to ROSES-2018 so that its historically early due dates could be maintained. The cross-division program on exoplanets is described in program element E.3. Investigations related to the detection and characterization of planetary systems that are directly tied to the NASA strategic goal to search for Earth-like planets are of interest to the Astrophysics Division.

9. Habitable Worlds Program

The cross-division program on habitable planets is described in program element E.4. The Astrophysics Division will consider supporting investigations that are focused upon the characterization of potentially habitable exoplanets and their atmospheres in order to inform targeting and/or operational choices for current NASA Astrophysics missions and/or formulation data for future NASA Astrophysics observatories.

10. SmallSat Studies

This program supports six-month studies of spaceflight mission concepts that can be accomplished for low cost using small spacecraft in standard form factors, including CubeSats, CubeSat constellations, Expendable Launch Vehicle Secondary Payload Adapter (ESPA) and ESPA-grande-ring compatible spacecraft, launched as secondary payloads. The placeholder for this Astrophysics Science SmallSat Studies will be replaced with the final text for this program element by amendment to this NRA no less than 90 days prior to the proposal due date.

D.2 ASTROPHYSICS DATA ANALYSIS

The Astrophysics Data Analysis Program (ADAP) is not soliciting proposals in ROSES-2019. Because of the delayed release of ROSES-2019 caused by the extended partial government shutdown, a Second ADAP was solicited as program element D.16 in ROSES-2018, on a schedule similar to the one that this program has had for several years. Interested proposers should check that program element for details.

1. Scope of Program

Over the years, NASA has invested heavily in the development and execution of an extensive array of space astrophysics missions. The magnitude and scope of the archival data from those missions enables science that transcends traditional wavelength regimes and allows researchers to answer questions that would be difficult, if not impossible, to address through an individual observing program. To capitalize on this invaluable asset and enhance the scientific return on NASA mission investments, the Astrophysics Data Analysis Program (ADAP) provides support for investigations whose focus is on the analysis of archival data from NASA space astrophysics missions.

3. Summary of Key Information

Point of contact concerning this program	Douglas M. Hudgins Astrophysics Division Science Mission Directorate NASA Headquarters Washington, DC 20546-0001 Telephone: (202) 358-0988 Email: Douglas.M.Hudgins@nasa.gov

D.3 ASTROPHYSICS RESEARCH AND ANALYSIS PROGRAM

NOTICE: Amended September 3, 2019. This APRA program element for calendar year 2020 has been shifted to ROSES-2020. The deadlines will be announced in ROSES-2020, to be released in February 2020.

For planning purposes, prospective proposers should anticipate that the mandatory Notice of Intent deadline will be in October 2020 and the proposal deadline will be in December 2020. This is roughly 9 months later than in previous years. This will enable the planned start date for funding for all proposers to begin on October 1 following the proposal deadline, as opposed to the present different dates for NASA and non-NASA PIs.

The annual funding for APRA is unchanged. Therefore, this schedule modification will not change the scope of APRA in overall budget or number of investigations, but rather will affect when proposals are selected to fill the APRA program.

Additionally, prospective proposers should anticipate that the allowance for "Co-Investigator Proposals" for suborbital and suborbital-class investigations (see Section 1.2.1.4 of APRA 2018 for example) will be absent from the APRA element in ROSES-2020.

Questions regarding this program element and/or this amendment should be directed to the point of contact given below.

Main point of contact concerning this program element	Dominic J. Benford Astrophysics Division Science Mission Directorate NASA Headquarters Washington, DC 20546-0001 Telephone: (202) 358-1261 Email: Dominic.Benford@nasa.gov

D.4 ASTROPHYSICS THEORY

NOTICE: Corrected May 31, 2019. The Summary Table of Key Information in Section 4 has been modified to reflect that ~50-60 new Astrophysics Theory Program (ATP) awards are expected to be made as part of ROSES-2019, with an expected total first year budget of ~$8M. This is consistent with the number of new ATP awards made in ROSES-2017, when the program moved to biennial solicitations with a higher first year budget available per solicitation.

Beginning in ROSES-2017, the Astrophysics Theory Program element of ROSES is accepting proposals on a biennial basis. Thus, ATP is accepting proposals as part of the ROSES-2019 solicitation, but will not in ROSES-2020.

1. Scope of Program

The Astrophysics Theory Program (ATP) supports efforts to develop the basic theory for NASA's space astrophysics programs. Abstracts of previously selected ATP projects may be found online at http://nspires.nasaprs.com/ (choose "Solicitations" then "Closed/Past Selected" on the left). The periods of performance of investigations for this research element may range from one to four years. Most awards will have a duration of three years, but four-year awards may be made if the need for the longer duration is sufficiently well justified in the proposal.

The Astrophysics Theory Program does not permit multiple Principal Investigators (PIs) (see Section IV(b)i of the *Summary of Solicitation*). Each proposed investigation must be led by a single PI. The PI institution is expected to fund Co-Investigator(s) (Co-I(s)) participating via subawards, except where the Co-I is at a Government institution, including the Jet Propulsion Laboratory (JPL).

The proposed work submitted for this program must both:

- Be directly relevant to space astrophysics goals by facilitating the interpretation of data from space astrophysics missions or by leading to predictions that can be tested with space astrophysics observations; and
- Consist predominantly of theoretical astrophysics studies or the development of theoretical astrophysics models.

ATP proposals satisfying both of the above requirements may involve development of data analysis methods for astrophysics missions and may incidentally include actual data analysis as a test of the theory or the method.

Proposals to the ATP program may not:

- Consist primarily of data reduction or data analysis (such proposals should be directed to the mission-specific programs or the Astrophysics Data Analysis Program (ADAP) described in Program element D.2 in this solicitation);
- Propose theoretical work pertaining to atomic and molecular astrophysics and other topics directly related to Laboratory Astrophysics (these should be proposed

to the Astrophysics Research and Analysis (APRA) program element described in Program element D.3);

- Develop experimental payloads to test theories of gravitation and fundamental physics (such proposals should be submitted to the APRA program element described in Program element D.3);
- Address theoretical topics that are predominantly unrelated to the needs of NASA's space astrophysics programs (such proposals should be directed to other appropriate Federal agencies);
- Deal strictly or predominantly with Solar System objects or solar-terrestrial interaction studies, including solar energetic particles (see Appendices B and C for appropriate programs);
- Propose to develop technologies or experimental concepts for future NASA missions (these proposals should be submitted to the APRA program element described in Program element D.3 or the Strategic Astrophysics Technology program element described in Program element D.7);
- Propose to develop new data analysis methods for future space missions (these proposals should be submitted to the APRA program element described in Program element D.3)
- Primarily aim at studying new mission concepts; or
- Request support for organizing and/or hosting scientific meetings.

2. <u>Proposal Category and Research Areas</u>

ATP proposals will only be accepted from individual Principal Investigators (PIs) whose proposed work has a clear, single focus. Group proposals, i.e., those in which several researchers submit an omnibus proposal of related, but separate, theoretical research investigations under a designated PI, are not solicited for the ATP and will be considered unresponsive to this program element. However, individual theory PIs may include as many Co-Investigators and Collaborators as they wish on their proposals.

Investigators may submit more than one proposal to the ATP if the research program of each proposal is significantly distinct. If a proposal is submitted as a successor to work supported by an earlier proposal, the new proposal must identify the related work and clearly summarize all significant results from it.

For the purposes of conducting the peer review, every proposal for this ATP must identify one (or more, if appropriate) of the Topic Categories from the list below in both its Notice of Intent to propose and in the proposal submission itself. The primary use of these Topic Categories is to facilitate the assignment of the proposal to an appropriate review panel. NASA reserves the right to assign a proposal to a different category. Depending on the mix of proposals received, review panels may not correspond exactly to these categories:

1. Exoplanet Astrophysics (e.g., circumstellar disks, exoplanet atmospheres, planet formation);
2. Stellar Astrophysics (e.g., astrochemistry, asteroseismology, brown dwarfs, convection, stellar evolution, stellar mass loss);
3. Collapsed Objects and X-ray Astrophysics (e.g., black-hole binaries, cataclysmic variables, neutron stars, X-ray binaries, white dwarfs);

4. Supernovae and Gamma Ray Bursts;
5. Star Formation, Interstellar Medium, Cosmic Rays, and Galactic Structure (e.g., dark clouds, diffuse galactic emission, HII regions, interstellar dust, planetary nebulae, protostars, star-forming clouds, stellar clusters, supernova remnants);
6. Galaxies (e.g., accretion disks and jets from active galactic nuclei (AGNs), circumgalactic medium, interacting galaxies, quiescent galaxies, starburst galaxies);
7. Galaxy Formation (e.g., evolution of galaxies and AGN, population studies);
8. Large Scale Cosmic Structure and Dark Matter (e.g., clusters of galaxies, diffuse photon backgrounds, intracluster medium, lensing studies);
9. Dark Energy and the Cosmic Microwave Background (e.g., dark energy models, theoretical cosmology, theoretical studies of cosmological observation techniques);
10. Gravitational Astronomy (e.g., computation of gravitational radiation waveforms, gravitational wave sources); and
11. Other Astrophysics Theory (NASA Headquarters will assign the proposal to what it deems is the most appropriate review panel).

3. Availability of High-End Computational Resources

Those investigators whose research requires high-performance computing should refer to the *Summary of Solicitation*, Section I(d), "NASA-provided High-End Computing Resources." This section describes the procedure that proposers to the Astrophysics Theory program must follow to apply for computing time on either of two NASA computing facilities at the Goddard Space Flight Center's Computational and Information Sciences and Technology Office or at the Ames Research Center's Advanced Supercomputing Division. ATP proposers may instead request support for the purchase of computing equipment or computing time from non-NASA providers of high-performance computing systems and services. In this case, the budget narrative should include a comparison between the cost of the proposed computing solution and that set out for NASA systems at https://www.hec.nasa.gov/user/policies/sbus.html. ATP proposers requesting support for non-NASA computing may not also request NASA HEC resources, and vice versa. All computing resource requests will be evaluated under the cost reasonableness criterion by the science peer review panels (see Section VI(a) of the *Summary of Solicitation*).

4. Summary of Key Information

Expected program budget for first year of new awards	~~~$4M~~ **~$8M [Corrected May 31, 2019]**
Number of new awards pending adequate proposals of merit	~~~30~~ ~**50-60 [Corrected May 31, 2019]**
Maximum duration of awards	4 years; shorter term proposals are encouraged; four-year proposals must be well justified
Due date for Notice of Intent to propose (NOI)	See Tables 2 and 3 of this ROSES NRA
Due date for proposals	See Tables 2 and 3 of this ROSES NRA

Planning date for start of investigation	No earlier than 6 months after the proposal due date, but no later than July 1 in the year following the proposal due date.
Page limit for the central Science-Technical-Management section of proposal	15 pp; see also Table 1 of ROSES and the *NASA Guidebook for Proposers*
Relevance	This program is relevant to the Astrophysics questions and goals in the NASA Science Plan. Proposals that are relevant to this program are, by definition, relevant to NASA.
General information and overview of this solicitation	See the *ROSES Summary of Solicitation*.
Detailed instructions for the preparation and submission of proposals	Please see ROSES *Summary Of Solicitation Section I(g)* Order of Precedence and the *NASA Guidebook for Proposers*
Submission medium	Electronic proposal submission is required; no hard copy is required or permitted.
Web site for submission of proposal via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Web site for submission of proposal via Grants.gov	http://grants.gov (help desk available at support@grants.gov or (800) 518-4726)
Funding opportunity number for downloading an application package from Grants.gov	NNH19ZDA001N-ATP
Point of contact concerning this program	Evan S. Scannapieco Astrophysics Division Science Mission Directorate NASA Headquarters Washington, DC 20546-0001 Telephone: (202) 358-3730 Email: HQ-ATP@mail.nasa.gov

D.5 NEIL GEHRELS SWIFT OBSERVATORY GUEST INVESTIGATOR – CYCLE 16

NOTICE: Amended August 16, 2019. This Amendment releases final text and sets the due date for Phase-1 proposals to this program element. The only content changes are: 1) the expected budget is now $1.4 rather than $1.2M and 2) Phase-1 proposals are due by 7:30 p.m. Eastern time September 26, 2019 (via ARK/RPS). Other than that, the content is unchanged from when ROSES-19 was released.

1. Scope of Program

1.1 Overview

The Neil Gehrels Swift Observatory (hereafter known as Swift) Guest Investigator (GI) Program solicits proposals for basic research relevant to the Swift gamma-ray burst mission. The primary goal of this mission is to determine the origin of gamma-ray bursts (GRBs) and use these bursts to probe the early Universe. Swift is also a valuable asset for obtaining multiwavelength images, spectra, and light curves on interesting Targets of Opportunity (ToOs) and other non-transient sources.

Cycle 16 observations and funding will commence on or around April 1, 2020, and last approximately 12 months. Further details on the Cycle 16 program will be posted on the Swift web pages (https://swift.gsfc.nasa.gov/proposals) in August 2019. As was the case in Swift GI Cycles 4 through 15, observing time will be made available to scientists at U.S. and non-U.S. institutions to study a wide variety of astrophysical sources. Consistent with Explorer Program policy, there will be no proprietary data rights to observations conducted with Swift. All science data will be made freely available through the Swift Quick Look web site (https://swift.gsfc.nasa.gov/cgi-bin/sdc/ql), as soon as they are received and processed.

Funding through the NASA Swift GI Program is available only to scientists at U.S. institutions who are identified as the Principal Investigators (PIs). U.S. based Co-Investigators (Co-Is) on foreign-led proposals do not qualify for funding. Funding for accepted target proposals will be initiated only after the relevant observations have begun. Proposers from non-U.S. institutions are strongly encouraged to include a letter of commitment promising financial support.

The Swift GI program is intended to provide the following to participating scientists:

1. Funding (U.S. GIs only) for:
   - New Swift projects;
   - Correlative GRB and non-GRB observations;
   - Other correlative GRB projects; and
   - Theoretical investigations that will advance the Swift mission science return.
2. Observations (and funding for U.S. GIs) for:
   - Non-ToO observations of non-GRB targets;
   - ToOs;
   - Large Programs requesting more than 100 targets or more than 100 kiloseconds (ks) total exposure time;
   - "Fill-in" targets; and

- Key projects.

1.2 The Swift Mission

Swift is a Medium-class Explorer mission developed at the NASA Goddard Space Flight Center. The lead domestic partners include Pennsylvania State University and Los Alamos National Laboratory. Groups in the United Kingdom and Italy made significant contributions to the hardware development and are active participants in the operations, including provision of the Italian ground station at Malindi. The Swift Mission Operations Center (MOC) is at Pennsylvania State University, and the Swift Science Center (SSC) is at the NASA Goddard Space Flight Center.

The Swift mission was launched on November 20, 2004, from Cape Canaveral Air Force Station, Florida. Swift was launched into a low Earth orbit with an inclination of 21 degrees and an altitude of 600 km. The baseline mission duration was two years, but the mission has been extended beyond this initial period because of its continuing scientific productivity. The orbital lifetime of the satellite is estimated to be approximately 20 years.

The Swift spacecraft carries three science instruments: a wide-field gamma-ray Burst Alert Telescope (BAT) and two sensitive, co-aligned narrow-field instruments – the X-ray Telescope (XRT) and the Ultraviolet/Optical Telescope (UVOT). The spacecraft can be autonomously pointed to direct the XRT and UVOT toward events detected by the BAT. The BAT is a wide-field gamma-ray imager that detects GRBs and rapidly sends positions of arcminute accuracy to the spacecraft and to the ground. The BAT operates in the 15–350 keV range and has a 1.4 steradian (half-coded) field-of-view. The BAT has a GRB detection sensitivity ~2 times better than the Burst and Transient Source Experiment (BATSE) that flew on the Compton Gamma-Ray Observatory (CGRO). In addition to detecting GRBs, the BAT is performing a survey of the hard X-ray sky to a sensitivity of ~1 mCrab (2×10^{-11} erg cm^{-2} s^{-1}). The BAT also scans most of the sky each 90-minute orbit and serves as a sensitive monitor for high-energy transients. Positions and spectra of transients detected by the BAT are telemetered to the ground and distributed immediately to the community.

In response to GRB alerts from the BAT, the spacecraft reorients on a time scale of ~1 minute to point the XRT and UVOT instruments at a GRB or other transient. These instruments perform multiwavelength measurements of the bright early afterglow (and also later-time afterglow) emission to provide subarcsecond positions, precise photometry, and fine spectroscopy. The XRT is a Wolter 1 grazing incidence telescope that operates in the 0.2–10 keV band and has a field-of-view of 23.6 arcminutes with an angular resolution of 18 arcseconds (Half Power Diameter) and positional determination accuracy of better than 5 arcseconds. The detector is a cooled CCD, providing spectroscopy with a resolution $E/\Delta E$ ~10 at 1 keV and an effective area of 120 cm^2. The UVOT is a Ritchey-Chrétien folded-optics telescope operating in the 170–650 nm band. It has a field-of-view of 17 arcminutes $\times$ 17 arcminutes, with an angular resolution of 2.5 arcseconds and positional determination accuracy of 0.3 arcseconds. UVOT provides a sensitivity to afterglows of 22^{nd} magnitude for a 1,000 second integration in its V filter, one of six filters for color photometry. It also has a white-light filter and two grisms for fine spectroscopy ($E/\Delta E$ ~ 300) of sources brighter than 17^{th} magnitude. The narrow-field instruments yield an accurate position and X-ray spectra of the afterglow within a few minutes of the burst. This information is distributed immediately over the Internet. Data from continued observations of the afterglow are made available via Circulars and Reports on the Gamma-ray bursts Coordinates Network (GCN, http://gcn.gsfc.nasa.gov/) and on a public web site (https://swift.gsfc.nasa.gov/archive/). Notification of transient source detections is made through IAU Circulars (http://www.cbat.eps.harvard.edu/services/IAUC.html) and Astronomer's Telegrams (ATELs, http://www.astronomerstelegram.org/). Data from serendipitous source detections in the field-of-view of both instruments are routinely sent to the ground for analysis.

Further information on the Swift mission may be found at https://swift.gsfc.nasa.gov/.

1.3 Types of Proposals

This Swift GI Program solicits proposals in the following areas:

1. New Swift projects not requiring GI-specified observatory pointing;
2. Correlative GRB observations involving new or enhanced IR ground-based capabilities for investigating high-redshift bursts, and other correlative GRB and non-GRB observations involving non- Swift instruments and observatories;
3. Theoretical investigations that will advance the Swift mission science return;
4. Non-GRB non-ToO observations that benefit from Swift's unique capability of simultaneous multiwavelength coverage;
5. ToO observations which promise large scientific return and capitalize on Swift's unique capabilities of rapid repointing and multiwavelength observations;
6. Large Programs requesting more than 100 targets or more than 100 ks total exposure time;
7. Fill-in targets to be observed in what would otherwise be gaps in the planned science timeline; and
8. Key Projects which aim at addressing major, high-impact scientific questions by making use of the strengths of Swift.

1.3.1 *New Swift projects*

GIs may propose to initiate their own Swift projects that supplement or enhance the Swift science return with their unique facilities, missions, capabilities, or methods. The extent to which the proposed research will enhance the science return from Swift and the demands placed upon mission resources by an investigation will be considered in the proposal evaluation process. Proposals in this category can also include changes or additions to current Swift strategies to detect and observe GRBs and other transient events (Swift detected or elsewhere) and can propose innovative data reduction and interpretation methods that increase our understanding of cosmic explosions. Proposals that require changes to Swift onboard capabilities or operational procedures may require special scrutiny during the review process by the Swift team for technical feasibility and may require formal approval by the Swift Configuration Control Board before implementation. Investigators considering such proposals are strongly urged to consult with the Swift team prior to proposal submission.

1.3.2 *Swift GRB and non-GRB Correlative Observations*

GRB and non-GRB correlative observations substantially augment the science return from Swift. The Swift instruments, for example, make unique measurements of GRB afterglows starting immediately following the burst, supernova (SN) shock breakouts, or tidal disruption events. However, it is not possible to follow up all targets on all time scales, since viewing constraints and scheduling conflicts will preclude some Swift observations. Also, the onboard capability, although significant, does not cover all of the scientifically valuable measurements that need to be made. Candidate correlative observations that will add significantly to the Swift science include radio imaging and photometry, spectroscopy, deep optical imaging and spectroscopy of the afterglow and possible host galaxy, surpassing the capability of the UVOT to reach 22nd V magnitude in 1,000 seconds, and rapid optical observations with time scales shorter than the 1-minute Swift response time.

To foster correlative observations, the Swift project has established joint GI observing programs with other ground- and space-based facilities: The National Radio Astronomy Observatory (NRAO), the Chandra X-ray Observatory, the International Gamma-Ray Astrophysics Laboratory (INTEGRAL), the X-ray Multi-Mirror Mission (XMM-Newton), and the Nuclear Spectroscopic Telescope Array (NuSTAR). Proposals for joint Chandra, INTEGRAL, and XMM-Newton observations should be submitted to those programs and the Swift time will be recommended by those reviews. For NRAO observations, the Swift GI program can award radio observations through the Swift's joint program with NRAO. There are a number of technical and policy details regarding the Swift/NRAO joint program, and proposers are strongly encouraged to refer to the Memorandum of Understanding: https://swift.gsfc.nasa.gov/proposals/nrao.html.

The Swift Guest Investigator program can award NuSTAR observations through a joint program with the NuSTAR mission. Observing time under this program will be awarded only to proposals that require use of both observatories to meet the primary science goals. Proposers are strongly encouraged to refer to the Swift/NuSTAR Memorandum of Understanding, which may be found under other documents on the NSPIRES page for this program element.

By this agreement, NuSTAR permits the Swift GI Program to award up to 300 ks of NuSTAR observing time. The minimum NuSTAR response time to Targets of Opportunity is 48 hours. ToO observations with a turnaround time less than one week must be well justified and of high scientific value. NuSTAR data acquired through the Swift GI Program will have a standard 12-month exclusive-use period commencing at the time of receipt of the processed data by the observer. This period is restricted to 6-months for peer-reviewed ToOs. The Swift Mission Project will make funding available to successful U.S.-based investigators who request NuSTAR observing time through the Swift GI process. No funds will be awarded from the NuSTAR project for joint investigations proposed to this Swift program element.

The NuSTAR GI Program will perform feasibility checks on the proposed observations and reserves the right to reject any observation determined for any reason to be technically unfeasible or to jeopardize the NuSTAR mission. Such a rejection would likely affect the entire proposed science program and could impact the award of Swift observing time as well. Selected proposals will be allocated NuSTAR observing time without additional scientific review, if judged technically feasible.

GRBs at high redshift are particularly compelling due to their distance and rely especially on high quality infrared (IR) observations for distance estimates, since the optical counterpart is redshifted out of Swift/UVOT's wavelength range. To encourage the development of rapid IR ground-based response to potentially high redshift GRBs, special consideration will be given to such projects. Proposals to bring new or enhanced ground-based IR capabilities online may require funding in the range of $100,000 per year. Such budget requests will be considered, provided they are strongly justified. A six-page limit for the scientific justification applies to proposals submitted in this high redshift "Correlative Observations" proposal category.

For all correlative investigations funded by Swift, rapid public availability of the data or results is in the interest of the Swift mission and the astronomical community and is strongly encouraged. Public data availability for correlative studies should be discussed in these proposals and will be considered in the evaluation of proposals.

1.3.3 *Theoretical Investigations*

GRB and non-GRB theoretical studies have the potential to significantly enhance the scientific impact of the Swift mission. GI proposals for such theoretical investigations are also solicited and should specifically address how the anticipated results will advance Swift science objectives.

1.3.4 *Non-GRB, non-ToO observations*

A total of two million seconds of observing time will be made available during Cycle 16 for non-GRB, non-ToO pointed observations. Swift observations in this category will be performed only as the result of an uploaded ground command through the normal planning process; slewing to the target will not occur autonomously. Non-ToO observations will have a lower scheduling priority than GRBs or ToOs and will be observed on a best-effort basis when time is available in the observing schedule. Hence, successful non-GRB/non-ToO GIs should be aware that they are not assured 100% of the time awarded. Every effort will be made to observe 80% or more of an accepted program within schedule limitations of the mission. A single observation is defined as one requested pointing to a target. Proposers should be aware that, due to Swift's low Earth orbit (95-minute orbit period) and scheduling priorities for other objects, any long observation may be broken up into several different pointings on different orbits. Observations longer than a few kiloseconds (ks) might be split into several days.

Non-ToO proposals are subject to the following limitations:

- The requested time per observation (i.e., a single visit to a target) must be between a minimum of 1 ks and a maximum of 40 ks;
- Monitoring programs are defined as programs requiring two or more observations of the same object, each of which is considered a "visit;" and
- No more than 2,000 visits will be permitted in this Cycle (total for all proposal categories, including both monitoring and non-monitoring requests).

Time-constrained observations are defined as observations that have to be performed within a certain time window. These can be ToOs or non-ToOs, either monitoring (more than one visit to a source) or non-monitoring observations, but not "fill-in" observations. This includes phase-constrained proposals, coordinated observing campaigns with ground-based or satellite-based facilities, etc. Note that the unique scheduling requirements of Swift put severe constraints on time-constrained programs. The window duration for time-constrained observations must exceed three hours.

For coordinated and constrained observations, it is the proposer's responsibility to inform the Swift Science Operations Team of the observing time windows at least one week before observations start. Proposers must clearly describe how their proposal capitalizes on the unique capabilities of Swift.

Only "Key Projects" observing programs may be carried over from Cycle 16 to Cycle 17. Regular proposal targets whose observations have commenced in Cycle 16 will be awarded carryover time in Cycle 17 until the proposed observations are substantially complete. GIs whose observing programs have not begun in Cycle 16 will be required to repropose in Cycle 17 if they wish to acquire observing time. Similarly, Cycle-15-accepted proposals that have not been initiated by the start of Cycle 16 will not be carried over. Cycle 15 GIs concerned that their programs may not be started before the end of the cycle should re-propose for Cycle 16.

1.3.5 *ToO Observations*

GIs are allowed to propose for ToOs in response to transient phenomena, including GRBs found by other observatories. A total of at most one million seconds of observing time will be made available to ToO proposals, subject to the constraints listed below. Swift ToO observations will only be performed as the result of an uploaded command by the Mission Operations Center and will not be slewed to autonomously. ToO observations will have a lower scheduling priority than GRBs and will be observed on a best-effort basis. Because of this restriction, successful ToO GIs should be aware that they are not assured 100% of the time awarded, even if their ToO is triggered. Every effort will be made to observe 80% or more of an accepted program. GIs submitting ToO proposals should note that:

- Each proposal should describe how it capitalizes on the unique capabilities of Swift;
- Proposals must give exact, detailed trigger criteria and a realistic estimate of the probability of triggering the ToO during Cycle 16; and
- Proposals must assign a priority to each ToO target based on the time criticality of the observation. From the time of the trigger, the priorities are defined as
    - Highest Urgency: Observation should be performed within four hours;
    - High Urgency: Observation should be performed within 24 hours;
    - Medium Urgency: Observation can be performed within days to a week; or
    - Low Urgency: Observations can be performed within weeks.

Because new GRBs are constantly being discovered, the Swift observing schedule is revised on a daily basis. Note that Highest Priority ToOs are particularly difficult to handle at night and on weekends when the Mission Operations Center is not staffed. These should be avoided in all but the most urgent cases (e.g., transient events like a

Galactic SN, a very bright GeV gamma-ray burst, or a giant soft gamma-ray repeater flare).

It is the responsibility of the Principal Investigator (PI) of an accepted ToO to alert the Swift Observatory Duty Scientist when trigger conditions for their accepted ToO have been met. This is done through the Swift ToO Request Form at https://www.swift.psu.edu/. It is highly recommended that ToO proposers register as Swift ToO users in advance at https://www.swift.psu.edu/. Registration is required in order to submit a ToO Request.

ToO proposals must have an astrophysical trigger. Once the trigger criteria have been met for an approved target, the PI should check if the target location is more than five hours in RA from the Sun and more than 20 degrees from the Moon before requesting Swift observations (http://heasarc.gsfc.nasa.gov/Tools/Viewing.html). ToO observations that require more than 6 ks on a given day and are closer to the Sun than five hours RA will be less likely to be approved unless they are of exceptionally high scientific priority. Observations greater than nine hours in RA from the Sun are particularly desirable. The purpose of the anti-Sun restriction for ToOs is to maximize the amount of time Swift is pointed toward the night sky in order to optimize optical follow-up observations of BAT-detected GRBs.

Accepted Cycle 16 ToO proposals may be triggered until March 31, 2021. GIs whose ToO programs do not trigger in Cycle 16 will be required to re-propose in later cycles should they wish to acquire observing time on their targets of interest. Only “Key Projects” ToO programs will be carried over from Cycle 16 to Cycle 17, and may be triggered until March 31, 2022.

Note that unsolicited ToO requests for exceptional transients will continue to be possible through the Swift ToO web site, even for those not accepted into the GI Program. The decision on whether or not to observe a ToO of either category will be made by the Swift Principal Investigator or his official designee. Such ToO requests are unfunded.

1.3.6 *Large Programs*

Proposals requesting more than 100 targets or more than 100 ks total exposure time are defined as Large Programs. A total of up to 1 Megasecond (Ms) of exposure time has been reserved for Large Programs, subject to the submission of proposals of high scientific merit.

Both long-duration observations of single targets, tiling of extended sources that exceed the fields of view of the Swift XRT and UVOT instruments, or shorter duration observations of many targets can be requested in the Large Programs proposal category. Proposers should be aware that, due to Swift’s low Earth orbit (95-minute orbit period) and scheduling priorities for other objects, any long observation exceeding a few kiloseconds will be broken up into several different pointings on different orbits.

The observations proposed for Large Programs must be completed within the 12-month period covered by this Cycle.

1.3.7 *Swift "Fill-in" Targets*

GIs may submit a list of targets for consideration as "Fill-in" targets. Their purpose is to provide a set of peer-reviewed targets to be used to fill in gaps in the planned science timeline. These must not be ToOs, must have no observational constraints, and can only be observed once (no multiple observations of the same target). UVOT Grism observations are not permitted as “Fill-in” observations because they require a slew-in-place. The minimum total integration time must be 1 ks per target. Accepted targets will be added to the Swift observing program at the discretion of the science operations team. They will be scheduled, as needed, around the higher priority GRB follow-up observations, ToO and non-ToO observations, to maximize the Swift science program. Funding is not provided for Fill-In proposals. Although GIs should have no expectation that their entire list of “Fill-in” targets will be observed, past experience has shown that fill-in proposals are usually undersubscribed and do get done. Due to the nature of Swift science planning, Swift GI “Fill-in” observations will be scheduled only about 24 hours prior to observation, and PIs will not be notified until observations have been completed for a given target. Scheduling information will be available to GIs via the daily observing plan (http://www.swift.psu.edu/).

To reiterate:

- Fill-in targets are not ToOs and cannot be triggered;
- Fill-in targets cannot be time constrained;
- No monitoring is allowed with fill-in targets. Proposers cannot request multiple target visits, but they can request more than 100 fill-in targets per proposal;
- No UVOT Grism observations are allowed; and
- Fill-in targets are scheduled at the convenience of the science planners. There is no guarantee that any of the targets in any fill-in program will be scheduled or completely observed in this Cycle.

1.3.8 *Swift Key Projects*

Key Projects are intended to greatly advance the Swift science program, enhance its breadth of impact, and represent an enduring legacy of Swift results. Proposals in this category may request support for new Swift projects, theoretical investigations, observations of non-GRB non-ToO targets, and observations of ToO targets. The proposed research plans can be carried out in one or two years. Proposals may also request funding in the range of $100,000 per year. Such budget requests will be considered, provided they are strongly justified.

The number of Key Projects funded in any given year will be limited. It is the responsibility of the proposers to strongly justify how the proposed program will address high-impact scientific questions by making use of the strengths of Swift. A six-page limit for the scientific justification applies to proposals submitted in this "Key Projects" proposal category.

Proposers requesting two-year projects that are selected at Phase 1 should not assume that they have been awarded two years of support; this determination will be made at Phase-2 of the review. PIs of approved multiyear Key Projects will be solicited for a progress report that will be reviewed by NASA to determine if appropriate progress is being made toward the proposed objectives. Because of the significant resources allocated to multiyear Key Projects, those that do not make progress consistent with the proposed investigation could be reduced or terminated.

2. Programmatic Information

2.1 General Information

It is anticipated that up to $1.4M will be available through this program element for the support of approximately 35 Guest Investigations of one-year duration each (except for Key Projects). Note that additional unfunded Guest Investigations are likely to be selected (for example, Fill-in proposals). Swift non-GRB pointed observations are open to all scientists at U.S. or non-U.S. institutions. Swift GI funding is open to all individuals who are identified as Principal Investigators and employed at U.S. institutions, including Swift science team members. Scientists participating in the Swift mission, including Associate Scientists and members of the Follow-up Team who are not funded by the Project, are eligible for support under this GI Program. Swift science team members who already receive support from the Project must provide a compelling justification for the award of additional funds under the GI Program.

NASA does not anticipate awarding contracts in response to proposals submitted to this program element, because it would not be appropriate for the nature of the work solicited.

2.2 Proposal Submission and Evaluation

2.2.1 *Submission of Proposals to the Swift GI Program*

The Swift GI program uses a two-phase proposal process. A Phase-1 proposal shall comprise the science/technical justification; proposals requesting funds need to include a budget narrative, describing in sufficient detail how the proposed funds will be used to achieve the goals outlined in the proposal. The science/technical justification should contain a brief description of previous Swift programs carried out by the PI. Only proposers whose Phase-1 proposals are accepted will be invited to submit budget proposals in Phase 2. It is not necessary for the PI of the Phase-2 proposal to be the science PI. Proposal content, including the list of investigators, must remain consistent between Phase-1 and Phase-2 proposals. All proposal materials will be submitted electronically.

Awards are expected to average $35,000 per year. Only proposals in the "Key Projects" category and in the high redshift "Correlative Observations" category may require funding substantially above the average award (i.e., in the $100,000 range per year), and will need to provide a detailed cost justification. The amount of the anticipated funding request must be entered into the box provided for this purpose on the Remote Proposal System (RPS) Cover Form. The detailed cost evaluation will be deferred until Phase 2. The funding amount requested in the Phase-2 cost proposal may not exceed the amount proposed in Phase 1. "Fill-in" proposals will be unfunded.

Proposers to the Swift GI Program must adhere to the following proposal submission procedures:

- All Proposers must submit their Phase-1 proposals electronically through the Astrophysics Research Knowledgebase (ARK)/Remote Proposal System (RPS)

website at http://heasarc.gsfc.nasa.gov/ark/rps/. Instructions for doing so are provided at the SSC web site, https://swift.gsfc.nasa.gov/;
- Target forms for all observation proposals are to be submitted through ARK/RPS;
- Due to the nature of prospective investigations within the Swift GI program, the Scientific/Technical/Management section of proposals is limited to four pages (six pages for high redshift "Correlative Observations" proposals and "Key Projects" proposals), instead of the default 15 pages specified in the *NASA Guidebook for Proposers*. The requirement for a table of contents in the body of the proposal is waived. No supporting material (e.g., curriculum vitae (CV), pending/current support) is required or allowed;
- Optional Latex and MS Word templates for the Scientific/Technical/Management section are provided on the SSC web site at https://swift.gsfc.nasa.gov/; and
- The Scientific/Technical/Management section must be uploaded to the RPS website as a PDF file.

All proposal materials must be submitted electronically by 7:30 p.m. Eastern time on the due date for this program given in Section 3 in order to be included in the proposal review for this cycle of the Swift Guest Investigator program. Note that the 7:30 p.m. deadline supersedes the deadline stated in the *NASA Guidebook for Proposers* and in the *ROSES Summary of Solicitation.*

Instructions for the formatting and content of ROSES proposals are given in the *ROSES Summary of Solicitation* and, for topics not addressed there, refer to the *NASA Guidebook for Proposers*. Swift GI Proposers must follow these instructions, except where they are overridden by the instructions given in the Astrophysics Research Program Overview or in this program element.

2.2.2 *Evaluation of Proposals submitted to the Swift GI Program*

Proposals will be evaluated by a peer evaluation panel with respect to the criteria specified in the *NASA Guidebook for Proposers*, where it is understood that the intrinsic merit of a proposal shall include the following factors:
- The suitability of using the Swift observatory and data products for the proposed investigation;
- The extent to which the investigation complements and enhances the anticipated science return from the Swift mission;
- The degree to which the proposed investigation places demands upon mission resources;
- The degree to which the proposed investigation capitalizes on the unique capabilities of Swift; and
- For theoretical investigations, the degree to which the investigation directly advances Swift science goals.

2.2.3 *Submission and Evaluation of Phase-2 proposals*

Subject to the availability of funding, successful Phase-1 proposers will be contacted by the Swift Program Officer and invited to submit a cost proposal in Phase 2. Upon notification of selection of a Phase-1 proposal, a proposer must respond by following the instructions for submitting a Phase-2 proposal given in the selection notification from the Phase-1 review. Phase-2 (cost) proposals must be submitted through the NASA NSPIRES electronic proposal website (http://nspires.nasaprs.com) by an Authorized Organizational Representative (AOR) of the proposing organization according to the instructions in the *Summary of Solicitation* of this NRA. The cost proposal will consist of a Budget Details (maximum of two pages) section and a Narrative section (maximum of two pages).

NASA program personnel (as opposed to peer reviewers) will evaluate the Phase 2 (cost) proposals for cost reasonableness and compare the proposed cost to available funds, as allowed by Section VI(a) of the *ROSES Summary of Solicitation*.

Note that since the Phase-2 proposals will not be peer reviewed, the requirement to redact the budget information (per Section IV(b)(iii) of the *Summary of Solicitation*) is waived. All costs must be included in the proposal.

2.3 Supplemental Information

Further details concerning the proposal submission requirements and process can be found at the Swift Science Center website https://swift.gsfc.nasa.gov/. This website provides a detailed mission description; technical information about the Swift mission, instruments, and observation feasibility; and instructions for completing the required proposal forms.

3. Summary of Key Information

Expected program budget for first year of new awards	~$1.4M
Number of new awards pending adequate proposals of merit	~35
Maximum duration of awards	1 year; 2 years for proposals in the "Key Projects" category
Due date for Notice of Intent to propose (NOI)	Option not available
Due date for phase-1 proposals	7:30 p.m. Eastern time September 26, 2019 via ARK/RPS, see Section 2.2.1.
Planning date for start of investigation	Funding will be awarded when the data are made available to the PI. NASA center proposers should use October 1 (6 months after start of Cycle 16 observing) as a planning date for start of observation
Page limit for Phase-1 proposals	4 pages for all proposal categories except for proposals submitted in the high redshift "Correlative Observations" category and in the "Key Projects" category, which are allowed up to 6 pages. The budget narrative has a 1-page limit that will not count toward the above page limits.

Relevance	This program is relevant to the Astrophysics questions and goals in the NASA Science Plan. Proposals that are relevant to this program are, by definition, relevant to NASA.
General information and overview of this solicitation	See the *ROSES Summary of Solicitation*.
General requirements for content of proposals	See Section 3 of the *NASA Guidebook for Proposers* and Section IV and Table 1 of *the ROSES Summary of Solicitation*.
Detailed instructions for the submission of proposals	See https://nspires.nasaprs.com/tutorials/ Sections 3.22-4.4 of the *NASA Guidebook for Proposers* and Section IV(b) of *the ROSES Summary of Solicitation*.
Submission medium	Electronic proposal submission is required in PDF format; no hard copy is permitted.
Web site for submission of Notice of Intent to propose (NOI)	Option not available
Web site for submission of Phase-1 proposal and required forms	https://heasarc.gsfc.nasa.gov/ark/rps/ (Help Desk available at http://heasarc.gsfc.nasa.gov/ark/rps/help/)
Web site for submission of Phase-1 proposal via NSPIRES or grants.gov	Option not available
Web site for submission of Phase-2 proposals	http://nspires.nasaprs.com; See Section 2.2
Programmatic information may be obtained from the Swift Program Scientist	Evan Scannapieco Astrophysics Division Science Mission Directorate NASA Headquarters Washington, DC 20546-0001 Telephone: (202) 358-3730 Email: evan.scannapieco@nasa.gov
Technical questions concerning this program element may be directed to the Swift Guest Investigator Program	Eleonora Troja Swift Guest Investigator Program Lead Code 662 Goddard Space Flight Center National Aeronautics and Space Administration Greenbelt, MD 20771-0001 Telephone: (301) 286-0941 Email: eleonora.troja@nasa.gov

D.6 FERMI GUEST INVESTIGATOR – CYCLE 13

NOTICE: Amended October 28, 2019. This Amendment releases final text for this program element. The due date for Phase-1 proposals has not changed, they are due by 4:30 p.m. Eastern Time February 19, 2020 (via ARK/RPS).

1. Scope of Program

1.1 Overview

The Fermi Guest Investigator (GI) program solicits proposals for basic research relevant to the Fermi mission. The primary goal of this mission is to perform 20 MeV to >300 GeV gamma-ray measurements over the entire celestial sphere, with sensitivity a factor of 30 or more greater than that obtained by earlier space missions. A secondary goal includes the study of transient gamma-ray sources with energies extending from 8 keV up to 300 GeV.

The Fermi GI program is intended to encourage scientific participation by providing funding to carry out investigations using Fermi data, to conduct correlative observations at other wavelengths, to develop data analysis techniques applicable to the Fermi data, and to carry out theoretical investigations in support of Fermi observations.

The Fermi GI program also encompasses a number of joint observation program opportunities. Fermi investigators may apply for radio, optical, X-ray, or Gamma-ray observing time through joint programs with the National Radio Astronomy Observatory (NRAO), the National Optical Astronomy Observatory (NOAO), the VERITAS ground-based Cerenkov telescope facility and, the INTErnational Gamma-Ray Astrophysics Laboratory (INTEGRAL).

Please refer to section 1.3.3 for important details on the joint observation programs Proposers may also apply for high-end computing resources in support of their proposed investigatoiin.

Investigators may propose Fermi pointed observations, but such observations will require strong scientific justification through simulations and exposure calculations because default survey mode observations will satisfy the scientific requirements of most studies.

The Fermi GI program is open to all investigators, but NASA funding is available only to principal investigators (PIs) who are employed at a U.S. institution at the time the Phase-2 proposal is submitted by that institution via NSPIRES.

There will be no exclusive-use period associated with the data from Fermi observations. All data will be made available through the HEASARC public data archive after ground processing.

1.2 The Fermi Mission

Fermi is an international and multiagency observatory-class mission that studies the cosmos in the 10 keV to 300 GeV energy range. The primary instrument, the Large Area Telescope (LAT), has a peak effective area (>8000 cm^2), angular resolution (<3.5º at 100 MeV, <0.15º above 10 GeV), field-of-view (>2 sr), and deadtime (<100 µs per event) that provides a factor of 30 or more advance in sensitivity compared to previous missions. The Fermi Gamma-ray Burst Monitor (GBM) also provides the capability for studying transient phenomena, with a field-of-view larger than the LAT and a spectral range that extends from the LAT's lower limit down to less than 10 keV. Although pointed observations are possible, the observatory primarily scans the sky continuously because of the LAT's large field-of-view. In the survey mode employed during the first 10 years of the mission Fermi provided nearly uniform sky exposure every ~3 hours.

Documents providing a more complete description of Fermi can be found at the [FSSC website](#).

Due to an anomaly with one of the solar array drive motors in 2018, alternative sky-survey strategies have been employed to ensure safe spacecraft operation. This leads to exposure nonuniformity on short (~weekly) timescales but near uniformity is eventually achieved. It also limits LAT coverage of the Sun and surrounding sky regions. The ability to respond to Targets of Opportunity (ToOs) or, more generally, to perform pointed observations or customized observation strategies will be very limited. Prospective proposers considering such observations are strongly advised to consult the Fermi Science Support Center prior to preparing their proposal. For more details, please see https://fermi.gsfc.nasa.gov/ssc/observations/types/post_anomaly/.

The product of a collaboration among NASA, the U.S. Department of Energy, and several international partners, the LAT is a pair-conversion telescope. Gamma rays pair-produce in tungsten foils, silicon strip detectors track the resulting pairs, and the resulting particle shower deposits energy in a CsI calorimeter. An anticoincidence detector provides discrimination against the large flux of charged particles incident on the LAT. The anticoincidence detector is segmented to eliminate the self-vetoing problem encountered by previous experiments.

Astrophysical photons are only a small fraction of all the events detected by the LAT on orbit. Most events are primary cosmic rays and their associated secondary charged and neutral particles produced in the surrounding spacecraft and the Earth's atmosphere. Therefore, event filtering on board reduces the ~3 kHz detected event rate to ~350 Hz. Events that survive the onboard filter are telemetered to the ground. Further ground processing yields a "true" celestial photon average rate of about 1 to 2 Hz.

The GBM detects gamma-ray bursts. Consisting of 12 NaI(Tl) (8–1000 keV) and 2 BGO (0.2–30 MeV) detectors, the GBM extends Fermi's burst spectral sensitivity from ~8 keV to ~30 MeV and monitors more than 8 sr of the sky, including the LAT's field-of-view. Bursts are localized by comparing rates in different detectors and rapidly distributed via the Gamma-ray bursts Coordinates Network (GCN). An initial location, computed automatically, is sent within several seconds, and is expected to have an accuracy of 5 to 10 degrees for strong bursts (fluence > ~10 photons cm^{-2}). A more accurate location (~3 degrees for strong bursts) is sent within 24 hours. The threshold of the onboard trigger is a flux of about 0.7 photons cm^{-2} s^{-1} (50 to 300 keV band), for a 1-second burst, and uses a variety of energy band and time windows.

Fermi was launched on June 11, 2008, into a circular, initial orbit of ~565 km altitude at an inclination of 25.6°. The mission design lifetime was five years, with a goal of ten years, which has been surpassed. After a checkout period, science operations began on August 4, 2008. Based upon the results of the NASA 2019 Senior Review, support for mission operations was extended through September 30, 2022.

The GI community is supported by the FSSC, which is managed by NASA's Goddard Space Flight Center. All publicly available data products, software, calibration files, and technical documents that have been developed jointly with the instrument teams are available through the FSSC.

1.3 Types of Proposals

The Cycle 13 Fermi GI program solicits proposals in the following areas:

1. The analysis of LAT or GBM data from the beginning of science operations or development of data analysis techniques. Investigators are encouraged, but not required, to make software or other resources supporting such new analysis techniques publicly available through the FSSC;
2. Requests for LAT pointed observations (but proposers should be aware that compelling science justification and analysis will be required to quantify the additional scientific benefit of such observations – see the Fermi Users' Group (FUG) analysis at http://fermi.gsfc.nasa.gov/ssc/proposals/pointing_analysis/). The total time allocated to pointed observations will be between 0 and 15% of the total available observing time in Cycle 13. Pointed observations will follow the same open data policy as sky survey data, i.e., they will become public immediately;
3. Analysis of correlative multiwavelength observations with other instruments and observatories (but excluding operation of such facilities) that are directly relevant to Fermi science objectives (see FUG recommendation at http://fermi.gsfc.nasa.gov/ssc/resources/multi/); and
4. Theoretical investigations that will advance the science return of the Fermi mission.

1.3.1 *Analysis of all LAT gamma-ray and GBM event data*

The LAT team's science goals are: (1) development of event-reconstruction and background-rejection techniques; (2) production of a comprehensive full-sky catalog of gamma-ray sources; and (3) a description of the diffuse gamma-ray emission. Proposed Fermi investigations should avoid duplication of the first two of these goals. The extent to which the proposed research will enhance the science return from Fermi will be considered in the proposal evaluation process (see Section 2.2 below).

The LAT's primary science data product is a list of events detected within the LAT's field-of-view. These events can be used to detect sources and study their temporal and spectral properties. Fermi observes the sky in a survey mode that provides nearly uniform sky exposure every ~3 hours; this mode will suffice for nearly all scientific observations. GIs may request funding to analyze any accumulated data and may receive funding even if they did not request a specific observation.

The GBM provides event lists with measured energies and arrival times, permitting both temporal and spectral studies. In addition, binned background count rates with differing temporal and spectral resolution are also available, enabling background studies and source detection through occultation steps.

The GBM science team is already funded to provide the community with a catalog of GRBs, including localizations and spectra. Proposals construed by peer reviewers as duplicative of this goal may, therefore, be deemed to have lower priority than those perceived as addressing other objectives.

New data analysis techniques that will maximize the mission's scientific yield are also encouraged. While the Fermi mission will provide a set of analysis tools with which a complete analysis of the data can be accomplished (see http://fermi.gsfc.nasa.gov/ssc/data/analysis/ for details), specialized analyses to address specific scientific issues, such as blind pulsar period searches, the discovery of faint transients, or the detection of sources through occultation steps in the GBM background light curves, may require alternative techniques and additional software. GI proposals for such new data analysis techniques must specifically address how the proposed techniques will advance Fermi science objectives.

1.3.2 *Requests for LAT pointed observations or modified observation strategies*

GIs may also request pointed observations, or in exceptional cases modified observation strategies, to accumulate sky exposure of a particular source at a rate higher than provided by survey mode observations. Similarly, GIs may request Target-of-Opportunity observations. As noted in Section 1.2 the capability to support such observations is more limited than in Cycles 1-11. It will, therefore, be incumbent upon the proposer to demonstrate that a pointed observation is required to achieve the scientific objectives. Proposers thinking of requesting pointed observations are strongly encouraged to contact the FSSC and anyone considering modified observation strategies must do so. (http://fermi.gsfc.nasa.gov/ssc/help/).

1.3.3 *Multiwavelength observations*

Because correlative observations will substantially augment the science return from Fermi, such proposals are encouraged. Examples of correlative observations that will add significantly to the Fermi science include monitoring of blazars, follow-up observations of gamma-ray bursts, and determination of pulsar ephemerides. To foster correlative observations, the Fermi project has established joint observation programs with other ground- and space-based facilities. The Fermi GI program can award optical, radio, X-ray or high-energy gamma-ray observations through Fermi's joint programs with NRAO, NOAO, VERITAS, and INTEGRAL. Note that only a single year of joint-program observations can be awarded through the Fermi GI Program regardless of the duration of awarded Fermi support. Any updated information will be posted on the FSSC website well in advance of the Phase-1 proposal deadline. There are a number of important technical and policy details regarding these joint programs and prospective proposers are strongly encouraged to refer to the respective MOUs:

http://fermi.gsfc.nasa.gov/ssc/proposals/nrao.html,

http://fermi.gsfc.nasa.gov/ssc/proposals/noao.html,

http://fermi.gsfc.nasa.gov/ssc/proposals/veritas.html, and

http://fermi.gsfc.nasa.gov/ssc/proposals/integral.html

The LAT instrument team will post the light curves (including spectral information) of the sources listed at http://fermi.gsfc.nasa.gov/ssc/data/policy/LAT_Monitored_Sources.html. The team will also announce the discovery of high-amplitude variations among these sources or of newly discovered bright transients to the community via Astronomer's Telegrams and GCN notices. The FSSC will provide light curves and locations for these new sources.

1.3.4 *Theoretical investigations*

Theoretical studies related to the observations conducted with Fermi hold the potential to significantly enhance the scientific impact of the mission. GI proposals for such theoretical investigations are also solicited and must specifically address how the anticipated results will advance Fermi science objectives.

1.4 Classes of Proposals

There are two proposal classes: (1) Regular proposals with research plans that can be completed in one year, and (2) Large proposals whose research plans are more expansive and may take up to three years to complete. Large programs will remain prioritized for projects that are inherently resource intensive and large in scope. The number of Large projects funded in any given year will be very limited.

The burden of justifying the need for Large projects is on the proposers. The peer-review committees will not be permitted to descope Large projects and must evaluate them as proposed. Proposing a project in duplication as a single year plus as a Large program is discouraged.

PIs of approved Large projects must submit a progress report annually on the proposal due date, rather than on the anniversary of the award date. The progress report must comply with the page limit and format requirements of Phase-1 Regular proposals. It must list the deliverables (papers, public software, etc.) that have resulted from the ongoing work, as well as adhere to the schedule specified in the original proposal. Progress reports must be submitted through the Astrophysics Research Knowledgebase Remote Proposal System (ARK/RPS) system. Because of the significant resources allocated to large multiyear projects, those that do not make progress consistent with the proposed investigation could be reduced or terminated.

1.5 Proposal Length and Format

The page limit for the Science/Technical/Management section of Phase-1 proposals is four pages for Regular proposals and six pages for Large proposals. These page limits include figures and references. An additional page is required to describe the technical justification for the observation time, as well as the telescope and instrumentation configurations being requested through the joint programs with NOAO, NRAO, INTEGRAL, and VERITAS.

Proposals must be single-spaced, typewritten, English-language text on standard US letter paper, using one column, and using an easily read font size 12-point or larger and having, on average, no more than 15 characters per horizontal inch. No smaller font is permitted in the subsections of the proposal, including references. However, text in figures and their captions may be in fonts as small as 10-point. In addition, the proposal shall have no more than 5.5 lines per inch of text. Pages should have at least one-inch (2.5 cm) margins on all sides. Proposals not conforming to this format will be declared noncompliant and may be rejected without further review.

2. Programmatic Information

2.1 General Information

Awards for Regular (one or two-year duration) proposals are expected to average around $75,000 per year and $125,000 per year for Large proposals. Phase-2 proposals requesting more than the above are unlikely to be approved without a compelling justification. See also the top row of the Summary Table in Section 3.

Awards for triggered analyses (e.g., transients meeting specific criteria) will not be released until after such triggers occur.

Only proposals led by a PI who is employed at a U.S. institution will be considered for funding.

Fermi science team members already receiving support from the Project are eligible for support, but must provide a compelling justification for the award of additional funds under the GI Program. It is the intent of this program that most of the available GI funding be awarded to proposers not formally associated with Fermi.

NASA does not anticipate awarding contracts in response to proposals submitted to this program element, because it would not be appropriate for the nature of the work solicited.

2.2 Proposal Submission and Evaluation

2.2.1 *Submission of Phase-1 Proposals to the Fermi GI Program*

The Fermi GI program will use a two-phase proposal submission process. The first phase will be the submission and evaluation of the science/technical justification. Phase-1 Proposals must include a management section with a statement of work and an estimate of the resources needed to accomplish the goals of this work. The required proposal forms must be submitted through RPS.

Proposals requiring more than one year of effort (Large proposals) must include a schedule and a list of expected deliverables and/or milestones for each year of the requested support. This schedule will be considered in the peer-evaluation of progress reports prior to years two and three.

Each proposer who anticipates requesting funding must provide a budget estimate, i.e., an estimated maximum of the total cost to NASA (including overhead) of his/her proposed investigation. A field for entering the total budget is provided on the RPS Cover Form.

In the second phase, proposers whose Phase-1 proposals are accepted will be invited to submit a budget for review through their home institution. Proposers must append, as an NSPIRES attachment, a budget narrative for each year of proposed work and specify what they expect to accomplish at the end of each of the years proposed. Every line item in the NSPIRES budget needs to be explained in the accompanying text. All proposal materials will be submitted electronically.

Proposers to the Fermi GI Program must adhere to the following procedures for proposal submission:

- Proposers will submit their Phase-1 proposals electronically through the RPS website at: http://heasarc.gsfc.nasa.gov/ark/rps/. Instructions for doing so are provided at the FSSC web site at: http://fermi.gsfc.nasa.gov/ssc/proposals/.
- Target lists are submitted through the RPS form. All proposals involving joint-program correlated observations or Fermi pointed observations, must include a target list.
- Due to the nature of prospective investigations within the Fermi GI program, the Scientific/Technical/Management section of proposals is limited to four pages for Regular proposals and six pages for Large proposals, instead of the default 15 pages specified in the *NASA Guidebook for Proposers*. Figures and references are included within these four or six page limits. An additional page must be added to describe the technical details of proposed joint gamma-ray, X-ray, radio, or optical observing programs.
- The standard ROSES requirement for a table of contents in the body of the proposal is waived.
- The Scientific/Technical/Management section will be uploaded to the RPS website as a PDF file.

All Phase-1 proposal materials must be submitted electronically by 4:30 p.m. Eastern Time on the due date for this program given in Tables 2 and 3 of *ROSES* in order to be considered in the proposal review for this cycle of the Fermi Guest Investigator program. Note that the 4:30 p.m. deadline replaces the standard midnight deadline.

Instructions for the submission of ROSES proposals are given in the *ROSES Summary of Solicitation* and, for topics not addressed there, refer to the *NASA Guidebook for* Proposers. Fermi GI proposers must follow these instructions, except where they are overridden by the instructions given in the Astrophysics Research Program Overview or in this program element.

2.2.2 *Evaluation of Phase-1 Proposals Submitted to the Fermi GI Program*

A peer review panel will evaluate all proposals with respect to the criteria specified in Section C.2 of the *NASA Guidebook for Proposers*, where it is understood that the intrinsic merit of a proposal shall include the following factors:

- The suitability of using the Fermi observatory and data products for the proposed investigation;
- The extent to which the investigation enhances the anticipated science return from the Fermi mission;
- The degree to which the proposed investigation places demands upon mission resources (this is particularly relevant for pointed observations); and
- In the case of Progress Reports (i.e., requests to continue multiyear projects), demonstrable progress towards the stated milestones of the original science proposal.

For data analysis development and theoretical investigations, the evaluation of relevance of a proposal shall include the degree to which the investigation directly advances Fermi science goals.

2.2.3 *Submission and Evaluation of Phase-2 proposals*

Subject to the availability of funding, successful Phase-1 proposers will be contacted by the NASA Selecting Official and invited to submit a cost proposal in Phase 2. Upon notification of selection of a Phase-1 proposal, a proposer must respond as follows:

- Follow the instructions for submitting a Phase-2 proposal given in the selection notification from the Phase-1 review. Phase-2 (cost) proposals must be submitted through the NASA NSPIRES electronic proposal website (http://nspires.nasaprs.com/) by an Authorized Organizational Representative (AOR) of the proposing organization.
- The total budget may not exceed the budget estimate the proposer provided in the Phase-1 proposal.
- Budget Details are limited to three pages, and the Budget Narrative is limited to two pages. Any substantive changes from the budget management plan already submitted in Phase 1 must be justified explicitly.

NASA program personnel (as opposed to peer reviewers) will evaluate the Phase-2 cost proposals against the third evaluation criterion, cost realism and reasonableness, and will also compare the proposed cost to available funds, as allowed by Section VI(a) of the ROSES Summary of Solicitation. Note that since the Phase-2 proposals will not be peer reviewed, budget information must not be redacted. All costs must be included in the Phase-2 proposal. This instruction supercedes the *Summary of Solicitation*.

2.3 Supplemental Information

Further details concerning the proposal submission requirements and process can be found at the Fermi Science Support Center website http://fermi.gsfc.nasa.gov/ssc/. This website provides a detailed mission description; technical information about the Fermi mission, instruments, and feasibility of different types of observations; and instructions for completing the required proposal forms.

3. Summary of Key Information

Number of new awards pending adequate proposals of merit.	The selection of ~30 Regular proposals with average awards of $75K and generally less than $80K per year, and 1-2 Large proposals with average awards of $125K per year and generally less than $150K per year. Deviations from these targeted figures are possible.
Maximum duration of awards	1 year for Regular proposals and up to 3 years for Large proposals (see Section 1.4)
Due date for Notice of Intent to propose (NOI)	Option not available
Due date for Phase-1 proposals	See Tables 2 and 3 of this ROSES NRA
Planning date for start of investigation	5-10 months after proposal due date.

Page limit for the central Science-Technical-Management section of Phase 1 proposal	4 pp for regular proposals, 6 pp for large proposals; 1 additional page is required to describe joint program observations (see Section 1.5). Page limits include figures and references. This instruction supersedes the limits given in the *NASA Guidebook for Proposers.*
Relevance	This program is relevant to the Astrophysics questions and goals in the NASA Science Plan. Proposals that are relevant to this program are, by definition, relevant to NASA.
General information and overview of this solicitation	See the *ROSES Summary of Solicitation*.
General requirements for content of proposals	See Section 3 of the *NASA Guidebook for Proposers* and Section IV and Table 1 of *the ROSES Summary of Solicitation*.
Detailed instructions for the submission of proposals	See https://nspires.nasaprs.com/tutorials/ Sections 3.22-4.4 of the *NASA Guidebook for Proposers* and Section IV(b) of *the ROSES Summary of Solicitation*.
Submission medium	Electronic proposal submission is required in PDF format; no hard copy is required.
Web site for submission of Notice of Intent to propose (NOI)	Option not available
Web site for submission of Phase-1 proposal and required forms	http://fermi.gsfc.nasa.gov/ssc/proposals/ (Help Desk available at http://heasarc.gsfc.nasa.gov/ark/rps/help/)
Web site for submission of Phase-1 proposal via NSPIRES	Option not available
Web site for submission of Phase-1 proposal via Grants.gov	Option not available
Fermi Science Support Center helpdesk	http://fermi.gsfc.nasa.gov/ssc/help/
Programmatic information may be obtained from the Fermi Program Scientist	Stefan Immler Astrophysics Division Science Mission Directorate NASA Headquarters Washington, DC 20546-0001 Telephone: (202) 358-0615 Email: Stefan.M.Immler@nasa.gov

Technical questions concerning this program element may be directed to the Fermi Science Support Center	Chris Shrader Code 661 NASA Goddard Space Flight Center Greenbelt, MD 20771-0001 Telephone: (301) 286-8434 Email: Chris.R.Shrader@nasa.gov Help Desk: http://fermi.gsfc.nasa.gov/ssc/help/
Questions concerning Fermi capabilities may be directed to the Fermi Project Scientist	Elizabeth Hays Code 661 NASA Goddard Space Flight Center Greenbelt, MD 20771 Telephone: 301-286-0345 Email: Elizabeth.A.Hays@nasa.gov

D.7 STRATEGIC ASTROPHYSICS TECHNOLOGY

NOTICE: Amended September 3, 2019. This SAT program element for calendar year 2020 has been shifted to ROSES-2020. The deadlines will be announced in ROSES-2020, to be released in February 2020.

For planning purposes, prospective proposers should anticipate that the mandatory Notice of Intent deadline will be in October 2020 and the proposal deadline will be in December 2020. This is roughly 9 months later than in previous years. This will enable the planned start date for funding for all proposers to begin on October 1 following the proposal deadline, as opposed to the present different dates for NASA and non-NASA PIs.

The annual funding for SAT is unchanged. Therefore, this schedule modification will not change the scope of SAT in overall budget or number of investigations, but rather will affect when proposals are selected to fill the SAT program.

Questions regarding this program element and/or this amendment should be directed to the point of contact given below.

Main point of contact concerning this program element	Nasser Barghouty Astrophysics Division Science Mission Directorate NASA Headquarters 300 E Street SW Washington, DC 20546-0001 Telephone: (202) 358-1211, Email: nasser.barghouty@nasa.gov

D.8 NANCY GRACE ROMAN TECHNOLOGY FELLOWSHIPS IN SPACE ASTROPHYSICS FOR EARLY CAREER RESEARCHERS

NOTICE: September 3, 2019. Given that D.3 APRA has been deferred to ROSES-2020, no new Fellows are solicited until then, but those already named as Roman Technology Fellows may submit their proposal for funds this year, as per prior guidance. Please communicate with the point of contact for this program element regarding submission of Fellowship Funds Proposals.

1. Overview

The goals of the Nancy Grace Roman Technology Fellowship (RTF) program in astrophysics are to provide early-career researchers the opportunity to develop the skills necessary to lead astrophysics flight instrument development projects, including suborbital investigations, in preparation to become Principal Investigators (PIs) of future NASA astrophysics missions; to develop innovative technologies for space astrophysics that have the potential to enable major scientific breakthroughs; and to foster new talents by putting early career instrument builders on a trajectory towards long-term positions. NASA is committed to supporting deserving early career researchers by selecting one or more Roman Technology Fellows every year.

This program consists of two components with two different submission procedures. The first component is the one-page application from an early career individual to be named a Roman Technology Fellow (RTF), see Section 2. The second component is the subsequent submission of a proposal for up to $300K in Fellowship Funds by a previously selected RTF once that individual obtains a permanent or permanent-track position, in order to start a laboratory or develop a research group at the Fellow's institution (see Section 3). Please see Section 2.1 for the definition of an early career position, and Section 4.1 for the definition of a permanent or permanent track position.

2. Eligibility and Application to be named a Roman Technology Fellow

The application to become a Nancy Grace Roman Technology Fellow does not involve a separate proposal to this program element. Rather, the RTF application is a one-page application submitted along with a proposal submitted to the Astrophysics Research and Analysis (APRA) Program described in program element D.3 of this ROSES solicitation. The PI of a successful technology-centered APRA proposal who is designated as a Roman Technology Fellow based on this one-page application has the opportunity to apply for Fellowship Funds in the future, as described in Section 3.

2.1 Eligibility

To be eligible to be named a Nancy Grace Roman Technology Fellow (as opposed to the application for start up funds, see Section 3), proposing PIs must meet the following requirements at the time of proposal submission:

- Have received a Ph.D. degree on or after January 1 of a year that is no more than eight years prior to the issuance date of the ROSES NASA Research Announcement (NRA) to which the APRA proposal is submitted. Individuals who have interrupted their careers for substantive reasons, such as family leave or health problems, may seek a waiver to this requirement. Applicants who submit a written request for prior concurrence from NASA before the due date for Notices of Intent to propose to APRA will receive a written response from NASA within three weeks of receipt of this request.

- Hold an early career position such as a postdoctoral, tenure-track, term civil service, or an equivalent non-permanent position, as defined in Section 4.1. In the event that a proposer's institution does not allow non-tenured faculty or postdoctoral researchers to apply independently for NASA grants, the proposal may include a mentor as the Institutional PI with the fellowship applicant as the Science PI, as outlined in the *NASA Guidebook for Proposers.*
- Be a U.S. citizen or have lawful status of permanent residency (i.e., holder of a U.S. Permanent Resident Card, also referred to as the Green Card)[1] to be consistent with the RTF goal of fostering new talent by putting early career instrument builders on a trajectory towards long-term positions at a U.S. institution.
- Not hold, or have held, a career civil service, tenure, or other permanent position, as defined in Section 4.1 on or prior to the proposal due date of appendix D.3 APRA.
- Not be a current or former recipient of an RTF or a Presidential Early Career Awards for Scientists and Engineers (PECASE) award.

2.2 Fellowship Application

The procedure for applying to become an RTF Fellow is as follows:

1. Submit a technical proposal as PI (or Science PI, if necessary) to the APRA program element D.3 of this ROSES solicitation.
2. Indicate on the NSPIRES Cover Page of that proposal the desire to be named a Roman Technology Fellow, and meet the eligibility requirements in Section 2.1.
3. Include the required RTF application in the APRA proposal, as described below.
4. Receive an award letter for that APRA proposal.

Selection of the APRA proposal is a prerequisite for consideration as a Roman Technology Fellow, but does not guarantee selection. Those who are named as Roman Technology Fellows will receive an award letter from the RTF program explicitly conferring the title.

The RTF application is a free-form narrative limited to a single page in length. It should convey to the review panel and selecting officials the applicant's qualifications to be named a Roman Technology Fellow, addressing the evaluation criteria in Section 2.3. The application should describe the candidate's current employment position to establish eligibility for the RTF. It should outline career goals and plans, and discuss how an RTF will help advance the applicant's career and achieve those goals. The application should complement, not simply duplicate, the information provided in the Biographical Sketches section of the APRA proposal.

[1] The prospective fellow may submit a proposal to RTF if he or she is reasonably certain that the Green Card will be in hand soon after the proposal submission. The evaluation of proposals and announcement of selection takes approximately three to four months. NASA will not make an award if the submitting institution cannot certify the prospective fellow's eligibility.

The application should be included in the APRA proposal immediately following the PI's Biographical Sketch. The one-page RTF application does not count towards the page limits for the Science/Technology/Management section of the APRA proposal.

2.3 Evaluation Criteria for Fellowship Selection

The APRA proposal containing the RTF application will be reviewed along with other proposals in the pertinent APRA review panel, as determined by technical discipline. The application for the Roman Technology Fellowship will be separately evaluated according to the goals of the RTF program. The fellowship application should demonstrate that through the proposed APRA research, in conjunction with being named a Roman Technology Fellow, the early career researcher will develop the skills necessary to lead astrophysics flight instrument development projects, including suborbital investigations. The fellowship application is expected to demonstrate how these skills will prepare the Fellow to become a PI of future NASA astrophysics missions, or to develop innovative technologies for space astrophysics that have the potential to enable major scientific breakthroughs. The application is also expected to illustrate how the fellowship will put the applicant on a trajectory towards a long-term position.

2.4 Timing of Selections and Awards

The announcement of selections for the technical (APRA) proposals will be in accordance with the schedule of program element D.3 of the ROSES solicitation. The naming of the candidate a Roman Technology Fellow will occur within 3 months after the RTF-related APRA proposal has been selected.

3. Fellowship Funds

Individuals who have previously been named as Roman Technology Fellows may submit a proposal requesting up to $300K in Fellowship Funds to start a laboratory or develop a research group at their institution. This component of the program is intended to aid Fellows in establishing themselves in a permanent-track position. Accordingly, proposers for Fellowship Funds must be in a permanent-track or permanent position (see Section 4.1), and must submit the proposal to this program element from the organization where the permanent-track position is held. Awarding of Fellowship Funds is not guaranteed simply by having been named a Fellow. Awards are contingent upon favorable peer review and available budget.

The proposal may be submitted in response to this program element at any time within two years from the date of the RTF-related APRA proposal is selected. Proposers must contact the RTF Program Officer prior to submitting a proposal for Fellowship Funds, preferably within the first year of the Fellowship.

3.1 The Fellowship Funds Proposal

The Fellowship Funds proposal must establish that the Fellow's appointment meets the definition of a permanent-track or permanent position as defined in Section 4.1. The proposal must clearly describe how the funds will be used to establish or develop the PI's research and technology development program, how the proposed program will advance the state-of-the-art in astrophysics-related technologies, and how the proposed program is relevant to NASA's Astrophysics Program. The proposal should detail the near-term use of the Fellowship Funds, and outline the Fellow's long-term plans for maintaining the research and development program.

NASA encourages, but does not require, the submitting institution to contribute to the project supported by the Fellowship Funds. An example is support by the employing institution that would provide release time to enable the applicant to concentrate more fully on the activities related to the proposal. Institutional support of equipment purchases and co-funding of student and/or postdoctoral support is recognized by NASA as a valuable contribution. Any institutional commitments for laboratory space, matching or startup funds, and other institutional resources required for the proposed work should be included in the proposal.

The technical management section of the proposal is limited to seven pages, and the proposal must contain a detailed budget with a narrative justification. Projects devoted to technology development that are not expected to generate data need not provide data management plans, but must note on the NSPIRES cover page that they are technology projects that will not generate data. However, if the award does result in peer reviewed publications, then those must still meet the requirement that the data behind figures and tables be available electronically at the time of publication, ideally in supplementary material included with the article.

3.2 Evaluation Criteria for Fellowship Funds Proposals

Proposals for Fellowship Funds will be evaluated for merit, relevance, and cost realism and reasonableness. In addition to the factors stated in the NASA *Guidebook for Proposers*, intrinsic merit will also include the following factors:

- The long-term commitment to the early career researcher's career development by the employing institution.
- The likelihood that the early career researcher will develop the skills necessary to lead astrophysics flight instrument development projects, including suborbital (sounding rocket, balloon, CubeSat) investigations, in preparation to become a PI of future astrophysics missions, or to develop innovative technologies for space astrophysics that have the potential to enable major scientific breakthroughs.

The evaluation against these criteria will be independent of any prior evaluation of the affiliated APRA proposal or the one-page fellowship application.

If a Fellowship Funds proposal is not selected for award, the Fellow may propose again for Fellowship Funds if a material change in circumstances mitigates the deficiencies identified by the review of the prior proposal. Proposal submission is subject to the fellowship duration specified in Section 4.2.

4. Programmatic Information

4.1 Definition of Permanent and Permanent-Track Positions

A permanent position is one in which the organization substantially financially compensates the PI for his or her work and effort, without making it conditional on outside funding, nor limiting the term of employment. Examples of permanent positions include, but are not limited to, tenured faculty and permanent civil service appointments.

A permanent-track position is one with a clearly defined process and schedule that can lead to a permanent position. Examples of permanent-track positions include, but are not limited to, tenure-track faculty and certain term civil service appointments.

4.2 Award Type and Duration

Since the RTF funds award is contigent on a successful APRA proposal, NASA does not anticipate awarding a separate direct grant in response to proposals submitted to this program element. The APRA award can be augmented by the RTF funds award. RTF funds will be awarded over a period of no more than 3 consecutive years. However, the Fellowship designation will last through the duration of the funds award.

5. Summary of Key Information

Expected program budget for new awards	See program element D.3 APRA of this ROSES solicitation.
Number of new awards pending adequate proposals of merit	Approximately 1-3 early-career selections of technical proposals anticipated.
Maximum duration of awards	Fellowship funds will be awarded over a period of no more than 3 consecutive years.
Due date for Notice of Intent to propose (NOI)	Initial fellowship applications via program element D.3 APRA, see Section 2.2
Due date for proposals	Initial fellowship applications via program element D.3 APRA, see Section 2.2. Subsequent proposals for funds may be submitted in response to this program element at any time within two years from the date of the RTF-related APRA proposal is selected.
Planning date for start of investigation	For initial fellowship applications see Section 2 and D.3 APRA. For subsequent proposals for funds, please contact the POC below.
Page limit for the central Science-Technical-Management section of proposal	Initial fellowship application is a one-page addition to a proposal to program element D.3 APRA; 7 pp. for subsequent proposals for fellowship funding
Relevance	This program is relevant to the Astrophysics strategic goals and subgoals in NASA's *Strategic Plan*. Proposals that are relevant to this program are, by definition, relevant to NASA.
General information and overview of this solicitation	See the *ROSES Summary of Solicitation*.
Detailed instructions for the preparation and submission of proposals	Please see ROSES *Summary of Solicitation Section I(g)* Order of Precedence and the *NASA Guidebook for Proposers*
Submission medium	Electronic proposal submission is required; no hard copy is required or permitted. See Section IV of the *ROSES Summary of Solicitation* and the *NASA Guidebook for Proposers*.

Web site for submission of proposal via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Web site for submission of proposal via Grants.gov	http://grants.gov (help desk available at support@grants.gov or (800) 518-4726)
Funding opportunity number for downloading an application package from Grants.gov	Initial fellowship applications via program element D.3 APRA, see Section 2.2
Point of contact concerning this program	Nasser Barghouty Astrophysics Division Mail Code 3U36 Science Mission Directorate NASA Headquarters Washington, DC 20546-0001 Telephone: (202) 358-1211 Email: nasser.barghouty@nasa.gov

D.9 NuSTAR General Observer – Cycle 6

NOTICE: Amended October 25, 2019. This Amendment releases final text for this program element. The due date for Phase-1 proposals has not changed, they are due by 4:30 p.m. Eastern Time January 24, 2020 (via ARK/RPS). Major changes since last cycle include:

- **The Phase-1 proposal review will be done in a dual-anonymous fashion resulting in changes to how proposals are written (see Section 2.2.1 and the Guidelines for Anonymous Proposals) and**
- **Proposals requesting that observations occur over two cycles may be submitted (see Section 1.3.2).**

1. Scope of Program

1.1 Overview

The Nuclear Spectroscopic Telescope Array (NuSTAR) Small Explorer (SMEX) mission is the first orbiting telescope to focus light in the high energy X-ray region of the electromagnetic spectrum (E > 10 keV), with an effective bandpass of 3–79 keV. The observatory provides a combined improvement in sensitivity and spatial/spectral resolution by factors of 10 to 100 over previous missions that have operated at these energies. The NuSTAR General Observer (GO) Program solicits proposals for basic research relevant to the NuSTAR mission.

NuSTAR Cycle 6 will commence on or about June 1, 2020, and last for a nominal period of 12 months. Based upon the outcome of the 2019 NASA Astrophysics Senior Review process, NuSTAR operations are currently funded through September 30, 2022. Further details on the Cycle 6 program may be found on the NuSTAR GO Program website (http://nustar.gsfc.nasa.gov).

Observing time will be made available to scientists at both U.S. and non-U.S. institutions. Individuals may submit proposals for three general types of observations: "standard-mode", "Target-of-Opportunity" (ToO, see Section 1.3.4), and "Large Programs" (LP, see Section 1.3.5). In addition to proposals for ToO observations submitted in response to this program element, unsolicited requests for ToO observations may be made through the NuSTAR Science Operations Center. Note that unsolicited ToO requests are ineligible for funding under the NuSTAR GO Program. The data from NuSTAR observations selected under the Cycle 6 Call for Proposals will have a limited exclusive-use period dependent upon the observation type. Data from approved standard-mode GO and LP observations will have a nominal one-year exclusive-use period commencing at the time of the availability of the processed data to the observer. Data from approved ToO observations will have a corresponding six-month exclusive-use period. Note that Principal Investigators (PIs) may waive the exclusive-use period and opt for the observation(s) to be placed directly into the NuSTAR public archive. Data resulting from unsolicited ToO requests will have no exclusive-use period.

In addition to investigations utilizing NuSTAR observations only, proposals involving coordinated observations with the European Space Agency (ESA)/NASA X-ray Multi-Mirror Mission (XMM)-Newton X-ray observatory, NASA's Neil Gehrels Swift observatory, and NASA's Neutron star Interior Composition ExploreR (NICER) mission are also solicited under this Call for Proposals. Prospective proposers of joint observations with these facilities should refer to Section 1.3.1 for details concerning the evaluation and implementation of such proposals.

Opportunities for carrying out NuSTAR observations in conjunction with NASA's Chandra X-ray Observatory, Neil Gehrels Swift observatory, NICER, and with ESA's XMM-Newton and INTEGRAL observatories are also available through the relevant Calls for Proposals for those missions. More information is available on the NuSTAR website: https://www.nustar.caltech.edu/page/for_proposers

Funding for investigations selected under the NuSTAR GO Program is available only to individuals at U.S. institutions who are identified as Principal Investigators (PIs). U.S.-based Co-Investigators on non-U.S.-led proposals are not eligible for funding.

Proposals for investigations directed primarily towards the conduct of supporting theoretical or laboratory astrophysics research or ground-based observations relevant to the NuSTAR mission or observations primarily for calibration of NuSTAR or other instruments are not solicited under this program. Such requests should be made to the NuSTAR PI.

1.2 The NuSTAR Mission

NuSTAR is a PI-led NASA Small Explorer (SMEX) mission. The PI institution is the California Institute of Technology, which is responsible for the overall direction of the program. NASA's Jet Propulsion Laboratory (JPL) is responsible for the project management. The lead domestic partners include Columbia University, the University of California at Berkeley, and NASA's Goddard Space Flight Center. The Danish Technical University Space Centre and the Agenzia Spaziale Italiana (ASI) made significant contributions to the hardware and data analysis software development, respectively. ASI is an active participant in mission operations, providing access to the Italian ground station at Malindi, Kenya. The NuSTAR Mission Operations Center (MOC) is at the University of California at Berkeley Space Sciences Laboratory, and the Science Operations Center (SOC) is at the California Institute of Technology.

NuSTAR was launched on June 13, 2012, from the Kwajalein Atoll in the Marshall Islands into a low-Earth orbit with an inclination of 6 degrees and an altitude of 630 km x 610 km. After an initial six-week checkout period and subsequent two-year baseline mission, the NuSTAR GO program was initiated. Based upon the results of the NASA 2019 Senior Review, support for mission operations was extended through September 30, 2022. The observatory has no expendables, and the orbit lifetime is estimated at ~ 10–15 years from launch. Currently in its eighth year of operations, the observatory continues to function nominally.

The NuSTAR spacecraft carries two sensitive, co-aligned, narrow-field instruments. Table 1 summarizes the primary performance specifications. Details of the observatory and instrument design can be found at http://nustar.caltech.edu/, as well as the NuSTAR mission paper, Harrison et al. (2013; ApJ, 770, 103).

Table 1: Key Observatory Performance Parameters

Parameter	Value
Energy range	3–78.4 keV
Angular resolution (HPD)	58″
Angular resolution (FWHM)	18″
FoV (50% resp.) at 10 keV	10′
FoV (50% resp.) at 68 keV	6′
Sensitivity (6–10 keV) (10^6 s, 3σ, ΔE/E = 0.5)	2 x 10^{-15} erg cm^{-2} s^{-1}
Sensitivity (10–30 keV) (10^6 s, 3σ, ΔE/E = 0.5)	1 x 10^{-14} erg cm^{-2} s^{-1}
Background in HPD (3–10 keV) Background in HPD (10–30 keV)	9.0 x 10^{-4} counts s^{-1} 1.1 x 10^{-3} counts s^{-1}
Strong source (>10σ) positioning	1.5″ (1σ)
ToO response time	< 48 hr
Slew rate	0.06° s^{-1}
Settling time	200 s (typically)

1.3 NuSTAR Cycle 6 General Information

The total amount of time allocated to GO during NuSTAR Cycle 6 is expected to be 11.3 Ms (70% of the total available observing time), of which 8.5 Ms will be allocated to NuSTAR observations selected through this program element. The remaining GO time will be allocated to joint observations:

- Up to 1.5 Ms to NuSTAR/XMM-Newton joint proposals submitted to the XMM-Newton Cycle 19 Call for Proposals.
- Up to 0.5 Ms to NuSTAR/Chandra joint observing proposals submitted to the Chandra Cycle 22 Call for Proposal.
- Up to 400 ks to NuSTAR/NICER joint observing proposals submitted to the NICER Cycle 2 Call for Proposals.
- Up to 300 ks to NuSTAR/Gehrels Swift joint observing proposals submitted to the Gehrels Swift Cycle 16 Call for Proposals.
- Up to 100 ks to NuSTAR/INTEGRAL joint observing proposals submitted to the INTEGRAL Cycle 18 Call for Proposals.

It is anticipated that approximately 50 investigations will be selected for implementation under the NuSTAR Cycle 6 GO program.

The remaining 30% of the observing time will be allocated through the NuSTAR Project to the NuSTAR legacy survey observations (3%); NuSTAR PI discretionary time (17%), including unsolicited ToO observations open to the scientific community; and time reserved for calibration observations, engineering tasks, and resolution of operational issues (10%). The NuSTAR legacy surveys represent extensions of the Galactic and Extragalactic surveys conducted during the baseline mission (see http://www.nustar.caltech.edu/page/legacy_surveys for additional information).

Proposers to this program must clearly describe how their proposed investigation capitalizes on the unique capabilities of NuSTAR. Proposals for investigations involving targets previously observed or currently planned for observation with NuSTAR must provide a justification of the need for the requested additional data. The "as-flown" observing timeline for NuSTAR may be found at http://www.srl.caltech.edu/NuSTAR_Public/NuSTAROperationSite/AFT_Public.php, and lists of the approved NuSTAR GO targets from previous cycles are available at https://heasarc.gsfc.nasa.gov/docs/nustar/previous_cycles.html. Proposers may also search the NuSTAR master catalog (numaster) table for a complete list of targets planned for observations as well as completed observations, including NuSTAR targets awarded through other solicitations (e.g., by Chandra and XMM-Newton joint programs with NuSTAR). See https://heasarc.gsfc.nasa.gov/W3Browse/all/numaster.html

A list of approved ToO observations accepted through the NuSTAR GO and joint GO programs is available on the NuSTAR SOC website: http://www.srl.caltech.edu/NuSTAR_Public/NuSTAROperationSite/TOO_programs.php

Observations of targets proposed through this Call for Proposals will take precedence over legacy program observations of those targets that have not been executed as of the submission deadline. The applicable legacy observations will be suspended until the disposition of the proposed GO observations is determined in the Phase 1 review. Proposed GO observations of legacy targets that are not accepted as part of the Cycle 6 program will be restored to the legacy program. A list of legacy observations that are planned to be performed by the end of Cycle 6 will be made available on the NuSTAR website http://www.nustar.caltech.edu/page/legacy_surveys.

For those Phase-1 proposals recommended for implementation, the approved target observations will be assigned a Category A, B, C or L (L designates a Large program target, see section 1.3.5) and a recommended exposure time. Note that for proposals including observations of multiple targets, the priority of each target observation will be separately categorized. Assuming nominal operational efficiency, it is anticipated that observations of most standard-mode Category A, B or L targets will be carried out during Cycle 6. Any standard-mode, non-time-constrained Category A, B or L observations not observed during Cycle 6 will be carried over to Cycle 7. See section 1.3.2 for details about multi-year observing proposals.

Observations of Category C targets will be executed on a best-effort basis. Category C targets not scheduled during a particular observing cycle will *not* be carried over to the succeeding cycle; such observations may be re-proposed to a future observing cycle. Finally, note that proposals for observations of Cycle 5 Category C targets that have not been scheduled prior to the Cycle 6 proposal due date may be submitted to Cycle 6. Such proposals will be considered for selection in Cycle 6 only if the corresponding Cycle 5 observation is not executed in Cycle 5.

Proposers should note that NuSTAR's low-inclination (6°), low-Earth orbit allows, on average, a maximum continuous exposure of ~ 3.2 ks per 5.7 ks satellite orbit for targets below a declination |Dec| of ~ 65°; for targets at high declination, |Dec| > 65°, the unocculted period may be longer. Unless there is a specific reason why the total elapsed time of an observation is important, proposers should specify only the net exposure time required for achievement of the proposed science goals, excluding observational efficiency factors (Earth occultations and South Atlantic Anomaly passages) in the observing time calculation; specification of the total elapsed time requirement will result in the observation being classified as time-constrained (see Section 1.3.3).

1.3.1 *Programmatic constraints*

Proposals are subject to the following limitations:

- The requested time per observation (i.e., a single "visit" to a target) is constrained to a minimum of 20 ks;
- Targets for which time-constrained observations are requested will only be given highest priority for scheduling during Cycle 6 if they are designated Category A (see Section 1.3.3);
- Due to the limited number of ground station passes, observations of high count-rate targets place significant demands upon mission resources. Consequently, it is anticipated that the total time available for observation of bright sources (predicted instrument count rate above 100 counts s^{-1} for both modules using 50% PSF extraction with no deadtime) during Cycle 6 will be limited to a maximum of 1 Ms. Note that, for very bright sources, the instrument count rate is significantly lower than the incident event rate due to detector deadtime effects. Proposals requesting observations of bright sources with durations > 30 ks are operationally difficult to carry out. Accordingly, such proposals must provide a sufficiently compelling motivation to be considered for acceptance. In addition, proposals requesting observations of bright sources with exposures longer than 75 ks will be considered for implementation *only* if the total requested time is distributed in multiple observations, each with exposure < 75 ks and separated by more than 1 week;
- Sources with fluxes > 10^{-11} ergs s^{-1} cm^{-2} within 5° of the target may cause increased nonuniform background gradients due to stray light. Users should check observations for potential stray light contributions using the tools available at http://nustar.caltech.edu/page/researchers. If the results of the constraint check indicates that the position may have a 'Potential stray light issue', proposers should submit a request for a feasibility analysis to nustar-help@srl.caltech.edu at least two business days prior to the proposal submission deadline;
- Proposals for joint NuSTAR/XMM-Newton programs in Cycle 6 will be accepted up to a total of 1.5 Ms of XMM-Newton observing time. Joint proposals must provide a compelling justification of the need for both the NuSTAR and XMM-Newton data for achieving the primary science goals and receive a Category A, B or L rating to be considered for acceptance. Individuals considering submission of a Cycle 6 proposal for joint NuSTAR/XMM observations should consult the XMM-Newton Cycle 19 approved NuSTAR target list prior to submission of their

proposal. Duplicate observations of the same targets by NuSTAR will typically not be awarded;

- Proposals for joint NuSTAR/Neil Gehrels Swift programs in Cycle 6 will be accepted up to a total of 300 ks of Neil Gehrels Swift observing time. Joint proposals must provide a compelling justification of the need for both the NuSTAR and Neil Gehrels Swift data for achieving the primary science goals and receive a Category A, B or L rating to be considered for acceptance. Proposers are strongly encouraged to carefully read the Neil Gehrels Swift/NuSTAR memorandum of understanding. Neil Gehrels Swift data sets obtained through approved joint NuSTAR/Gehrels Swift proposals will not be proprietary and will be immediately released publicly via the HEASARC data archive. Note that for most NuSTAR pointings, 1–2 ks "snapshot" observations are routinely performed by Neil Gehrels Swift (unless there are multiple observations of the same target, coordinated NuSTAR observations with other X-ray observatories, and during times of Gamma-Ray Bursts and Neil Gehrels Swift ToOs) without the need for a specific joint observing proposal. Individuals considering submission of a Cycle 6 proposal for joint NuSTAR/Neil Gehrels Swift observations should consult the Neil Gehrels Swift Cycle 16 approved NuSTAR target list prior to submission of their proposal. Duplicate observations of the same targets by NuSTAR will typically not be awarded;
- Proposals for joint NuSTAR/NICER programs in Cycle 6 will be accepted up to a total of 250 ks of NICER observing time. Joint proposals must provide a compelling justification of the need for both the NuSTAR and NICER data for achieving the primary science goals and receive a Category A, B or L rating to be considered for acceptance. NICER data sets obtained through approved joint NuSTAR/NICER proposals have the standard NuSTAR exclusive-use period and will be released publicly via the HEASARC data archive. Individuals considering submission of a Cycle 6 proposal for joint NuSTAR/ NICER observations should consult the NICER Cycle 2 approved NuSTAR target list prior to submission of their proposal. Duplicate observations of the same targets by NuSTAR will typically not be awarded;
- Proposals requesting joint observing time with XMM-Newton, Neil Gehrels Swift, and/or NICER observatories will have an additional page of text to describe the proposed program.
- Proposals requesting coordinated observations with other space- or ground-based observatories will be designated time-constrained and subject to the restrictions described in Section 1.3.3.

1.3.2 *Multi-Year Programs*

The PI may request that observations (including ToO observations) be scheduled over a two-cycle period. Multi-year programs must be strongly justified in the proposal text. No multi-year programs awarded in Cycle 6 will be carried beyond Cycle 7, i.e., all observations must occur in Cycles 6 and 7. Multi-year joint programs may also be proposed. All approved multi-year programs must be category A, B or L. It is anticipated that Cycle 7 will commence on June 1, 2021 and have a duration of one year.

1.3.3 *Time-Constrained Observations*

Time-constrained observations are defined as observations that must be performed within a specific time window. This includes phase-constrained observations and coordinated observing campaigns with ground-based or space-based facilities. Time-constrained observations are subject to the following limitations:

- Time-constrained observations designated Category A, B or L will be given highest priority for scheduling during Cycle 6 (or Cycle 6 and 7 for multi-year programs). Time-constrained observations of Category C targets will be executed on a best-effort basis and therefore should be scientifically justified if the time constraint is not satisfied.
- The time constraints for multi-year program can occur in Cycle 6 and/or Cycle 7.
- Time-constrained Category A, B or L observations that are not part of a multi-year program and are not scheduled during Cycle 6 may be carried over to Cycle 7 where warranted by scientific or operational circumstances (e.g., in the case of coordinated observations with other space- or ground-based observatories). Category C time-constrained observations not scheduled during Cycle 6 will *not* be carried over to Cycle 7.
- Monitoring programs are defined as investigations requiring two or more observations of the same target, each of which is considered a "visit". For such programs, the time interval between successive visits must be ≥ 14 hours. Note that programs in which the time interval between any two successive visits is ≤ 1 week will be designated as time-constrained.
- Note that proposed Neil Gehrels Swift observing time can include monitoring that precedes, follows and/or (for ToOs) triggers NuSTAR observing time.

For coordinated or time-constrained observations, it is the proposer's responsibility to inform the NuSTAR SOC of the observing time windows as soon as possible, but at a minimum of one month before initiation of the observations. In cases where observations involve coordination with other space-based observatories, the NuSTAR SOC will be responsible for communicating detailed schedule constraints with the relevant operations team(s).

1.3.4 *Target of Opportunity (ToO) Observations*

A total of up to 500 ks of NuSTAR Cycle 6 observing time will be made available for proposals to observe ToOs, subject to the constraints listed below. Individuals interested in submitting ToO proposals should note the following:

- Proposals must provide exact, detailed trigger criteria and a credible estimate (including justification) of the probability of triggering the ToO during Cycle 6 (and Cycle 7 for multi-year proposals);
- Proposers should indicate on the Astrophysics Research Knowledgebase (ARK)/Remote Proposal System (RPS) proposal submission form (http://heasarc.gsfc.nasa.gov/ark/rps/) the response time required to meet the scientific objectives. Note that the minimum response time that may be specified for NuSTAR observations is 48 hours; proposals will be evaluated based on this criterion. However, a more rapid response time may be requested by the PI; such requests will be accommodated on a best-effort basis;

- The observations must have an astrophysical trigger and be designated as Category A;
- Proposals for ToO observations that can be triggered from a class of objects or set of potential targets are permitted;
- Active ToO programs submitted to the Chandra/NuSTAR, XMM-Newton/NuSTAR, INTEGRAL/NuSTAR, Neil Gehrels Swift/NuSTAR or NICER/NuSTAR GO Program Calls for Proposals approved prior to the Cycle 6 solicitation will take precedence over NuSTAR Cycle 6 proposals with the same targets and trigger criteria.
- ToO programs accepted as part of the NuSTAR Cycle 6 GO program will take precedence over unsolicited ToOs.
- In the case of Large Program ToOs with multiple observations, only the initial observation is counted against the 500 ks maximum ToO exposure time (since subsequent observations are considered to be monitoring observations).

It is the responsibility of the PI of an accepted ToO proposal to alert the NuSTAR SOC when the trigger conditions for their accepted ToO have been satisfied. This is done via submission of a NuSTAR ToO Request Form; detailed information is available at http://nustar.caltech.edu/page/too_policy. Prior to submission of this form, the PI should verify the visibility of the target at http://www.srl.caltech.edu/NuSTAR_Public/NuSTAROperationSite/CheckConstraint.php Multi-year ToO programs may be triggered in Cycle 6 or Cycle 7. Accepted Cycle 6 ToO observations not designated as multi-year can only be triggered until the end of the cycle and observations not triggered during Cycle 6 will not be carried over to Cycle 7. Such observations may be re-proposed to a subsequent cycle. Data from approved Cycle 6 ToO observations will have a six-month exclusive use period after which the data will be placed in the public archive.

Note that requests for observations of unsolicited ToOs may be submitted via the NuSTAR ToO web site (http://www.srl.caltech.edu/NuSTAR_Public/GO/GOsubmit.php). Decisions regarding the disposition of unsolicited ToO requests will be made by the NuSTAR Principal Investigator or official designee. Requests for such unsolicited ToO observations are ineligible for funding under the NuSTAR GO Program.

NuSTAR Level 1 science requirements, which defined mission capabilities, included studying local core-collapse SN in the Milky Way and Type Ia supernovae in the Local Group, should such events occur. Accordingly, observations of either a core-collapse supernova in the Local Group or a Type Ia event to the distance of the Virgo Cluster will be executed by the NuSTAR Project, and all data will be released to the public with no period of exclusive use. Hence, ToO proposals for this category of observations will not be accepted.

1.3.5 *Large Programs (LPs)*

A total of up to 2 Ms of NuSTAR Cycle 6 observing time will be made available for the Large Program (LP) category. The minimum total exposure time for LP proposals is 500 ks, and such proposals are allowed an additional page of text to describe the proposed program. Data from approved Cycle 6 LPs will have a one-year exclusive use period after which the data will be placed in the public archive. A single-trigger ToO may be proposed as part of an LP (e.g., where a long observation is needed after the initial trigger). Data from an approved LP with a ToO will have a six-month exclusive use period.

2. Programmatic Information

2.1 General Information

It is anticipated that at least $3.0M will be available for the support of General Observations during Cycle 6. Proposals ranked as Category A, B or L by the Phase-1 peer review panel will be given the highest priority for funding. However, limited support will be made available for Category C proposals that are executed during Cycle 6. NuSTAR GO funding is open to individuals who are identified as Principal Investigators and employed at U.S. institutions. The amount of funding awarded to PIs of Category A, B or L proposals will be based upon NASA’s evaluation of the cost realism and reasonableness of the Phase-2 cost proposal. In addition, eligible PIs of proposals with Category C targets that are executed during Cycle 6 can expect awards of $10,000 to support the publication of the results. NuSTAR science team members and scientists participating in the NuSTAR mission are eligible for support under this GO Program. Note that GO proposals from NuSTAR team members who receive funding from the Project must clearly demonstrate that the proposed investigation is not redundant with their science team responsibilities. U.S. Co-Is on a U.S. PI proposal can only receive funding through a subaward from the PI institution. Following the Phase-1 peer review, Phase-2 (cost) proposals will be solicited from eligible PIs and subsequently evaluated for cost realism and reasonableness via the Phase-2 review process. Joint NuSTAR/XMM and NuSTAR/Gehrels Swift, and NuSTAR/NICER Phase 1 proposals selected through this Call for Proposals are eligible for funding solely through the NuSTAR GO program; the corresponding Phase-2 cost proposals may request support for the analysis of both the NuSTAR and XMM-Newton, Neil Gehrels Swift, or NICER data. Such proposals should not be submitted to the U.S. XMM-Newton General Observer Facility nor to the Gehrels Swift or NICER Projects.

Proposals from non-U.S. institutions are acceptable and will only be considered on a no-exchange-of-funds basis. Non-U.S. proposals will be reviewed to the same standards as proposals from U.S. institutions and selected solely by NASA.

2.2 Proposal Submission and Evaluation

The NuSTAR GO program utilizes a two-phase proposal process. Phase-1 proposals shall provide a detailed description of the proposed investigation, including the requested NuSTAR observation(s) and associated scientific/technical justification. The Phase-1 peer review will be executed in a "dual-anonymous" fashion, where not only are proposers unaware of the identity of the members on the review panel, but the reviewers do not have explicit knowledge of the proposal teams (see Section 2.2.1).

After review, U.S. PI's whose Phase-1 proposals with targets assigned a Category A, B or L rating by the peer review panel will be invited to submit a Phase-2 (cost) proposal. Category C programs do not require a Phase-2 proposal. Subject to acceptance of the associated Phase-2 cost submission, proposals for standard-mode observations (excluding proposals involving ToO or time-constrained observations) assigned a

Category A, B or L rating will be eligible for funding immediately. Due to the uncertainty of their execution, the remaining accepted Phase-2 proposals will become eligible for funding only after the proposed observations have been carried out. Phase-2 proposals must include a detailed budget and accompanying narrative, providing a detailed description of how the requested funds will be used to achieve the goals outlined in the proposal. It is nominally expected that the PI of the Phase-1 proposal will serve as the Phase-2 proposal PI; however, for administrative purposes, an alternate individual from the Phase-1 PI's institution may serve as PI on the Phase-2 proposal. All proposal materials shall be submitted electronically, as specified below.

Instructions for the formatting and content of ROSES proposals are given in the *ROSES Summary of Solicitation* and, for topics not addressed there, refer to the *NASA Guidebook for Proposers*. Proposers must follow these instructions, except where they are overridden by the instructions given in the Astrophysics Research Program Overview or in this program element. Templates for Phase-1 proposals will be made available on the NuSTAR GO website at https://nustar.gsfc.nasa.gov.

2.2.1 *Specific Instructions for Dual-Anonymous Review Proposals*

The overarching objective of dual-anonymous peer review is to reduce unconscious bias in the evaluation of the merit of a proposal. Under this system, not only are proposers unaware of the identity of the members on the review panel, but the reviewers do not have explicit knowledge of the proposal teams.

Proposers should consult the "Guidelines for Anonymous Proposals" document in the "Other Documents" section of the NSPIRES page for this program element for detailed instructions on writing proposals appropriate for dual-anonymous peer review. The bottom line is that Phase-1 proposals may not include anything that identifies the names of investigators or their institutions. Instead, proposers will upload a separate "Team Expertise and Background" document, that is not anonymized. The "Guidelines for Anonymous Proposals" contains complete information on how to write this separate document.

In order to meet the objectives of dual-anonymous peer review, review panels will be instructed to evaluate the anonymized proposals based on their scientific merit, without taking into account the proposing team qualifications. As a final check, and only after the scientific evaluation is finalized for all proposals, the panel will be provided with the "Team Expertise and Background" documents. The panel will assess the qualifications of the team in order to allow the reviewers to assess the team capabilities required to execute a given proposed science investigation.

A summary of the key factors for PIs to keep in mind are:

- Phase-1 Proposals may not include language that identifies the names of investigators or their institutions, as discussed in the Guidelines for Anonymous Proposals
- PIs are required to upload a one-page "Team Expertise" PDF through ARK as a separate upload when submitting the science justification.

- The experience from the Hubble Space Telescope dual-anonymous reviews is that revising previous proposals to be compliant requires some thought but is straightforward in most cases.
- NASA understands that dual-anonymous peer review represents a major shift in the evaluation of General Observer/General Investigator proposals and, as such, there may be occasional slips in writing anonymized proposals. However, NASA reserves the right to return without review proposals that are particularly egregious in terms of the identification of the proposing team.

2.2.2. *Submission and Evaluation of Phase-1 NuSTAR GO Proposals*

Individuals submitting Phase-1 proposals to the Cycle 6 NuSTAR GO Program must adhere to the following proposal submission procedures:

- Proposers must submit their Phase-1 proposals (including the accompanying target forms) electronically through the ARK/RPS website at http://heasarc.gsfc.nasa.gov/ark/rps/. Instructions for submitting proposals via ARK/RPS are provided at the HEASARC NuSTAR web site: http://nustar.gsfc.nasa.gov/;
- Due to the nature of prospective investigations within the NuSTAR GO program, the Scientific/Technical/Management section of proposals is limited to four pages (five pages for LP proposals and proposals requesting joint NuSTAR/XMM-Newton, NuSTAR/Gehrels Swift or NuSTAR/NICER observations), in lieu of the default 15 pages specified in the *NASA Guidebook for Proposers*. The requirement for a table of contents in the body of the proposal is waived. No supporting material (e.g., Curriculum Vitae, pending/current support) is required or allowed other than what is specified in the supplemental documentation concerning the dual-anonymous review procedure.
- The proposals should have margins of no less than 1" on US letter size paper (8.5" x 11") and the text body font size should be no smaller than 15 characters per inch. Figure captions and references may be smaller but must be legible. Optional LaTeX and MS Word templates for the Scientific/Technical/Management section consistent with these requirements are provided at http://nustar.gsfc.nasa.gov;
- Proposals must not contain hyperlinks to additional material other than references to public information that do not identify the PI, Co-Is or their institutions; web pages with material specific to the proposal such as target lists are not allowed.
- The Science Justification and the Team Expertise documents must be uploaded to the RPS website as PDF files.
- Proposals not in compliance with these specifications may be returned without review.

In order to be included in the review of proposals for this cycle of the NuSTAR General Observer Program, all proposal materials must be submitted electronically by 4:30 p.m. Eastern Time on the Phase-1 due date provided in Tables 2 and 3 of ROSES.

Proposals will be evaluated by a science peer panel with respect to the criteria specified in Section VI(a) of the *ROSES Summary of Solicitation*, where it is understood that the intrinsic merit of a proposal shall include the following factors:

- The extent to which the proposed investigation complements and enhances the anticipated science return from the NuSTAR mission;
- The suitability of using the NuSTAR observatory and associated data products for the proposed investigation, including the degree to which the investigation exploits the unique capabilities of NuSTAR;
- The feasibility of accomplishing the objectives of the proposed investigation with the requested observations, including the degree to which the proposal satisfies NuSTAR observational constraints and the feasibility of the proposed analysis techniques;
- For joint observing proposals, the relevance and feasibility of the corresponding XMM-Newton, Gehrels Swift or NICER observations
- The degree to which the proposed observation(s) places demands upon mission resources.
- In the case of ToO proposals the justification of the trigger probabilities.

2.2.3 *Submission and Evaluation of Phase-2 proposals*

Subject to the availability of funding, eligible Phase-1 proposers with Category A, B or L observations will be contacted by the NuSTAR Program Scientist and invited to submit a Phase-2 (cost) proposal. Upon notification of selection of a Phase-1 proposal, proposers eligible for Phase-2 must follow the instructions for submitting a Phase-2 proposal given in the selection notification letter from the Phase-1 review. Phase-2 proposals must be submitted through the NASA NSPIRES electronic proposal website (http://nspires.nasaprs.com) by an Authorized Organizational Representative (AOR) of the proposing organization following the instructions in the *Summary of Solicitation* of this NRA. The cost proposal shall consist of a "Budget Details" section (maximum of two pages) and a "Budget Narrative" section (maximum of two pages).

NASA program personnel (as opposed to peer reviewers) will evaluate the Phase-2 cost proposals for cost reasonableness and will also compare the proposed cost to available funds as allowed by Section VI(a) of the *ROSES Summary of Solicitation.* Subject to the conditions stated above, proposers will be notified regarding the award amount for their Cycle 6 investigation(s) by NASA upon completion of the Phase-2 review process.

2.3 Supplemental Information

Further details concerning the proposal submission requirements and process can be found at the NuSTAR General Observer website (http://nustar.gsfc.nasa.gov/). This website provides instructions for completing the required proposal forms. A detailed description of the NuSTAR mission, including technical information relevant to the observatory, instruments, and observation feasibility can be found at http://nustar.caltech.edu/page/researchers. Answers to frequently asked questions can be found at http://heasarc.gsfc.nasa.gov/docs/nustar/nustar_faq.html.

3. Summary of Key Information

Expected program budget for Cycle 6 awards	~ $3.0 M
Expected number of new awards pending adequate proposals of merit	30–50
Maximum duration of awards	1 year (2 years for multi-year programs)
Due date for Notice of Intent to propose (NOI)	Option not available.
Due date for Phase-1 proposals	See Tables 2 and 3 of this ROSES NRA.
Planning date for start of investigation	Funding will be awarded when the data are made available to the PI. NASA Center proposers should use October 1, 2020 (4 months after start of the Cycle 6 observing program) as a planning date for start of observations.
Page limit for Phase-1 proposals	Standard & ToO proposals: 4 pages. Large Program (LP) and Joint Observing Proposals: 5 pages. LaTeX and MS Word templates (available for download at http://nustar.gsfc.nasa.gov/) can be used for the proposals. No supporting material (e.g., pending/current support) will be considered for Phase-1 except what is specified in the Guidelines for Anonymous Reviews. Page limits include figures and references. This instruction supersedes the limits given in the *NASA Guidebook for Proposers*.
Relevance	This program is relevant to the Astrophysics questions and goals in the NASA Science Plan (https://science.nasa.gov/about-us/science-strategy). Proposals that are relevant to this program are, by definition, relevant to NASA.
General information and overview of this solicitation	See the *ROSES Summary of Solicitation*.
General requirements for content of proposals	See Section 3 of the *NASA Guidebook for Proposers* and Section IV and Table 1 of *the ROSES Summary of Solicitation*.

Detailed instructions for the submission of Phase-1 proposals	See https://heasarc.gsfc.nasa.gov/docs/nustar/nustar_prop.html
Detailed instructions for the submission of Phase-2 proposals	See https://nspires.nasaprs.com/tutorials/ Sections 3.22-4.4 of the *NASA Guidebook for Proposers* and Section IV(b) of *the* *ROSES Summary of Solicitation*.
Submission medium	Electronic proposal submission is required in PDF format; no hard copy is required or permitted.
Web site for submission of Notice of Intent to propose (NOI)	Option not available.
Web site for submission of Phase-1 proposal and required forms	http://heasarc.gsfc.nasa.gov/ark/nustar/ (Help Desk available at: http://heasarc.gsfc.nasa.gov/ark/rps/help/)
Web site for submission of Phase-1 proposal via NSPIRES	Option not available.
Web site for submission of Phase-1 proposal via Grants.gov	Option not available.
Web site for submission of Phase-2 proposals	http://nspires.nasaprs.com; See Section 2.2.3
Programmatic information may be obtained from the NuSTAR Program Scientist	Hashima Hasan Astrophysics Division Science Mission Directorate NASA Headquarters Washington, DC 20546-0001 Telephone: (202) 358-0692 Email: hhasan@nasa.gov
Technical questions concerning this program element may be directed to the NuSTAR General Observer Program Office	Andrew Ptak NuSTAR Mission Scientist Code 662 Goddard Space Flight Center National Aeronautics and Space Administration Greenbelt, MD 20771-0001 Telephone: (301) 286-1154 Email: andrew.ptak@nasa.gov

D.10 TESS GUEST INVESTIGATOR – Cycle 3

NOTICE: October 16, 2019. Cycle 3 includes the following changes from the previous two cycles and from when ROSES-2019 was released:

- **TESS Cycle 3 observations will be collected during the first year of the extended mission, running from July 2020 until June 2021, covering observing sectors 27–39;**
- **A new 20-second cadence mode will potentially be available. Once commissioned, approximately 1,000 target slots per sector will be available in this mode. Guest Investigator (GI) observations in this mode will be collected at "shared risk";**
- **A 10-fold increase in the number of 2-minute cadence targets is available to the GI program. More than 15,000 target slots will be available in each sector; a total of approximately 200,000 target slots are available in Cycle 3, facilitating very large GI programs;**
- **The full-frame image cadence is planned to be reduced from 30 minutes to 10 minutes. This change in cadence will be considered a "shared risk";**
- **A new Key Project proposal category is available. These programs have a maximum duration of 27 months. The programs may be continued into TESS Cycle 4 and may propose to select targets in both Cycles 3 and 4 (although only Cycle 3 target lists are solicited at this time);**
- **Ground-based observing focused programs are solicited provided they support the analysis and/or interpretation of TESS data. Up to $500,000 is available to support ground-based observing programs;**
- **Large programs and Key Projects have a 5-page limit for the scientific/technical/management section;**
- **References are not included in the page limits;**
- **Joint TESS-Swift proposals are solicited. Up to 100 ks of Swift time will be available for proposals using Swift observations to augment TESS-focused projects;**
- **Starting in Cycle 3, proposals aimed at detecting small planets in 2-minute cadence data are solicited.**

1. Scope of Program

1.1 Overview

The TESS Guest Investigator (GI) Program solicits proposals for the acquisition and analysis of scientific data from the Transiting Exoplanet Survey Satellite (TESS) mission, a NASA Explorer mission that was launched in April 2018 and began science operations in July 2018. Additionally, proposals that support the acquisition and analysis of scientific data from ground-based telescopes are solicited. Such ground-based measurements must directly support the analysis and/or interpretation of TESS scientific data.

Currently completing a 2-year near all-sky survey, TESS has been monitoring the brightness of nearby, bright F, G, K, and M stars in order to photometrically search for transiting planets smaller than Neptune. (See [Ricker et al., 2015, *Journal of Astronomical Telescopes, Instruments, and Systems*, 1, 014003], for a detailed description). TESS was designed to monitor the brightness of more than 200,000 stars spread over the celestial sphere with a photometric sensitivity sufficient to permit detection of transiting planets with a radius less than 2.5 Earth radii. TESS's high-precision, continuous baseline photometric capability is also well suited to time domain astronomy, which includes studies of stellar variability and asteroseismology research, and analyses of both Galactic and extragalactic astrophysical sources.

The lead institution for TESS is the Massachusetts Institute of Technology (MIT), which hosts the Principal Investigator, Dr. George Ricker.

TESS will begin extended mission operations in July 2020. Observations associated with the TESS Guest Investigator (GI) Cycle 3 solicitation will be collected during the first year of the extended TESS mission, running from July 2020 until June 2021, covering observing sectors 27–39.

There is no exclusive-use period associated with the data from TESS observations. All data will be made available through the Mikulski Archive for Space Telescopes (MAST) public archive once data processing and validation is complete.

Funding through the NASA TESS GI Program is available only to scientists at U.S. institutions who are identified as the Principal Investigators (PIs). No sub-awards will be made except in the case of Civil Servant Co-Is, who are eligible for direct sub-awards. U.S. based Co-Is on foreign-led proposals do not qualify for funding. Funding for accepted target proposals will be initiated only after the first data collected for the proposed investigation are uploaded to the MAST.

1.2 The TESS Mission

A detailed discussion of the TESS prime mission and its scientific objectives can be found at https://tess.gsfc.nasa.gov. The TESS instrument consists of four wide field-of-view (FOV) cameras, each of which observes a 24x24 square degree field. The cameras are aligned with their fields adjacent, such that the instantaneous field-of-view is 24x96 square degrees.

During Cycle 3, TESS will enter its extended mission and will observe each sector continuously for two spacecraft orbits (2x approximately 14 days), with the boresight of the four-camera array pointed nearly antisolar, obtaining full-frame images (FFIs) every 10 minutes, 2-minute cadence sub-image data for ~15,000 pre-selected targets within the field, and 20-second cadence sub-images for approximately 1,000 targets awarded through the GI program. The 10-minute FFI cadence and 20-second sub-image cadence will be considered "shared risk" observations, with modifications to the observing plan possible following testing and evaluation by the project. After two orbits, the FOV is shifted eastward in ecliptic longitude by ~27 degrees, to observe the next (adjacent) sector. Adjacent sectors have overlapping regions in proximity to the ecliptic poles, providing longer-term coverage for stars falling in these regions, which in turn provides sensitivity to, e.g., smaller and longer-period planets; objects within ~12 degrees of the ecliptic poles may be observed for ~1 year. As with Cycle 2 Sectors 14–16, it may be necessary to off-point several sectors in Cycle 3 to avoid light from the Earth and Moon entering Cameras 1 and 2.

Cycle 3 will observe fields in the Southern Ecliptic Hemisphere. A total of 13 sectors will be observed in Cycle 3. The observing plan for Cycle 3 can be found at https://tess.gsfc.nasa.gov.

1.2.1 *Observing Modes and Data Products*

Data for specific targets are saved onboard and transmitted as "postage stamp" subimages, with an area sufficiently large to accommodate the optimal aperture for the astrophysical target. Extended or very bright objects can be accommodated with more appropriately chosen subimage pixels. Postage stamp observations are collected at either 2-minute or 20-second cadence. Additionally, the full 24x96 square degree field-of-view of all four TESS cameras is collected at 10-minute cadence.

The TESS data are processed with a data reduction pipeline based on software that was developed for the Kepler mission. This pipeline performs pixel-level calibration, background subtraction, aperture photometry, identification and removal of systematic errors, and the search for transit signals in the 2-minute cadence postage stamp data. The calibration corrects for bias level, smear, galactic cosmic rays, flat fielding, dark current, background, and instrument noise.

Data distribution and archival services will be performed through the Space Telescope Science Institute's MAST. Final data products available to GI observers are expected to include original and calibrated target pixel files, pipeline-produced light curves for each 2-minute cadence postage stamp target, and raw and calibrated images for the FFI data.

Data will be archived in standard FITS formats for images and light curves. TESS light curves produced through the pipeline software are optimized for the detection of small exoplanets. Proposers should be aware that pipeline-generated light curves may not be optimal for all science programs and plan their analyses accordingly.

The 10-minute FFI cadence and 20-second cadence mode for individual targets are "shared risk" observations. "Shared risk" means that details of the instrument and pipeline performance for these observing modes has not been fully tested at the time of the release of this call. These shared risk modes are not guaranteed to be available for the entire duration of Cycle 3, and the quality of the shared risk data returned to PIs may not meet expectations. These modes will be made available for science as soon as is feasible after the start of Cycle 3.

1.2.2 *Instrumentation and Technical Capabilities*

TESS has neither changeable filters nor dispersing elements. Photometry is taken through a broad bandpass ranging from 600 to >1000 nm. There is no hard brightness limit for TESS. Additional details can be found in the Instrument Handbook here: https://archive.stsci.edu/tess/#section-b285b7ac-171e-40e2-a9a4-e813a661fa2d (v0.1 dated 12/18 is the current version as of October 2019).

The TESS Input Catalog (TIC) is intended to contain most optically-persistent objects in the sky down to the limits of available photometric catalogs, to enable the selection of optimal targets for planet transit searches, and the calculation of flux contamination in the TESS subimage for each target. The TIC has been publicly released (v8, as of October 2019; these will be superseded by revisions as available) and are searchable via MAST at http://archive.stsci.edu/tess/. The TIC is documented by Stassun et al. (2019; https://ui.adsabs.harvard.edu/abs/2019AJ....158..138S/abstract).

1.3 Permitted Guest Investigator Science

The primary purpose of the TESS Guest Investigator Program is to enhance and maximize the science return from TESS. The program facilitates and supports both postage stamp observations with TESS, research undertaken with the FFIs, and ground-based supporting observations of TESS targets, including radial velocity measurements of TESS exoplanet host stars. Proposals may be a combination of postage stamp target requests, FFI analysis, and ground-based observing support. Proposers wishing to utilize 10-minute FFI cadence or 20-second cadence observing modes during Cycle 3 must identify the impact upon their science goals if only 30-minute FFIs and 2-minute cadence modes are available at the time of the observations. If the program cannot achieve its science goals without 20-second cadence or 10-minute FFI modes, this must be stated.

The scientific justification of a GI proposal should focus on a compelling investigation that requires the collection of new TESS data or new ground-based data that supports the analysis and/or interpretation of TESS data. The proposed TESS Guest Investigation must clearly enhance the science return of the TESS mission. The proposal may include theoretical components, software development, and/or data simulation that strengthens the proposal, but at least 70% of the work effort should be focused on exploiting TESS data products, except in the case of ground-based observing focused proposals. Proposed investigations in which the primary emphasis is theory/modeling or archival (TESS Cycle 1 and/or Cycle 2) data analysis will be non-compliant. The ROSES NASA Research Announcement provides alternative opportunities to exploit or support the TESS mission in these areas:

- Investigations for which the primary emphasis is theory and/or modeling may be proposed to the Astrophysics Theory Program (ATP; Program Element D.4), or the Exoplanet Research Program (XRP; Program Element E.3).
- Investigations for which the primary emphasis is analysis of archival data may be proposed to the Astrophysics Data Analysis Program (ADAP; Program Element D.2), or the Exoplanet Research Program (XRP; Program Element E.3).
- Investigations for which the primary emphasis is the collection and/or analysis of ground-based data may be proposed to the Exoplanet Research Program (XRP; Program Element E.3), or the NSF Astronomy and Astrophysics Research Grants Program (AAG). However, note that PIs are not permitted to submit proposals that are substantively similar to both this call and the XRP.

Proposals that are focused on ground-based observing programs must have a clear science driver and describe how the ground-based component is both feasible and required for analysis and/or interpretation of TESS data. Programs in this category that will collect observations from ground-based facilities contemporaneously with TESS observations are particularly encouraged. Proposals must describe how the funding would be used to support the collection or analysis of new data in support of TESS, including for example buying telescope time, instrument development, travel to observatories, support for students, etc. Funding awards of all sizes will be considered; the TESS GI program is expected to award up to $500,000 to ground-based observing programs.

Proposals must clearly describe the plans to make any new software, higher level data products and/or supporting data publicly available. Software developed with TESS GI funds must add value to the TESS science community, be free, and open source. Ground-based data collected with TESS GI funding support must be made publicly available in a timely fashion at either the NASA Exoplanet Science Institute (NExScI) ExoFOP service (https://exofop.ipac.caltech.edu) or as a MAST High-Level Science Product (http://archive.stsci.edu/hlsp/). Other data products created with TESS GI funding support should be archived as a MAST High-Level Science Product (http://archive.stsci.edu/hlsp/).

To foster correlative observations, TESS has established joint observing programs with the Hubble Space Telescope (HST) and the Neil Gehrels Swift Observatory. Proposals for joint HST observations should be submitted through the HST GO program and the TESS targets will be recommended by that review.

The TESS Guest Investigator program can also award Swift observations through a joint program with the Swift mission. Observing time under this program will be awarded only to proposals that require use of both observatories to meet the primary science goals. Up to 100 ks Swift time will be available through this program. TESS GI funding is available to successful U.S.-based investigators who request Swift observing time through the TESS GI process. No funds will be awarded from the Swift project for joint investigations proposed to this TESS program element.

1.4 Target of Opportunity Observations

The TESS GI program recognizes the category of Target of Opportunity (ToO) observations of rapidly evolving phenomena whose occurrence is not predictable at the time of the TESS proposal due date. Due to TESS mission constraints, ToO-triggered target definitions can only be uploaded to the spacecraft for the next observing sector. Details regarding the circumstances in which a ToO is triggered must be included in the scientific justification and on the target form. ToO proposals must also include an estimated probability for triggering the observations; the latter will be used in the accounting of total allocated targets. ToOs remain active during the cycle; ToOs not carried out during the cycle must be re-proposed to subsequent solicitations. ToO observations would commence after the spacecraft upload following a trigger. The impact to science of delays between trigger and data collection of several weeks should be addressed in proposals requesting ToO observations.

1.5 On-source Monitoring Times

The visibility tool on the TESS Science Support Center website should be consulted to verify the duration of visibility of targets to be proposed.

1.6 Target Lists

Proposals requesting postage stamp targets are required to submit a target list. Targets must be submitted electronically, at the same time as the science proposal, via the Remote Proposal System (RPS; https://heasarc.gsfc.nasa.gov/ark/rps/). A definition of each column and a detailed description of the example table can be found at the link to the table template at the TESS Science Support Center website. If a proposed target does not appear in the TIC, the information required to append the target to the TIC must be provided.

2. Programmatic Information

2.1 General Information

$3.0M in Cycle 3 will be available to US-based PIs through this solicitation for the support of approximately ~36 Guest Investigations. The performance period of each award will be 1 year; PIs will be allowed to request a no-cost extension for one additional year as needed. The Cycle 3 GI program will also include unfunded non-US-based investigations of high merit, as determined by peer review. Additional Guest Investigation targets will be drawn from proposals that are not selected for funding, if target resources permit. Scientists participating in the TESS mission, including members of the Follow-up Team, are permitted to propose to the GI program and are subject to the same program rules as the rest of the science community.

2.2 Proposal Submission and Evaluation

2.2.1 *Submission of Proposals to the TESS GI Program*

The TESS GI program uses a two-phase proposal process. All proposal materials will be submitted electronically. A Phase-1 proposal shall comprise the science/technical justification; all proposals must include a one paragraph work plan in the science/technical section. This work plan must give details on how the proposed effort will be carried out, including the allocation of effort amongst investigators. Investigators who are proposing to continue a program that was selected for funding in one or more previous cycles must justify why additional data and/or funds are required in Cycle 3. All proposals requesting funds must also provide upon submission a bottom-line budget number in the provided field of the Astrophysics Research Knowledgebase (ARK) RPS submission form; this number should not be included in the body of the proposal. Only proposers whose Phase-1 proposals are accepted will be invited to submit budget proposals in Phase-2. Proposal content must remain consistent between Phase-1 and Phase-2 proposals. It is not necessary for the PI of the Phase-2 proposal to be the science PI.

There are three categories of investigations: Small, Large, and Key Projects. Awards for the majority of investigations (i.e., focused analysis and/or small numbers of targets) are expected to be capped at approximately $50,000. Proposals requiring more complex analysis, specialized software development, or a large number of targets, may require funding substantially above the average award (i.e., up to $200,000 range per award). Key Projects are anticipated to be large multi-year programs with very broad scopes (up to 27 months and up to $200,000 per year). We anticipate awarding at least one Key Project that proposes many tens of thousands of 2-minute cadence targets, subject to available slots for targets as well as funding. Key Projects and large programs are expected to provide additional benefit to the science community beyond publishing scientific papers (e.g. software releases, value-added data products, etc.). Such proposals will need to provide a compelling justification for the higher funding level. Approximately $2.5 million will be available to support standard Small, Large, and Key Projects.

Another $500,000 is anticipated to be available to programs that focus on ground-based observing. Ground-based focused proposals should be identified in ARK/RPS as such and will be reviewed in a panel separately from other proposals submitted to the TESS GI program. All size programs are encouraged, and proposers should identify their program as a Small or Large program. Proposers of ground-based TESS investigations will not be permitted to submit the same proposal, in part or in full, to the ROSES-2020 Exoplanet Research Program (XRP; E.3).

The science/technical section may be no more than 4 pages for Small proposals. Large proposals and Key Projects are allocated an additional page to describe the benefits that the program will provide to the science community.

The amount of the anticipated funding request must be entered into the box provided for this purpose on the RPS Cover Form. The detailed cost evaluation will be deferred until Phase 2. The funding amount requested in the Phase-2 cost proposal may not exceed the amount proposed in Phase 1.

The generic instructions for the submission of ROSES proposals are given in Table 1 of the *ROSES Summary of Solicitation* and the *NASA Guidebook for Proposers.* TESS GI Proposers should follow generic instructions, except where they are overridden by more specific guidance given in the *ROSES Summary of Solicitation* or in this Program Element (see for example Section I(g) of the *ROSES Summary of Solicitation*). Proposers to the TESS GI Program must adhere to the following proposal submission procedures:

- All Proposers must submit their Phase-1 proposals electronically through the Astrophysics Research Knowledgebase (ARK)/Remote Proposal System (RPS) website at https://heasarc.gsfc.nasa.gov/ark/rps/. Instructions for doing so will be provided at the TESS Science Support Center web site, https://heasarc.gsfc.nasa.gov/docs/tess/;
- Target tables for all observation proposals are to be submitted through ARK/RPS;
- The Scientific/Technical/Management section of proposals is limited to four pages for small programs and five pages for large and Key Projects, instead of the default 15 pages specified in the *NASA Guidebook for Proposers*. The requirement for a table of contents in the body of the proposal is waived. No supporting material (e.g., Curriculum Vitae, pending/current support) is required or allowed;
- Optional Latex and MS Word templates for the Scientific/Technical/Management section will be provided on the TESS Science Support Center web site at https://heasarc.gsfc.nasa.gov/docs/tess/;
- The Scientific/Technical/Management section must include a one paragraph work plan;

- The Scientific/Technical/Management section must be uploaded to the RPS website as a PDF file.

Proposals from non-U.S. institutions are acceptable and will only be considered on a no-exchange-of-funds basis. Non-U.S. proposals will be reviewed to the same standards as proposals from U.S. institutions and selected solely by NASA.

All proposal materials must be submitted electronically by 4:30 pm Eastern time on the due date for this program given in Tables 2 and 3 of ROSES to be included in the proposal review for this cycle of the TESS Guest Investigator program. Note that the 4:30 pm deadline supersedes the default deadline stated in the *Guidebook for Proposers* and in the *ROSES Summary of Solicitation.*

2.2.2 *Evaluation of Phase-1 Proposals submitted to the TESS GI Program*

All Phase-1 proposals with be evaluated for Relevance, Cost and Intrinsic Merit as defined in Appendix D of the *NASA Guidebook for Proposers* and consistent with Section VI(a) of the ROSES *Summary of Solicitation*. The evaluation of merit will include:

- The suitability of using the TESS survey and data products for the proposed investigation (not applicable for ground-based observing focused programs, although ground-based programs should make clear the need for ground-based data in order to analyze or interpret TESS data);
- The extent to which the investigation complements and enhances the anticipated science return from the TESS mission;
- The degree to which the proposed investigation places demands upon mission resources (this includes justification of the observing cadence requested and the impact on science if a given observing mode is not available during Cycle 3); and
- The degree to which the proposed investigation capitalizes on the unique capabilities of TESS.

2.2.3 *Submission and Evaluation of Phase-2 proposals*

Subject to the availability of funding, successful Phase-1 proposers will be contacted by the TESS Program Scientist and invited to submit a budget proposal in Phase 2. Upon notification of selection of a Phase-1 proposal, a proposer must respond as follows:

Follow the instructions for submitting a Phase-2 proposal given in the selection notification from the Phase-1 review. Phase-2 proposals must be submitted through the NASA NSPIRES electronic proposal website (https://nspires.nasaprs.com/) by an Authorized Organizational Representative (AOR) of the proposing organization. The budget proposal will consist of Budget Details (maximum of two pages) section and a Narrative section (maximum of two pages).

NASA program personnel will evaluate the Phase-2 cost proposals for cost reasonableness and will compare the proposed cost to available funds, consistent with Section VI(a) of the *ROSES Summary of Solicitation.*

2.3 Supplemental Information

Further details concerning the proposal submission requirements and process can be found at https://heasarc.gsfc.nasa.gov/docs/tess/, the TESS Science Support Center website. This website provides a detailed mission description; technical information about the TESS mission, instrument, and observation feasibility; and instructions for completing the required proposal forms. The Web TESS Viewing Tool found at the TESS Science Support Center website (https://heasarc.gsfc.nasa.gov/docs/tess/) also provides the capability to see when user-provided TESS targets will be observed and to get estimated TESS magnitudes and photometric precisions for point sources.

3. Summary of Key Information

Expected program budget for first year of new awards	$3.0M with $500,000 anticipated to be awarded to ground-based observing focused programs.
Number of new awards pending adequate proposals of merit	~36 (made up of approximately 1 Key Project, 6 large programs and 28 small programs)
Maximum duration of awards	2 years (large and small programs), 27 months (Key Projects)
Due date for Phase-1 proposals	4:30 pm on the due date given in Tables 2 and 3 of ROSES.
Planning date for start of investigation	Cycle 3 observations are expected to start in July 2020. Funding will be released to the PI when the first data collected for the proposed investigation are uploaded to the MAST. The earliest such date is approximately August 2020.
Page limit for Phase-1 proposals	4 pages for small programs and 5 pages for large programs and Key Projects. The use of LaTeX or MS Word templates (available at https://heasarc.gsfc.nasa.gov/docs/tess/) is encouraged. Page limits include figures but do not include references. This instruction supersedes the limits given in the *NASA Guidebook for Proposers.*
Relevance	This program is relevant to the Astrophysics questions and goals in the NASA Science Plan. Proposals that are relevant to this program are, by definition, relevant to NASA.
General information and overview of this solicitation	See the *ROSES Summary of Solicitation*.
Detailed instructions for the preparation and submission of Phase-2 proposals	Please see Section 2.2.3
Submission medium	Electronic proposal submission is required; no hard copy is required or permitted.
Web site for submission of Phase-1 proposal and required forms	https://heasarc.gsfc.nasa.gov/ark/rps/ (Help Desk available at http://heasarc.gsfc.nasa.gov/ark/rps/help/)
Web site for submission of Phase-2 proposals	http://nspires.nasaprs.com; See Section 2.2.3

Programmatic information may be obtained from the TESS Program Scientist	Martin Still Astrophysics Division Science Mission Directorate NASA Headquarters Washington, DC 20546-0001 Telephone: (202) 358-4462 Email: martin.still@nasa.gov
Technical questions concerning this program element may be directed to the TESS Guest Investigator Program	Thomas Barclay Code 667 Goddard Space Flight Center National Aeronautics and Space Administration Greenbelt, MD 20771-0001 Telephone: (301) 286-5079 Email: thomas.barclay@nasa.gov

D.11 NICER Guest Observer – Cycle 2

NOTICE: Amended August 14, 2019. This Amendment releases final text and sets the due date for Phase-1 proposals to program element. Phase-1 proposals are due by 4:30 p.m. Eastern time November 13, 2019 (via ARK/RPS).

1. Scope of Program

1.1 Overview

The Neutron Star Interior Composition Explorer (NICER) is an X-ray experiment on the International Space Station dedicated to high-resolution timing and spectroscopy of neutron stars and other rapidly variable X-ray sources in the 0.2-12 keV band. NASA is issuing this solicitation for Cycle 2 of the NICER Guest Observer (GO) program. Proposals for observations with NICER addressing all areas of astrophysics are solicited, with 7 Ms of available time and a limited amount of funding available in FY20.

Proposers also have the opportunity to request coordinated NuSTAR observations of their proposed NICER targets. A total of up to 400 ks of NuSTAR observing time is available within this Cycle.

Proposals will be submitted in two stages, with Phase-1 focusing on the science goals and observation parameters. Selected Phase-1 proposers will be invited to submit a budget for Phase 2. Proposers may request, and must justify, an exclusive-use period of up to 6 months for GO data in this Cycle; by default, data will be subject to the existing NICER data-release policy (validated data are made available in the public HEASARC archive within two weeks of acquisition), with no exclusive-use period.

1.1.2 *New for Cycle 2*

The following items have changed compared to Cycle 1:

- ToO requests with unknown targets are allowed.
- More flexible observing strategies are available for monitoring programs.
- Multi-year proposals, with sufficient science justification, are allowed.
- Erroneously high background estimates in PIMMS (see below) have been corrected.

1.2 The NICER Mission

NICER is a Principal Investigator (PI)-led NASA Mission of Opportunity in the Astrophysics Explorers Program. The PI institution is NASA's Goddard Space Flight Center, which is responsible for the overall direction of the program and the project management. Science partners include the Massachusetts Institute of Technology (MIT) Kavli Institute. The NICER Science and Mission Operations Center (SMOC) is located at NASA's Goddard Space Flight Center.

NICER was launched aboard a SpaceX Falcon 9 rocket to the International Space Station (ISS) on June 3, 2017, and is installed externally on ISS, ExPRESS Logistics Carrier 2, site 7 (starboard). It offers active pointing over nearly the full hemisphere about the zenith direction.

NICER was designed to perform high time-resolution and spectroscopic observations in the 0.2–12 keV energy range to study the physics of ultra-dense matter in the cores of neutron stars. It carries an X-ray Timing Instrument (XTI) that employs concentrator optics and detectors to register X-ray photon energies and times of arrival. The XTI is a non-imaging instrument that collects X-rays from within a single 6 arcmin (FWHM) field of view. NICER science data consist of photon energies and detection times.

NICER's XTI is an assembly of 56 X-ray concentrators (XRC) and detectors, of which 52 are functional on orbit. NICER's pointing system enables XTI to track and slew between targets over nearly 2π steradians. Each XRC collects photons over a large (~40 cm^2) effective geometric area from a ~30 arcmin^2 patch of sky, and focuses them onto small silicon drift detectors (SDDs). The SDDs detect individual X-ray photons, recording their energies and times of arrival to high precision. Together, this assemblage provides a photon counting capability with large effective area, high time resolution, moderate energy resolution, high throughput, and relatively low background. (Note that in preparations for Cycle 1, a bug in the HEASARC PIMMS tool's implementation of NICER's response produced erroneously high background estimates in some circumstances. The error has now been corrected.)

SDDs offer energy resolutions typical of silicon-based detectors, approaching the Fano limit. NICER's on-orbit performance is better than ~150 eV energy resolution at 6 keV and ~80 eV at 1 keV. The payload-level photon time-stamping uncertainty is less than 100 nsec RMS. NICER's event background is dominated below 2 keV by the diffuse cosmic X-ray background (0.3 cts/sec over the 30 arcmin^2 non-imaging field of view at high Galactic latitudes), and by unrejected particle background at higher energies (~0.1 cts/sec/keV across the NICER passband). Table 1 summarizes the most important NICER characteristics for proposal preparation.

Table 1: Key NICER Performance Parameters

Parameter	Value
Energy range	0.2–12 keV
Non-imaging angular resolution (FWHM)	6.2 arcmin
Energy resolution at 1 keV	~ 80 eV
Energy resolution at 6 keV	~ 150 eV
Sensitivity (0.5–10 keV) (10^4 s, 5σ)	1 x 10^{-13} erg cm^{-2} s^{-1}
Background (0.25–10 keV)	~ 1 counts s^{-1} (typical)
Temporal resolution	< 100 ns RMS
Target of opportunity response	Within 4 hours during regular business hours; otherwise, within 72 hours
Slew rate	1° s^{-1}
Minimum Sun angle	60º, for optimal XTI performance. Targets may be observed between 45º and 60º from the Sun, but with some degradation of spectral and timing performance.

Details of the NICER payload and instrument design can be found at the NICER documentation web page (https://heasarc.gsfc.nasa.gov/docs/nicer/nicer_docs.html) and the NICER mission paper (Gendreau, K.C., et al. 2016, Proc. SPIE 9905, download PDF file). Simulated NICER count rates and spectra can be derived using the WebPIMMS and WebSPEC tools.

Please note that investigations making use of the Station Explorer for X-ray Timing and Navigation Technology (SEXTANT) algorithm are not supported by this call.

1.3 Available GO Time and Visibility Constraints

The expected total amount of observing time available for the Cycle 2 NICER GO phase is 7 Ms. Proposed observations may span both Cycles 2 and 3 (March 1, 2020 – February 28, 2022), but requests for observations extending beyond the end of Cycle 2 must be scientifically justified. It is anticipated that approximately 50 GO observing programs will be selected for NICER Cycle 2, depending on the proposed exposure times. The remaining observing time will be used for legacy science, PI discretionary time, ToOs, unanticipated science not covered by the GO program, and calibration and background observations. A short-term schedule of planned NICER observations can be found at https://heasarc.gsfc.nasa.gov/docs/nicer/schedule/nicer_sts_current.html.

Accepted targets will be designated as Category A, B, or C. Assuming nominal operational efficiency, we anticipate that all Category A and B observations will be executed during Cycle 2. Category C observations will be completed on a best-effort basis.

Proposers should be aware that ISS structure, orbit inclination (51.6°) and altitude (approximately 250 miles), together with Sun/Moon/Earth avoidance criteria, impose significant target visibility constraints, allowing uninterrupted exposures of at most 2.4 ksec per 92-minute ISS orbit, but typically half that amount. Guest observers should request total exposure times necessary for the proposed science goals, excluding observational efficiency factors (e.g., Earth occultations and South Atlantic Anomaly passages) in their calculations, unless there is a specific reason why the elapsed time of an observation is important.

Proposals are subject to the following limitations:

- Proposals requesting time-constrained observations must be designated Category A in order to guarantee scheduling (see Section 1.3.1).
- Proposals requesting coordinated observations with other space- or ground-based facilities will be designated time-constrained and subject to the restrictions described in Section 1.3.1.

1.3.1 *Time-Constrained Observations*

Time-constrained observations are defined as observations that must be performed within a certain time window. This includes phase-constrained proposals and coordinated observing campaigns with ground-based or space-based facilities. Time-constrained observations are subject to the following limitations:

- Time-constrained targets must be designated as Category A to guarantee scheduling. Time-constrained observations in Categories B and C will be executed on a best-effort basis.
- NICER's flexibility affords a wide range of monitoring programs. Targets can be observed multiple times per day, week, month. etc. Proposed observing programs should use common sense in requesting closely-spaced observations.
- Proposers should take note of any constraints associated with monitoring programs that request NuSTAR observing time; specifically, the minimum 20ks exposure time requirement for each visit.

For coordinated and constrained observations, it is the proposer's responsibility to inform the NICER SMOC of the observing time windows at the earliest possible opportunity, but at minimum two weeks before observations start. Where observations involve coordination with other space-based observatories, the NICER SMOC will be responsible for communicating detailed schedule constraints with the relevant operations team.

1.3.2 *ToO Observations*

ToO proposals of both known and unknown targets (e.g., "the next black-hole transient") will be accepted through this solicitation for NICER Cycle 2. ToO requests will be considered by the NICER project through a submission process found at https://heasarc.gsfc.nasa.gov/docs/nicer/.

1.3.3 *Joint NuSTAR observations*

Combined NICER and NuSTAR observations are a powerful diagnostic of high-energy sources, in the total energy range 0.2–79 keV. The NuSTAR Project has made up to 400 ks available to NICER Cycle 2 proposers who want to take advantage of this opportunity. Proposals requesting NuSTAR coordinated observations must demonstrate the unique value of adding NuSTAR exposures for the proposed science and present a detailed feasibility case in support of this. Joint observations with NuSTAR must be designated as Category A or B to be approved for observations in Cycle 2.

The requested NuSTAR exposure time per observation (i.e., a single visit to a target) is constrained to a minimum of 20 ks and the time interval between successive visits must be $\geq$ 14 hours. Sources with fluxes $>10^{-11}$ ergs s^{-1} cm^{-2} within 5° of the target may cause increased nonuniform background gradients due to stray light. Users should check observations for potential stray light contributions using the tools available at http://nustar.caltech.edu/page/researchers. If a field is designated as heavily contaminated, proposers should submit a request for a feasibility analysis to nustar-help@srl.caltech.edu at least two business days prior to the proposal submission deadline.

NuSTAR observations of high count-rate targets (>50 cps/NuSTAR focal-plane module) require special planning and increased downlink capacity. High count-rate observations of duration >30 ks are difficult and can be accepted only if well motivated. High count-rate observations longer than 75 ks will be considered only if the total requested time is distributed in multiple observations, each with exposure time <75 ks and separated by more than 1 week.

Proposers should carefully review NuSTAR technical documentation available from the NuSTAR websites: http://nustar.caltech.edu and https://heasarc.gsfc.nasa.gov/docs/nustar/nustar_prop.html.

2. Programmatic Information

2.1 General Information

It is anticipated that limited funding will be available through this solicitation for the support of Guest Observations. Only proposals with Category A and B targets will be eligible for funding. Award funding will depend on the analysis complexity and total awarded observing time. NICER GO funding is open to all individuals who are identified as Principal Investigators and employed at U.S. institutions, including NICER science team members. Scientists participating in the NICER mission are eligible for support under this GO Program. Note that GO proposals that would support those who receive funding from the Project must clearly demonstrate that the proposed investigation is not redundant with their science team responsibilities. Budgets will be invited as Phase-2 proposals in response to selected Phase-1 Cycle 2 proposals. NASA does not anticipate awarding contracts in response to proposals submitted to this program element, because it would not be appropriate for the nature of the work solicited.

2.2 Proposal Submission and Evaluation

2.2.1 *Submission of Proposals to the NICER GO Program*

The NICER GO program uses a two-phase proposal process. A Phase-1 proposal shall comprise the science/technical justification. Only proposers whose Phase-1 proposals are accepted will be invited to submit budget proposals in Phase 2. The Phase-2 proposals must include a budget narrative describing, in sufficient detail, how the proposed funds will be used to achieve the goals outlined in the proposal. It is nominally expected that the PI of the Phase-1 proposal will serve as the Phase-2 proposal PI; however, for administrative purposes, an alternate individual from the Phase-1 PI's institution may serve as PI on the Phase-2 proposal. All proposal materials will be submitted electronically.

Proposers to the NICER GO Program must adhere to the following proposal submission procedures:

- All Proposers must submit their Phase-1 proposals electronically through the ARK/RPS website at http://heasarc.gsfc.nasa.gov/ark/rps/;
- Target forms for all observation proposals are to be submitted through ARK/RPS;
- Due to the nature of prospective investigations within the NICER GO program, the Scientific/Technical/Management section of proposals is limited to four pages, instead of the default 15 pages specified in the *NASA Guidebook for Proposers*. The requirement for a table of contents in the body of the proposal is waived. No supporting material (e.g., CV, pending/current support) is required or allowed;
- The Scientific/Technical/Management section must be uploaded to the ARK/RPS website as a single PDF file.

All proposal materials must be submitted electronically by 4:30 p.m. Eastern time on the due date for this program in order to be included in the proposal review for this cycle of the NICER GO program. Note that the 4:30 p.m. Eastern time deadline supersedes the default NSPIRES deadline.

LaTeX and MS Word templates are available for download at https://heasarc.gsfc.nasa.gov/docs/nicer/ to aid in the preparation of Phase-1 proposals. No supporting material (e.g., CV, pending/current support) will be considered for Phase 1. Page limits include figures and references. These instructions supersede any given in the ROSES NRA and/or the *NASA Guidebook for Proposers*.

Proposers who have approved multi-year programs will be requested to submit 1-year budget proposals in both Cycle 2 and Cycle 3.

2.2.2 *Evaluation of Proposals submitted to the NICER GO Program*

Phase-1 Proposals will be evaluated by a peer evaluation panel for Merit and Relevance (see Section VI(a) of the *ROSES Summary of Solicitation*), with the evaluation of merit including:

- The suitability of using the NICER observatory and data products for the proposed investigation;
- The degree to which the proposed observations place demands upon NICER mission resources; and
- The degree to which the proposed observation capitalizes on the unique capabilities of NICER.

2.2.3 *Additional Proposal Constraints and Requirements*

GO proposals for targets with existing or planned NICER observations must justify why additional data are warranted. Proposers are strongly encouraged to familiarize themselves with the content of the archive; the onus is on the proposer to demonstrate that their proposed project does not significantly duplicate the goals of past or current NICER science programs.

Proposers who wish to acquire coordinated NuSTAR exposures with their proposed NICER observations must demonstrate in the proposal the value of adding NuSTAR data, and present a detailed feasibility study of the combined observations. Proposers must check the appropriate box in the ARK/RPS submission form requesting coordinated NuSTAR time.

2.2.4 *Submission and Evaluation of Phase-2 Proposals*

Subject to the availability of funding, successful Phase-1 proposers will be contacted by the NICER Program Officer and invited to submit a cost proposal as their application for Phase 2. Upon notification of selection of a Phase-1 proposal, a proposer must respond as follows:

Follow the instructions for submitting a Phase-2 proposal given in the selection notification from the Phase-1 review. Phase-2 (cost) proposals must be submitted through the NSPIRES electronic proposal website by an Authorized Organizational Representative (AOR) of the proposing organization according to the instructions in the *Summary of Solicitation* of this NRA. The cost proposal will consist of a Budget

Details (maximum of two pages) section and a Narrative section (maximum of two pages) with a detailed justification of all proposed items for funding. Please also attach a copy of the original 4-pages technical proposal.

NASA personnel will evaluate the Phase-2 cost proposals against the third evaluation criterion, cost reasonableness.

2.3 Supplemental Information

Further details concerning NICER, the proposal submission requirements and process can be found at the NICER website (https://heasarc.gsfc.nasa.gov/docs/nicer/). NICER data are archived at the HEASARC (https://heasarc.gsfc.nasa.gov) in the standard (OGIP/HEASARC) high-energy FITS file formats. Supporting software, in the form of mission-specific FTOOLS (the NICERDAS package within HEASoft), is available through the HEASARC.

NuSTAR simulation tools and additional technical information may be found at https://heasarc.gsfc.nasa.gov/docs/nustar/nustar_prop.html.

3. Summary of Key Information

Expected total program budget for new awards.	The total program budget of $1.5M will allow the selection of ~30 proposals with average awards of ~$50k. Deviations from these targeted figures are possible.
Period of performance of the award	1 year
Due date for Notice of Intent to propose (NOI)	Option not available.
Due date for Phase-1 proposals	4:30 p.m. Eastern time November 13, 2019 via ARK/RPS, see Section 2.2.1.
Planning date for start of investigation	Six months after proposal submission.
Page limit for Phase-1 proposals	4 pages. See Section 2.2.1 for details.
Relevance	This program is relevant to the astrophysics questions and goals in the NASA Science Plan. Proposals that are relevant to this program are, by definition, relevant to NASA.
General information and overview of this solicitation	See the *ROSES Summary of Solicitation*.
Detailed instructions for the preparation and submission of proposals	See the *NASA Guidebook for Proposers* at http://www.hq.nasa.gov/office/procurement/nraguidebook and additional information in Section 2.2
Submission medium	Electronic proposal submission is required in PDF format; no hard copy is required or permitted.
Web site for submission of Notice of Intent to propose	Option not available.

Web site for submission of Phase-1 proposal and required forms	https://heasarc.gsfc.nasa.gov/ark/rps/ Phase-1 proposals may not be submitted via NSPIRES or grants.gov.
Programmatic information may be obtained from the NICER Program Officer	Rita Sambruna Astrophysics Division Science Mission Directorate NASA Headquarters Washington, DC 20546-0001 Telephone: (202) 358-2166 Email: Rita.M.Sambruna@nasa.gov
Technical questions concerning this program element may be directed to the NICER Guest Observer Program	Keith Gendreau, NICER PI Code 662 Goddard Space Flight Center National Aeronautics and Space Administration Greenbelt, MD 20771-0001 Telephone: (301) 286-6188 Email: Keith.C.Gendreau@nasa.gov

D.12 ASTROPHYSICS SCIENCE SMALLSAT STUDIES

NOTICE: Corrected October 1, 2019. Studies are twelve months in duration. Additional POCs have been added to Section 3.1. New text is in bold, and deleted text is struck-through.

NOTICE: Amended September 17, 2019. This amendment releases the final text for this program element. Notices of intent to propose are not requested. The due date for proposals is December 19, 2019. No data management plan will be collected for this program element.

1. Scope of Program

This program element solicits proposals for ~~six~~ **twelve**-month studies of spaceflight mission concepts that can be accomplished for low cost using small spacecraft in standard form factors, including CubeSats, CubeSat constellations, and secondary (RideShare) payloads launched as Expendable Launch Vehicle Secondary Payload Adapter (ESPA) and ESPA-grande-ring compatible spacecraft. All proposed investigations must be responsive to the science goals of the Astrophysics Division, as described in the 2014 NASA Science Mission Directorate Science Plan and the NASA 2018 Strategic Plan. All proposed investigations must be more capable than the suborbital-class CubeSat missions that are solicited within the Astrophysics Research and Analysis (APRA) program (D.3 of ROSES-2018).

The Astrophysics Science SmallSat Studies (AS^3) program is intended to capitalize on the creativity in the astrophysics science community to envision science enabled by smaller and significantly lower cost missions. NASA expects to make awards for mission concept studies that will span the breadth of possible science investigations enabled by CubeSat/SmallSat technologies and available secondary launch opportunities. Mission design assistance, if required, for these mission concepts will be offered by NASA during the ~~six~~ **twelve**-month studies (see Section 3.1). If such assistance is proposed, the proposal must include its cost within the submitted budget. NASA solicited missions of this class in the recent 2019 Astrophysics Explorers Missions of Opportunity solicitation and plans to do so at each future Astrophysics Explorers solicitation.

NASA recognizes and supports the benefits of having diverse and inclusive scientific, engineering, and technology communities and fully expects that such values will be reflected in the composition of all proposal teams as well as peer review panels (science, engineering, and technology), science definition teams, and mission and instrument teams.

2. Background

Small satellites have been suggested as a means to execute scientific missions at far lower cost and complexity than typical space science missions.[1,2] There are frequent

[1] http://sites.nationalacademies.org/SSB/CurrentProjects/SSB_160539
[2] http://kiss.caltech.edu/final_reports/SmallSat_final_report.pdf

launch opportunities for CubeSats as secondary payloads. CubeSats are small satellites that are built from a set of standardized subunits that each measure 10x10x10 cm and weigh 1.33 kg (designated '1U'). Common configurations include 1U, 2U, 3U, and 6U (2Ux3U) spacecraft. 12U and 27U configurations are also being developed, although they are not yet fully documented as standard formats. NASA has previously developed Astrophysics 6U CubeSat missions for low-Earth orbit operations (e.g., ASTERIA, HaloSat) as well as constellations of SmallSats (CYGNSS) for Earth observing. Another class of SmallSats for which frequent launch opportunities are available are Evolved Expendable Launch Vehicle Secondary Payload Adapter (ESPA) and ESPA-grande mounted satellites. Proposals to this program element may propose to use CubeSat form factors (from 1U to 27U) as well as ESPA or ESPA-grande mounted satellites. It is expected that spacecraft larger than 12U will be dispensed from an ESPA ring and that additional form factors for ESPA rings will be developed. Hosted payload concept studies are not solicited at this time.

Because of the availability of frequent launch opportunities, it is anticipated that the majority of the selections will be for investigations that would operate in low Earth orbit (LEO), geosynchronous orbit (GEO), or sun-synchronous orbit (SSO); other orbits are allowed provided the case is made that launch opportunities as a secondary payload could reasonably be expected. Concepts that launch to cis-lunar space as a secondary and use the NASA Gateway for a communication relay may also be proposed. More details on the NASA RideShare program can be found in the 2019 ESPA Rideshare Users Guide in the 2019 SMEX MO Program Library.

It is acceptable that some, but not all, proposed science investigations would, by necessity, push the current state-of-the-art for payload and spacecraft technologies, and involve innovative thinking, advanced engineering, and technology development for instruments, optical systems, and/or spacecraft systems.

Mission cost ranges (Phases A through F) to be explored are up to $35M and mass ranges from 1U (~1.3kg) to ESPA and ESPA-grande class over a variety of form factors. Given the lower cost point and possible use of new technologies, NASA would adopt a risk posture described as "streamlined Class D"[3] for these astrophysics SmallSat missions; see in particular the document “Guidance for… Space Flight Projects with Life-Cycle Cost Under $150M”. Because this program element solicits mission concepts that, if proposed to a future Astrophysics Explorer Mission of Opportunity AO, would likely be capped at $35M, this cost cap includes standard margins and reserves. This $35M should be in fixed FY19 dollars.

For information on NASA’s small satellite platform technologies, visit the NASA Small Satellite Technology Program website.

3. Requirements

Studies must be led by a designated Principal Investigator (PI) with a small science and engineering team. Student involvement is welcome. Mission design will be a critical part of these studies as teams make trades, explore feasibility, and refine the mission

[3] https://soma.larc.nasa.gov/standardao/ClassD.html

concept. Proposals should include team members to conduct mission design and/or a statement that arrangements have been made to partner with an appropriate NASA mission design team. Since some science teams may lack access to the necessary mission design capability, NASA field centers will provide study teams access to mission design assistance if needed. It is up to the proposing team to contact one of the field center contacts in Section 3.1 to determine the cost associated with the support required. The negotiated cost is to be included in the proposal as a separate line item. For evaluation purposes, the design assistance cost will be considered part of the entire cost of the study. If you are at a NASA center and using your local design center, this cost should be included along with other costs in the main part of your budget. If you are not, please include this cost in Section F ("Other Direct Costs") of the budget pages, line 8 or 9, labled with the name of the center facility, e.g., Ames Research Center - Mission Design Center". These funds will be sent directly to the center and proposers may not charge overhead on this portion of the award.

3.1 SmallSat/CubeSat Design Assistance Points of Contact **[POCs added 10/01/19]**

Ames Research Center - Mission Design Center
http://www.nasa.gov/centers/ames/engineering/divisions/missiondesign/
Ryan Vaughan, ryan.vaughan@nasa.gov, 650-604-3109.-

Goddard Space Flight Center's Wallops Flight Facility – Mission Planning Lab
https://sites.wff.nasa.gov/mpl/index.html
Benjamin Cervantes, benjamin.w.cervantes@nasa.gov, 757-824-1526.

Jet Propulsion Laboratory, Team Xc
http://jplfoundry.jpl.nasa.gov/
https://www.jpl.nasa.gov/cubesat/teamxc.php
Keith Grogan, keith.grogan@jpl.nasa.gov, 818-354-2617.

Johnson Space Center - Partnerships Office
http://www.nasa.gov/centers/johnson/partnerships/JSC-Partnership-Gateway/
Linda Ham, linda.j.ham@nasa.gov, 281-483-6881.

Marshall Space Flight Center - Advanced Concepts Office
https://www.nasa.gov/centers/marshall/capabilities/advanced_concepts.html
Joseph Casas, joseph.casas@nasa.gov, 256-961-3029.

Kennedy Space Center – University Partnerships and Small Sat Capabilities
https://kscpartnerships.ksc.nasa.gov
Jose Nunez, jose.l.nunez@nasa.gov, 321-867-5922

Langley's Engineering Design Studio
https://www.nasa.gov/centers/langley/news/researchernews/rn_IDC.html
David.G.Goggin@nasa.gov, 757-864-5705

Successful proposers will be required to produce a publicly releasable mission concept study summary and fact sheet and present a summary of their study at a special session of a domestic astrophysics science conference, to be arranged by NASA after awards have been made. Additionally, a full written report to NASA is required (see

Section 5.4).

Short proposals (up to 15 pages) are solicited that clearly summarize the mission concept, science target(s) and objectives, relevance to NASA Astrophysics Science objectives, and the nature of the science advancement expected from the mission. Proposals must include a baseline spacecraft design and architecture from which the study will begin, and a rationale for why the mission could be realizable for under $35M. Proposals must clearly describe the nature of work to be carried out during the proposed study, and should include a work plan for the study. As this solicitation is for mission concept studies and not for building missions, a work plan for construction of the concept mission is not expected.

This program element solicits only concept studies for astrophysics science SmallSat missions; it does not solicit technology development, flight instrumentation, or any hardware development. Proposals for mission concepts not appropriate for astrophysics science programs, and those not adhering to the guidelines in Section 4, will not be considered.

4. Mission Concept Parameters

Mission concepts that are proposed must adhere to the following parameters:

- The missions must carry out a NASA astrophysics science program.
- Mission concept architectures requiring multiple spacecraft are permitted.
- Mass/Volume of up to 27U CubeSat format, ESPA or ESPA-grande mounted secondary payload are allowed.
- Studies must determine if new dispenser/deployment designs will be required to accommodate the mission design.
- The mission concepts must target mission costs of up to $35M, excluding launch and integration into carrier (if required), but including normal margins and reserves.

NASA intends to award a range of studies across the spectrum of astrophysics science, mission mass, mission volume, and mission cost.

5. Programmatic Information

Answers to questions will be posted as an FAQ on the NSPIRES web page for this program element under "Other Documents".

5.1 Additional Proposal Guidelines

As well as following the guidelines in the *NASA Guidebook for Proposers*, proposers should be aware of the following additional guidelines when preparing their proposals:

- Proposal teams must be led by a PI and supported by a small science team. Since proposal teams have the option of being partnered with NASA mission designers, proposal teams are encouraged, but not required, to have members with engineering or mission design expertise.
- Proposals must include a description of how and to what extent the mission concept study work done by this proposal will advance our current state of knowledge.

- Mission concept studies must be completed within one year of award.
- NASA expects to fund a number of studies at a level of $100,000 to $150,000 per study that span the range of CubeSat/SmallSat science, capability, and mission cost.
- Proposals must strictly conform to the formatting rules in Section IV(b)ii of the *ROSES Summary of Solicitation*. Proposals that violate the rules may be rejected without review.
- Proposers must allocate sufficient travel funds to be able to present their concept study results at a special session of a domestic Astrophysics Science meeting, to be arranged by NASA after awards have been made.

5.2 Evaluation Criteria

The three basic evaluation criteria for this program are listed in the *ROSES Summary of Solicitation* Section VI (a) and Appendix D of the *NASA Guidebook for Proposers*. These criteria are intrinsic merit, relevance, and cost realism/reasonableness of the proposed study. Clarifications specific to this program element are listed below.

For this program, the evaluation of merit specifically includes:

- Impact and importance of the science advancement expected from the mission and
- Realism and feasibility of the proposed study plan.

For this program, the evaluation of cost specifically includes:

- Likelihood that the concept being studied will be achievable at up to the $35M funding guideline.

For this program, relevance will be evaluated according to:

- Relevance of the proposed mission concept's science investigation to NASA astrophysics objectives as demonstrated by linkages between the mission concept objectives and the 2014 NASA Science Mission Directorate Science Plan.

5.3 Compliance Requirements

Proposals must be submitted by an institution hosting a scientist serving as the Principal Investigator (PI) for the study. Proposals must contain all elements described in Table 1 "Checklist for ROSES-2019 Proposals" of the ROSES-19 Summary of Solicitation and the Guidebook for Proposers. The Scientific/Technical/Management section of the proposals is limited to 15 pages. This section must discuss/include the following elements:

- High-level summary of mission concept study (maximum one page).
- Science objectives for the concept mission, science target(s), and rationale for the mission concept study (maximum two pages; it is recommended that the objectives take at most a full page).
- Aspects of the mission concept that will be evaluated during the study, with emphasis on the flowdown from the science objectives to the science requirements to the technical requirements.
- It is anticipated that some concepts may use technologies with Technical Readiness Levels (TRLs) lower than that typically associated with Explorer concepts; if so, the

current and projected TRL and rationale for use must be adequately addressed.

5.4 Final Report

It is expected that mission design work during the study will lead to changes in the original mission concept described in the proposal. Selected studies must provide a final report to NASA describing the final mission concept and the rationale for changes from the original proposed mission concept, including the technological challenges and gaps identified. Reports marked as "Proprietary" will be treated as such. This report is due ~~six~~ **twelve** months after the start date of the award and must, as a minimum, contain the following elements:

- Science objectives,
- Science requirements, traceable to the science objectives, and the proposed instrument complement with supporting rationale,
- Core science team expertise and traceability to science objectives,
- Mission design/architecture (orbit LEO/GEO/SSO, multiple spacecraft, etc.),
- Spacecraft concept (CubeSat form factor, ESPA or ESPA-grande class), mass budget, power budget, telemetry rates,
- Technology needs, quantified gaps, and development required,
- Concept of Operations,
- Launch vehicle interface and deployment method,
- Estimated Mission Costs and explanation of the cost estimation method, and
- Top mission risks and key mission trades to be studied in the future.

A two-page publicly-releasable mission fact sheet must be provided with the final report.

6. Summary of Key Information

Expected annual program budget for new awards	$1.0 M
Number of new awards pending adequate proposals of merit	~6 to 10
Maximum duration of awards	12 months
Due date for proposals	See Tables 2 and 3 of this ROSES NRA.
Planning date for start of investigation	June 2020
Page limit for the central Science-Technical-Management section of proposal	15 pp; see also Table 1 of ROSES and the *NASA Guidebook for Proposers*
Relevance	This program is relevant to the Astrophysics questions and goals in the NASA Science Plan. Proposals that are relevant to this program are, by definition, relevant to NASA.

General information and overview of this solicitation	See the *ROSES Summary of Solicitation*.
Detailed instructions for the preparation and submission of proposals	Please see *Section I(g)* Order of Precedence and Table 1 of the ROSES *Summary of Solicitation* and the *NASA Guidebook for Proposers*.
General requirements for content of proposals	See Section 3 of the *NASA Guidebook for Proposers* and Section IV and Table 1 of *the ROSES Summary of Solicitation*.
Detailed instructions for the submission of proposals	See https://nspires.nasaprs.com/tutorials/ Sections 3.22-4.4 of the *NASA Guidebook for Proposers* and Section IV(b) of *the ROSES Summary of Solicitation*.
Web site for submission of proposal via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Web site for submission of proposal via Grants.gov	http://grants.gov (help desk available at support@grants.gov or (800) 518-4726)
Funding opportunity number for downloading an application package from Grants.gov	NNH19ZDA001N-AS3
Point of contact concerning this program	Michael Garcia Astrophysics Division Science Mission Directorate National Aeronautics and Space Administration Washington, DC 20546 Telephone: (202) 358-1053 Email: michael.r.garcia@nasa.gov

D.13 System-Level Segmented Telescope Design – Technology Maturation

NOTICE: Amended April 4, 2019. This amendment presents a new program element in ROSES-2019. Only for-profit U.S. industrial organizations are eligible to submit proposals to this program element. There are no restrictions on the types of organizations that participate as subawardees. Proposals are due June 13, 2019. No NOIs or Step-1 Proposals are requested.

1. Introduction

NASA is soliciting industry proposals to carry out a two-year technology maturation development effort and associated testbed demonstrations to advance technologies that enable large segmented-aperture (10-meter-class or larger) or large monolithic (4-m or larger) telescopes. These architectures will include integrated coronagraphs that advance the design maturity (e.g., Technology Readiness Level, TRL, of components and system), and identify future technology investments. These advancements will enable implementation of the next generation of large space telescopes.

2. Scope of Program

On December 1, 2017, NASA issued a the predecessor program element "System-Level Segmented Telescope Design" (ROSES-2017 D.15) specifically designed to mature integrated system architectures that will enable the next generation of large space telescopes. NASA solicited industry proposals to carry out one-year end-to-end system-level engineering design and modeling studies. The technologies under consideration enable large segmented-aperture or large monolithic telescopes, including integrated coronagraphs that led to the identification of priority technology investments and subsequent support for maturation of these technologies.

In preparation for the 2020 Astronomy and Astrophysics Decadal Survey, NASA identified four large mission concepts in early 2016 and chartered study teams to develop compelling science cases and associated mission architectures for consideration and prioritization as large missions by the 2020 Decadal Survey. These concepts are likely candidates for development to follow the James Webb Space Telescope (JWST) and Wide-Field Infrared Survey Telescope (WFIRST). Three of the four concepts may require precise, stable, segmented opto-mechanical systems to achieve the large apertures required for their scientific priorities: the Origins Space Telescope (OST), the Habitable Exoplanet (HabEx) Observatory, and the Large Ultraviolet/Optical/InfraRed (LUVOIR) Surveyor. More information about these studies can be found at:

- OST: https://asd.gsfc.nasa.gov/firs/
- HabEx: https://www.jpl.nasa.gov/habex/
- LUVOIR: https://asd.gsfc.nasa.gov/luvoir/

NASA is interested in developing end-to-end integrated telescope/coronagraph systems-level engineering designs, conducting modeling studies, implementing testbed demonstrations and advancing the technology maturation of critical components. These studies and demonstrations would identify and substantiate error budgets leading to a specific hardware technology development roadmap intended to be funded in subsequent years.

Should NASA choose to develop a mission flowing from any selected study, responsibility for development of that mission will be assigned by NASA. There is no expectation that the mission concept study teams, participating organizations, or groups responding to this program element will necessarily participate in the eventual mission development.

3. Solicited Technical Scope

This call solicits proposals to advance the TRL of technologies required to close key and crucial technology gaps identified in Section 3.2. By maturing relevant technologies to higher TRLs, it is expected that funded projects will retire or mitigate project risk and/or decrease fabrication lead times and overall cost in implementing any one of the three normal-incidence mission concepts: LUVOIR, HabEx, or OST. In this program element, subscale technology advancements via component and/or system demonstrations are emphasized.

The scope of this program element is to advance technology based on the current best understanding of the subject matter by offerors or from public state-of-the-art information sources. This knowledge could include recent innovations, advancements and studies that could increase technical performance and/or reduce risk or fabrication cost. These innovations are certainly highly desirable and should be included in the proposed development efforts.

Offerors should justify their proposed technology development based upon either information provided by Science and Technology Definition Teams (STDTs) development roadmaps for the three mission concepts listed above, or from the predecessor awards' reports or from the offeror's own internal systems engineering studies.

3.1 Recommended Best Practices for Proposal Content and Proposed Activities

- The objective of this program element is to increase technology maturation that promises the greatest reduction of risk and/or cost for producing telescope element systems for future large space telescopes.
- Technology gaps that are cross-cutting, scalable, or applicable to any of the three large mission concepts are preferred since any of these missions could be recommended for implementation. Advancements resulting in technologies that are mature enough to require no further significant adjustments or changes are considered ideal.
- Propose technologies, components, and/or subsystems that are amenable to demonstration via scalable fabrication and/or verification via relevant environment testing.
- Use of high-fidelity modelling and sophisticated analytical techniques are desirable to connect relevant environment testing and subscale fabrication to flight-scale predictions, which could be accomplished using system simulators.
- Include technologies to sense and control segment-to-segment alignment and stability to levels indicated by end-to-end error budget analysis (obtained in Phase 1 or from STDT mission concept analysis), needed to enable coronagraphy.
- Consider manufacturing readiness level (MRL) in addition to TRL associated with the component, subsystems, and full system.
- The proposed work should consider activities beyond the state-of-the-art, including current and recent funded work for development of strategic technologies by the

Astrophysics Division, either via the Strategic Astrophysics Technology (SAT) program or other programs and solicitations. Such information is available in a searchable database available at http://www.astrostrategictech.us/.

- Proposing teams should avoid duplicating test facilities available at NASA Centers, including but not limited to, the ultra-stable test facility at GSFC, the X-ray and Cryogenic Facility (XRCF)/Stray-Light test facility at MSFC, and the Coronagraph test facility at JPL. If the proposing team plans to use these facilities and/or government support teams, that cost must be properly included in the proposal.

3.2 Projected Scope

Based on the current state-of-the-art of the relevant technologies, information provided by the STDTs technology roadmaps, and on accomplishments and maturity achieved by the end-to-end system-level engineering studies conducted by the prior awardees, the recommended areas of future focus are elements to be selected from Sections 3.2.1 or 3.2.2. below. These technology advancements should include component and/or subsystem demonstrations or testbeds, and when appropriate, measurements and control mechanisms.

3.2.1 *Prioritized Technology Gaps*

Select a suitable number of technology gaps to close or to retire from the prioritized lists issued by the relevant mission concept STDTs or from the information included in the reports from the predecessor awards (see Section 4, on how to access these reports via NSPIRES). Consider the following elements in this development process:

a. Demonstrate that these advancements close identified technology gaps.
b. Show how these advancements could enable the mission, mitigate risk, and/or provide cost reductions.
c. Document the entrance and final TRLs of critical technologies.
d. Describe the assumptions, modeling, and implementation of testing an integrated coronagraph with the segmented mirror architectures.
e. In the case of segmented architectures, include active phasing control such as: edge-sensing geometry and/or edge-sensor resolution; impact of controllability, observability, uncertainty; achievable phasing bandwidth vs. control system stability margin.
f. The choice of the telescope system for either a segmented or a monolithic should enable the use of a coronagraph with the ability to observe realistic scenarios across multiple pointing positions and target diversity.

3.2.2 *Mature Key Technologies*

Develop and mature (e.g., design, fabricate to scale, test, integrate, etc.) the following possible relevant and key technologies:

a. Vibration isolation, microthrusters, and/or precision pointing.
b. Passive isolation and disturbance damping.
c. Mirror materials.
d. Structure materials, bonds, latches, deployment mechanisms, etc.
e. Picometer-level metrology.
f. Picometer-level actuators.

g. Mirror figure and alignment sensing and active/passive control.
h. Low-disturbance mechanisms.
i. Adaptive optics.
j. Coronagraph and related technologies (e.g., deformable mirrors and out-of-band sensing).
k. Data/command/power transmission minimizing thermal and mechanical disturbances.
l. Thermal sensing and control (local and system-wide).
m. Technology to characterize, off-load and/or compensate for primary-mirror gravity sag to achieve a total on-orbit surface figure defined by the error budget to achieve a 400-nm diffraction-limited-performance telescope.
n. Technology (passive or active) to produce a primary mirror assembly that achieves the on-orbit thermal wavefront stability defined by the error budget to perform coronagraphy.

3.3 Deliverables

Based on the selected prioritized technology gaps and/or key technologies by the proposing teams, include the following deliverables, as applicable:

- Provide end-to-end final error budgets and their derivation methodologies.
- Verify that matured component and/or subsystem performance meets requirements defined by end-to-end error budgets through the following by providing:
  - Analytical models that advance the understanding, dependency, sensitivity, and dynamics of the components involved.
  - List of effects that risk the system's ability to meet all requirements, along with analyses and/or technology development efforts that mitigate or eliminate those risks.
  - A risk list and mitigation plans for the technology being developed within the Performance Work Statement (PWS).
  - Technology demonstrations based on simulations, subscale testbed components, fabrication of key components, and/or small-sat technology demonstrators.
- Perform operation modes of plausible observing scenarios.
- Create a credible integration, verification, and validation plan.
- Provide a realistic schedule and budget for technology development and for flight-system development, integration, and verification.
- Present a credible maturation plan of all subsystems to TRL 5 within 2 to 3 years of the conclusion of this award, and of the overall system to TRL 4 within the same time frame.
- Provide justification that matured technologies close identified technology gaps (traceable to error budget) via model or test.
- Supply a list of deliverables for the PWS and delivery dates.

3.4 Intellectual Property Resulting from Awards

Data Rights: The objective of a contract awarded under this program element is to provide recipients with the incentive to develop commercial applications of technologies developed through this contract. Therefore, offerors shall submit a list containing any and all data rights exemptions other than "unlimited rights" for this acquisition. If a list is not provided, the offeror is in agreement that the Government will have unlimited rights to any technical data created under this contract. Normally, the Government has unlimited rights to technical data created under a NASA agreement. However, recipients may protect qualifying limited rights data and restricted computer software by withholding the data from the Government and instead delivering form, fit, and function data. Delivery or third-party licensing of proprietary software or data developed solely at private expense will not normally be required except as specifically negotiated in a particular agreement to satisfy NASA's minimum needs.

4. Programmatic Information

Proposals in response to this program element are limited to for-profit U.S. industrial organizations of any size, although partnership with and/or subcontracts to other types of organizations is permitted. As described below, coordination with NASA-funded mission concept studies of future major astronomy missions is expected. Industry teams that did not participate in the studies that resulted from the predecessor awards may propose to this program element. However, all proposers must include, in their work plan, analysis and justification commensurate with the level of development achieved at the conclusion of the prior award. This could be achieved by demonstrating advances at the end-to-end system-level engineering design and modeling studies of potential architectures leading to a choice of relevant and key technology gaps to focus on if selected.

Please note that the final reports issued by the industry teams that received awards from the predecessor call will become available starting April 29, 2019, on the NSPIRES page of this program element under "Other Documents".

4.1 Eligibility of Applicants

Proposals received after the deadline will not be considered for award, regardless of technical difficulties associated with submission. In addition, proposals shall include a complete "Proposal Adequacy Checklist" (outside of the 30-page Technical and Management section) in accordance with NASA FAR Supplement 1852.215-85. Proposals that do not include an adequacy checklist will not be considered for award.

4.2 Proposal Evaluation Factors

The evaluation criteria considered in evaluating a proposal are its relevance to NASA's objectives, intrinsic merit, and cost. The failure of a proposal to be rated highly in any one of these elements is sufficient cause for the proposal to not be selected.

The evaluation of intrinsic merit includes consideration of the following factors, as applicable to the proposal:

- Overall technical quality of the proposed work, including, but not limited to, the quality of the management plan, the breadth and project timeline for carrying out the work and the effectiveness and resilience of the proposed experimental designs, methods, techniques, and approaches for achieving the proposed technology maturation and testbed demonstrations.
- The qualifications, capabilities, past performance, and related experience of personnel demonstrated by the proposal (e.g., publications, delivered products, and

other measures of productivity and/or expertise) that would affect the likelihood of achieving the objectives.

- Facilities, instruments, equipment, and other resources or support systems presented in the proposal that would be contributed to the study and would affect the likelihood of achieving the proposed objectives, including prior or current successful technology development programs.

During evaluation proposals are compared to the state-of-the-art engineering designs of comparable concepts (e.g., public presentations of the designs for one of the three STDTs above). Review panels will not compare proposals to each other.

Evaluation of the cost of a proposed effort may include the reasonableness of the number of technology gaps selected and their proposed cost, as well as whether costs are allowable and allocable to the project. Cost-sharing, though highly encouraged, is not an evaluation factor.

4.3 Award Type and Budget

The total budget available for awards resulting from this program element is approximately $8.4M for two years, which we estimate may support up to three successful proposals. The government reserves the right to not select any responses to this program element.

Successful responses to this program element are likely to result in Firm-Fixed-Price contract awards, which will be made according to the NASA FAR. These contracts shall be incrementally funded through milestone payments.

4.4 Proposal Format

Table 1 in the ROSES-2019 *Summary of Solicitation* provides a checklist of required information to be included in proposals. Except as noted in this program element, proposals submitted to ROSES must strictly conform to the formatting rules outlined in Section IV(b)ii of the ROSES-2019 *Summary of Solicitation*. Proposals that violate the rules may be rejected without review or declined following review if violations are detected during the evaluation process.

4.5 Reporting Requirements

Semi-annual technical progress reports will be required. A final report, due at the expiration of this award, will be submitted to the NASA point of contact for this solicitation. The proposers should assume that the product of their work will be treated as both competition sensitive and restricted following the requirements of the International Trade in Arms Regulations (ITAR), unless the proposers request otherwise. Successful teams are encouraged to make presentations of unrestricted material derived from this activity at suitable public conferences or workshops that could be coordinated with the NASA point of contact.

In coordination with the NASA point of contact, a more sensitive and restrictive presentation or report of the results of the study may be requested.

4.6 Planned Follow-on Activities

For planning purposes, NASA intends to build upon these technologies beyond this solicitation. Following review of the results of this phase, and pending the recommendations of the 2020 Astronomy and Astrophysics Decadal Survey, NASA plans a subsequent NRA to be issued soliciting three-year efforts at a level of $5M per year that build upon the results of the advancements of this solicitation and are responsive to NASA's programmatic priorities.

4.7 Solicitation Schedule

NASA will allow 70 days for submission of proposals in response to this program element, with a deadline for proposals given in Tables 2 and 3 of ROSES-2019. Successful proposals are expected to be announced on or about August, 2019.

4.8 Model Contract

Potential proposers should review the model contract including a Data Procurement Document with a list of data requirements descriptions (DRDs), posted under "other documents", on the NSPIRES page for this program element. This document contains an overview of expected contract clauses to be implemented upon award. Note that these are subject to change based on the content of the selected proposals. Some possible Data Requirements Deliverables (DRDs) are below. The contractor shall include associated costs to comply with anticipated/applicable DRDs and clauses in the model contract.

4.8.1 *Contract Data Requirements Deliverables*

The Contractor shall report and document the performance of this work in the Performance Work Statement (PWS)/Statement of Work (SOW) and fulfill the requirements of associated DRDs as outlined in Data Procurement Document (DPD) 1648 (Attachment J-2). The contractor shall determine the data restriction that applies to each data deliverable and mark or transmit the data restriction in accordance with section 2.3.3 of the DPD.

The contractor shall provide technical information concerning any invention, discovery, improvement, or innovation made by the contractor in the performance of work under this contract. Technology Reports shall be prepared in accordance with DRD 1648CD-001.

The contractor shall prepare and submit System Error Budget in accordance with DRD 1648EE-001.

The contractor shall prepare and submit an Environmental Compliance Report that complies with Executive Order 13834 in accordance with DRD 1648EE-001.

The contractor shall prepare and maintain a report identifying and listing all equipment, tools, etc., provided by the Government for use by the contractor in the performance of contracted effort, and for which the contractor has been given physical custody. The contractor shall provide a property plan which describes the contractor's methods and processes for the identification, control, maintenance, and safeguard of government property. This government property management plan shall be prepared and maintained in accordance with DRD 1648LS-001.

The contractor shall prepare and submit a Final Scientific and Technical Report that complies with the requirements of NFS 1852.235-73 in accordance with DRD 1648MA-001.

The contractor shall prepare and submit a monthly financial reports (in addition, to the technical semi-annual progress report described in Section 4.5) in accordance with DRD 1648MA-002.

The contractor shall report mishaps and safety statistics to the MSFC Industrial Safety Branch in accordance with DRD 1648SA-001. The contractor shall submit directly into the NASA Mishap Information System (NMIS) or shall use the forms listed in section 15.4 of DRD 1648SA-001 or electronic equivalent to report mishaps and related information required to produce the safety metrics.

5. Summary of Key Information

Expected program budget for awards	Approximately $8.4M total; $4.2M per year
Expected number of new awards pending adequate proposals of merit	Up to 3, but no fewer than 2
Maximum duration of awards	Up to 24 months
Due date for electronic submission of proposal	See Tables 2 and 3 of ROSES-2019
Anticipated selection date	August, 2019
Anticipated award date	September, 2019
Anticipated award end date	September, 2021
Anticipated study report due to NASA	September, 2021
Page limit for the central Technical and Management sections	30 pp; see also Table 1 of the ROSES-2019 *Summary of Solicitation* and the *NASA Guidebook for Proposers.*
Relevance	This program is relevant to the mission concept studies in anticipation of the 2020 Decadal Survey. Proposals that are relevant to this activity are, by definition, relevant to NASA.
General information and overview of this solicitation	See the *ROSES Summary of Solicitation*
Detailed instructions for the preparation and submission of proposals	Please see *ROSES Summary of Solicitation Section 1(g)* Order of Precedence and the *NASA Guidebook for Proposers.*
Submission medium	Electronic proposal submission is required in PDF format; no hard copy is permitted.
Website for submission of proposals via NSPIRES	http://nspires.nasaprs.com (help desk available at nspires-help@nasaprs.com or 202-479-9376)

Point of contact concerning this program	Mario R. Perez Astrophysics Division Science Mission Directorate NASA Headquarters Washington, DC 20546-0001 Telephone: (202) 358-1535 Email: mario.perez@nasa.gov

APPENDIX E: CROSS-DIVISION RESEARCH

E.1 CROSS-DIVISION RESEARCH OVERVIEW

1. Introduction

The Science Mission Directorate (SMD) sponsors program elements that apply across more than one of its four science research areas as defined in Section I of the *ROSES Summary of Solicitation*. Such cross-division program elements are listed here in Appendix E of the ROSES NASA Research Announcement (NRA). At the time of the initial release of this NRA, there are three such programs, see below. Unless otherwise noted in the individual program elements, no contracts will be issued in response to proposals submitted to program elements in Appendix E, as it does not seem appropriate for the nature of the work currently solicited.

2. Data Management Plans

Most proposals to ROSES require a data management plan (DMP) or an explanation of why one is not necessary given the nature of the work proposed. The three program elements in Appendix E handle this quite differently. The kinds of proposals that require a data management plan are described in the NASA Plan for increasing access to results of Federally funded research and in the SARA Frequently Asked Questions (FAQs) for ROSES. Proposers to E.2 Topical Workshops, Symposia, and Conferences (TWSC) will not be asked for a data management plan, because those are not research proposals. However, any peer reviewed publications that come out of awards from E.2 (such as conference proceedings) must still meet the requirement that the data behind figures and tables be available electronically at the time of publication, ideally in supplementary material with the article. Proposers to E.3 The Exoplanets Research Program, must satisfy the DMP requirement by responding to the compulsory NSPIRES cover page question about the DMP. Proposers to E.4 The Habitable Worlds Program, must meet the more involved requirements described in Appendix C.1.

3. Program Elements

The Topical Workshops, Symposia, and Conferences (TWSC) program element (E.2) solicits proposals for topical workshops, symposia, conferences, and other scientific/technical meetings that advance the goals and objectives of the Earth Science, Heliophysics, and Planetary Science Divisions. This program has no fixed due date or budget; proposals may be submitted at any time, but are dependent on the availability of funds in the specific program or focus area. Thus, before submitting potential proposers to TWSC are strongly urged to contact an appropriate SMD Program Officer(s) (at http://science.nasa.gov/researchers/sara/program-officers-list/) to investigate the availability of funds.

The Exoplanets Research Program (E.3) solicits basic research proposals to advance our knowledge and understanding of exoplanetary systems. Its objectives are the detection and characterization of planets and planetary systems outside of our Solar System, including the determination of their compositions, dynamics, energetics, and chemical behaviors. Research supported by this call may include observations, theoretical studies, and modeling. Since XRP was solicited a second time late in

ROSES-2018 as E.5 to maintain its schedule (Step-2 proposals due 5/29/18) it is not solicited in ROSES-2019. Interested proposers should see the second solicitation of Exoplanets Research as program element E.5 of ROSES-18. The text has been revised to explicitly allow observational proposals searching for biosignatures on exoplanets, notes that selected PIs are eligible for participation in the "NfoLD Research Network", and includes points of contact for all four SMD Divisions.

The Habitable Worlds Program (E.4) solicits basic research proposals about processes and conditions that create and maintain potentially habitable environments. This Program includes aspects of research relevant to the Astrophysics, Heliophysics and Planetary Science Divisions. A common goal of these programs is to identify the characteristics and the distribution of potentially habitable environments in the Solar System and beyond.

Any other cross-division programs that are defined during the calendar year will be issued as amendments to ROSES, typically 90 days in advance of their established Proposal Due Dates.

E.2 TOPICAL WORKSHOPS, SYMPOSIA, AND CONFERENCES

NOTICE: Amended July 11, 2019. The text has been clarified in a number of ways: Section 4.2.1 Limitations on Participants has a small change moving one sentence and a significant clarification based on 2 CFR 200.463 regarding the requesting and justifying costs for non-U.S. persons. Under Section 4.3 Availability of Funding, three new subsections have been added: 4.3.1 Non-U.S. and U.S. Sources, 4.3.2 Pass-Through Awards and Connections with Professional Networks or Societies and Research Platforms, and 4.3.3 Technology and Data. New text is in bold and deleted text is struck through.

Not all SMD programs regularly participate in this program element. Until at least one SMD Program Officer confirms relevancy and/or availability of funds, please do not prepare or submit a proposal. Contact information for SMD's Program Officers can be found at: http://science.nasa.gov/researchers/sara/program-officers-list/

1. Introduction

In order to address its strategic goals and objectives (see Section I of the *ROSES Summary of Solicitation*), the Science Mission Directorate (SMD) acknowledges the need to bring together members of scientific communities relevant to NASA in order to:

- encourage and facilitate the use of mission data,
- increase the efficiency of investigators through advanced scientific/technical training,
- increase the efficiency of investigators through the open exchange of ideas, and
- expose investigators to new subject areas.

The scope of this program element across SMD is described in Section 2. Section 3 describes how proposals submitted in response to this program element must convincingly connect the proposed content of the event to specific goals, e.g., in SMD program elements or the *NASA Science Plan*. Section 4 describes principles and constraints that constrain proposals in response to this program element; in particular, the proposed participants, logistics, and level of NASA support must be, and appear to be, appropriate given NASA's science goals and objectives.

2. Scope of Program

This program element solicits proposals for topical workshops, symposia, conferences, and other scientific/technical meetings (herein referred to as "events") that advance the goals and objectives of the following SMD Divisions: Earth Science, Heliophysics, and Planetary Science.

Until this program element is amended to specify Astrophysics criteria, priorities, etc., the Astrophysics Division will not accept TWSC proposals.

As long as there is an interested SMD program/funder, proposals that contribute to SMD's cross-divisional science, technology and exploration goals also are solicited.

Proposals are not limited to traditional in-person meetings of scientists, but may also include requests for support of other methods of bringing together members of the scientific communities relevant to NASA, such as online discussion forums and web-based collaboration portals, especially in support of a traditional event. Proposals for multiple related events should be well justified.

This program element is directed at and strictly limited to scientific and technical events of interest to SMD, and not education or public outreach conferences. Moreover, this program element does not support any type of research projects; course development; and/or scholarships or fellowships. Please note that travel or logistical support for students to participate in the proposed event is not a scholarship or fellowship.

Where other ROSES program elements specifically solicit for events, proposals must be submitted in response to those program elements instead of this one.

If an event-related proposal is not eligible for TWSC, other ROSES elements, or for SMD's other broad agency announcements, then have the interested NASA funding program point of contact consult with TWSC's overall POC listed in Section 6 regarding potential alternatives.

3. Relevance to SMD's Goals and Objectives

Proposals submitted in response to this program element must demonstrate the relevance of the event to SMD by showing how the scientific/technical area(s) to be covered will advance not only high-level SMD goals and objectives, but also specific (existing or anticipated) outcomes identified in ROSES program elements, SMD roadmaps, other SMD program documents, such as the *NASA Science Plan*, findings in decadal surveys, or the reports of NASA advisory bodies or groups relevant to NASA. The *NASA Science Plan*, *NASA 2018 Strategic Plan*, and other documents, may be found at https://science.nasa.gov/about-us/science-strategy/.

Proposers that choose to demonstrate relevance by reference to ROSES elements are not limited to those solicited in the current ROSES. While some program element calls do not appear every year, research in that area continues and proposals would still be considered relevant. The subjects of the proposed events are not limited to the targeted science itself (or data analysis that leads to science), but also include technologies, methods, and capabilities that enable the attainment of relevant goals, such as (but not limited to) code development, data compression algorithms, higher order data products, model intercomparisons, the enhancement and/or application of new equipment to make pertinent measurements, etc. Proposers must explicitly state from what source (e.g., ROSES program element, roadmap, or decadal survey) the claim of relevance derives.

3.1 Additional Information on Earth Science Relevance

Proposals for workshops, symposia, conferences, or scientific/technical meetings in Earth Science should be carried out in support of NASA Science Questions and Goals from the *2014 SMD Science Plan* for NASA's Science Mission Directorate.

NASA's Earth science research is conducted in four major areas: research and analysis, satellite missions, applied sciences, and enabling capabilities (e.g., data and information systems, high-end computing, airborne science, and technology development). Proposals for events under any of these four Earth science areas will be considered under this program element. NASA Earth Science's research and analysis programs emphasize interdisciplinary topics and interagency collaboration and coordination through the U.S. Global Change Research Program (http://www.globalchange.gov/). NASA's applied sciences area supports efforts to discover and demonstrate innovative and practical uses of NASA Earth science observations and research through applications projects carried out in partnership with end user organizations (http://AppliedSciences.nasa.gov/). NASA's enabling capabilities area supports efforts that engage the broader Earth science community to encourage partnerships and collaborations among data providers, users, and information technology experts to improve data and data system interoperability (https://earthdata.nasa.gov/earth-science-data-systems-program/policies). Thus, events proposed to address the goals of NASA Earth Science research must, in many cases, involve substantial participation by interagency partners and/or end user organizations, and such participation will be considered as a positive factor in establishing relevance to NASA.

4. Program Principles and Proposal Constraints

4.1 Allowable Focus of Proposals

The goal of any proposed activity must be to enable science and the support to pay for person time and/or logistics, which may be funded as a result of the proposed activity, are merely an incidental means to achieve that goal. Proposals to this program should be written so that the objective of the proposed activity is clearly focused on the desired effect that is to be achieved (e.g., science), rather than the means to that end (e.g., logistics). It is acceptable to have a goal of developing an output that is a prerequisite to achieving a target laid out in a ROSES program element, roadmap, decadal survey, etc., and to pay for the support for person time and/or logistics as an expense on the way to accomplishing that goal. However, a proposal with a stated goal of simply paying for logistics in support of an event would not be considered responsive to this program element.

4.2 Competition and Criteria for Selecting Event Participants

SMD principles include the use of competition to increase the effectiveness of awarded funds. Although SMD may provide only a fraction of the total funds required for an event, SMD expects the participants to be identified through competition; exceptions require adequate justification. If funds are requested for the costs of participants to attend an event, then an open call for abstracts is expected where their evaluation would play a role in selecting participants.

The scientific or technical merit of the abstract need not be the only factor in the review of abstracts. SMD acknowledges the need to consider other factors, such as but not limited to, geographic, institutional and/or career-stage types of diversity. As stated in Section III(a) of the *ROSES Summary of Solicitation*, NASA recognizes and supports the benefits of having diverse and inclusive scientific, engineering, and technology communities and fully expects that such values will be reflected in the composition of all proposal teams as well as peer review panels (science, engineering, and technology), science definition teams, and mission and instrument teams. This also applies to, for example, speakers at a NASA-funded event.

SMD reminds organizers of meetings of other responsibilities in addition to considering the scientific or technical merit of the abstract. As a condition of receipt of NASA funding, the institution acknowledges and agrees that it must comply (and require any subgrantees, contractors, successors, transferees, and assignees to comply) with applicable provisions of national laws and policies prohibiting discrimination. TWSC organizers share these Federal civil rights obligations. For more information visit: https://missionstem.nasa.gov/compliance-requirements-nasa-grantees.html.

There may be reasons to select some or all participants without competition in order to attain the stated scientific or technical or other aim of the event. In such cases provide in the proposal a thorough justification for invitational versus competitive participant selection.

4.2.1 *Limitations on Participants* **[Updated and clarified July 11, 2019]**

If the subject of the proposed event falls under International Traffic in Arms Regulations (ITAR) or Export Administration Regulations (EAR), then only a U.S. person may be proposed as the PI.

Events that include participants from only U.S. and People's Republic of China organizations may be considered bilateral activities and thus ineligible for funding because of prohibitions in Appropriation Acts ~~vs.~~ **See also Section III.c of the ROSES Summary of Solicitation regarding** NASA funding any work that involves the bilateral participation, collaboration, or coordination with China or any Chinese-owned company or entity, whether funded or performed under a no exchange of funds arrangement. ~~See Section III.c of the ROSES Summary of Solicitation.~~

Proposals that would fund individuals from organizations in "Designated Countries" will be subject to additional levels of scrutiny that may result in a proposal being denied. The "Designated Country List" can be found at the NASA Export Control website: https://oiir.hq.nasa.gov/nasaecp/. This list is regularly updated, therefore please consult the website to ensure use of the most up-to-date list.

Regarding participant support costs for non-U.S. persons, including travel and short-term visa costs, these costs may be proposed as a direct cost when part of recruiting costs. See 2 CFR 200.463. Short-term travel and visa costs (as opposed to longer-term, immigration visas) are generally allowable expenses that may be proposed as a direct cost.

Since short-term visas are issued for a specific period and purpose, they may be identified as directly connected to participation on a TWSC award. For these costs to be directly charged to a TWSC award; however, the budget narrative must demonstrate that a non-U.S. person(s):

(1) Is critical and necessary for the conduct of the TWSC event;
(2) Is allowable under the applicable cost principles;
(3) Is consistent with the non-Federal entity's cost accounting practices and non-Federal entity policy; and

(4) Meets the definition of "direct cost" as described in the applicable cost principles.

The proposal narrative also should provide sufficient explanation for how non-U.S. participant support is relevant to SMD in accordance with Sections 3 and/or 3.1 herein.

4.3 Availability of Funding **[Updated July 11, 2019]**

This program element has no dedicated budget, thus selected proposals will be funded by the relevant SMD Division. The number of proposals selected depends on the number and quality of proposals submitted and on the availability of funds from a relevant SMD program. Before submitting, potential proposers are to contact an appropriate SMD Program Officer(s) to investigate the availability of funds. Contact information for SMD Program Officers is available at http://science.nasa.gov/researchers/sara/program-officers-list/.

4.3.1 *Non-U.S. and U.S. Sources*

Subject to the Section 4.2.1 Limitations on Participants, the direct purchase of supplies and/or services that do not constitute research, e.g., key note speakers, facilitators, software licenses, etc. from non-U.S. and U.S. sources, including associated travel and related support, as a subaward by the U.S. award recipients is permitted. This ROSES program element, does not fund foreign or domestic research projects.

4.3.2 *Pass-Through Awards and Connections with Professional Networks or Societies and Research Platforms*

This program element does not allow for the award of pass-through funds, e.g., mini-grants, prizes, etc. to any individuals or organizations for research or educational activities, e.g., K-12 education teacher professional development. Criteria-based or competitively-based travel awards and recognition awards associated with a TWSC event, e.g., best student poster/paper, etc. are permitted, when justified in the proposal and budget as a type of purchase per 4.3.1 or participant support cost.

Proposals to support special events, e.g., landmark anniversaries in a society/profession association, etc. are welcome. Proposers also may plan events designed to increase the efficiency of investigators through advanced scientific/technical training that coincide or extend an annual or other meeting of a professional association, scientific society, etc.

TWSC is not a source of multi-year funding for sustaining content platforms, communities of practice, or other networks/professional societies infrastructure. To request infrastructure support that is not limited to meetings or events, contact the appropriate program manager in SMD at NASA Headquarters to inquire about the availability of other opportunities, such as invitation-only proposals.

4.3.3 *Technology and Data*

Proposals that involve traditional and non-traditional meetings, e.g., hackathons, in order to plan to develop new or emerging technologies/research agendas or that feature existing SMD data and technologies/research are both welcome.

If technology, data, etc. are required to support the purpose of the proposal, then the purchase and/or modification of existing products is permissible. However, the acquisition or creation or sustainability of new technologies, data, etc., may not be the main purpose of the proposal. TWSC proposals normally do not have a data management plans nor propose to create new or enhanced technologies. Proposals that need a data management plan and/or would generate a patent are probably research or development projects and not TWSC events.

4.4 <u>Constraints on Logistics</u>

The logistics of the event must be described well enough for SMD to ensure it will achieve the stated purpose(s). This includes and is not limited to the size, location, duration, scheduling, and cost of the event for both sponsors and attendees. No venue shall be proposed that discriminates on the grounds of race, color, age, ethnicity, religion, pregnancy, sexual orientation, gender identity, sex, marital status, disability, or status as a U.S. Veteran.

The funding request, whether a small grant to subsidize student participation or full sponsorship of a large symposium, must be commensurate with (a) NASA's stewardship roles for the subject science and the benefiting science community, (b) the importance of the event to SMD in attaining its goals and objectives, and (c) NASA's responsibility to manage federal, i.e., taxpayer, funds and their expectations.

4.4.1 *Geographic Location*

Proposers are encouraged to choose a U.S. location, e.g., one of the 50 states, the District of Columbia, a U.S. territory, etc.

Proposers are discouraged from choosing a non-U.S. location. NASA may not itself engage in any bilateral events with China nor Chinese-owned companies nor fund others to engage in such events. Events in "Designated Countries" will be subject to additional levels of scrutiny that may result in a proposal being denied. The "Designated Country List" can be found at the NASA Export Control website: https://oiir.hq.nasa.gov/nasaecp/. This list is regularly updated, therefore please consult the website to ensure use of the most up-to-date list.

4.4.2 *Facilities*

NASA encourages using facilities that are appropriate to the proposed event, e.g., an academic facility, a public or private conference center, a retreat facility, etc. NASA discourages proposing to use entertainment, recreation, sporting or luxury venues.

4.5 <u>Award Duration</u>

Most awards from this program element have a performance period of 12 months. Under certain circumstances, and if properly justified, it is permissible to propose multiple meetings that span across a longer performance period. For example, a pair of meetings before and after fieldwork, targets of opportunity (oil spills, comet appears, etc.) or another large project, make sense to plan and propose together. Otherwise, proposers should plan on a single meeting.

4.6 Antidiscrimination, Diversity and Inclusion

Everyone related to NASA science, including awardees associated with this program element, should report harassment claims in accordance with the NASA Policy Statement on Antidiscrimination in NASA Conducted or Funded Program, Activities, and Institutions signed by Administrator Bridenstine at https://missionstem.nasa.gov/docs/Bridenstine_Title_IX_Policy_Statement_TAGGED.pdf. For detailed guidance related to filing a harassment complaint to NASA visit https://missionstem.nasa.gov/filing-a-complaint.html.

NASA's MissionSTEM Web site is available to assist programs and activities that receive NASA funding to meet their obligations under equal opportunity laws and augments the Agency's ongoing civil rights compliance reviews of NASA grant recipients. MissionSTEM hosts video and other media on topics such as diversity and inclusion leadership; implicit bias in STEM environments; etc.

An event's diversity and inclusion policies and practices should make clear that everyone is welcome within NASA Science and strive to create an environment that is free of harassment and discrimination. Organizers of events must have a specific policy**,** code of conduct or meeting ground rules provided in advance and available during the event for all participants.

In the proposal include a brief overview of the meeting conduct principles or policies and identify a responsible person(s). Selected examples of such meeting rules include:

- American Geophysical Union (AGU) Meetings Code of Conduct at https://fallmeeting.agu.org/2018/agu-meetings-code-of-conduct/
- LPSC Statement on Harassment at https://www.hou.usra.edu/meetings/lpsc2018/
- American Astronomical Society (AAS) Anti-Harassment policy (which applies to all AAS and Division of Planetary Science meetings) at https://aas.org/policies/anti-harassment-policy-aas-division-meetings-activities.
- Ecological Society of America at https://esa.org/louisville/about/code-of-conduct/

4.7 Within NASA, Inter-Agency and NASA-as Primary Sponsor Awards

There are NASA Procedural Requirements documents or NPRs that will be important when planning an event involving a NASA Center or Facility. For example, NPR 9770.1 Subject: *NASA Conference Approval* and Reporting and NPR 9710.1 Subject: *General Travel Requirements* provide the financial management requirements for conference planning, approval, attendance, and reporting for NASA. These NPRs specify in section P.2 *Applicability* that these NPRs are applicable to recipients of grants and cooperative agreements *only to the extent specified or referenced in the award*. Therefore, these NPRs while applicable to intra-NASA funding transfers, normally will not apply to most TWSC grants and cooperative agreements.

If the proposer anticipates that the resulting award will not be a grant or cooperative agreement (i.e., if the proposing institution is a Government laboratory, including the Jet Propulsion Laboratory) and the result of the award is that NASA will be the primary sponsor of a conference then the proposal must clearly state this fact, because NASA must provide detailed reports for NASA-sponsored conferences. In addition, there are other constraints set by Office of Management and Budget (OMB) policy memorandum, statute and federal regulations that limit options for NASA-sponsored conferences.

5. Other Factors

The amount that NASA can spend on conferences is limited. Support from this program element is exclusively for scientific/technical subjects, see Sections 1 and 2.

This program element cannot result in the award of a contract, only a grant, cooperative agreement, an interagency agreement, or internal funding, i.e., an intra-agency transfer from Headquarters to a NASA Center or Facility.

Letters of affirmation from the relevant community are permitted for proposals to this program.

Not all proposals to this program element are peer reviewed. Depending on the availability of appropriately knowledgeable SMD staff and the size of the request, some submissions may be reviewed only by program managers at NASA Headquarters.

Events that are proposed in response to this program element should have a public purpose and/or benefit, i.e., the proposer’s event is primarily for its own purposes and NASA is merely supporting with financial or other assistance. Thus, NASA may not direct a recipient in arranging the event or in providing other services for NASA's benefit. The proposed event must be run by the recipient, not by NASA. NASA projects that would satisfy a NASA requirement or provide a crucial deliverable (such as a decadal survey) through an event cannot be supported through this call. Events sponsored or initiated by NASA primarily to meet a specific NASA need or obtain information for the direct benefit of NASA must be supported by means of a contract and may not be proposed in response to this program element.

No NSPIRES cover page question on data management plans is posed for proposals to this program element. However, if appropriate, then proposers may present one or NASA may require one.

In order to assist in routing a proposal to appropriate personnel, proposers are asked to provide on the NSPIRES cover page the name of a NASA Headquarters point of contact and to identify the relevant science program(s).

6. Summary of Key Information

Expected annual program budget for new awards	No dedicated budget; selected proposals will be funded by the relevant SMD program.
Number of new awards pending adequate proposals of merit	The number of proposals selected will be dependent on the number and quality of proposals submitted and on the availability of funds from the relevant SMD program.

Maximum duration of awards	Typically 1 year, but see section 4.5
Due date for Notice of Intent to propose (NOI)	No Notices of Intent are requested for this program element.
Due date for proposals	Proposals may be submitted at any time until 11:59 pm Eastern time on March 27, 2020
Planning date for start of investigation	6 months after proposal receipt.
Page limit for the central Science/Technical/Management section of proposal	5 pp; see also Table 1 in the *ROSES Summary of Solicitation* and the *NASA Guidebook for Proposers*.
Relevance	See section 3. Proposals that are relevant to this program element are, by definition, relevant to NASA.
General information and overview of this solicitation	See the *ROSES Summary of Solicitation*.
Detailed instructions for the preparation and submission of proposals	Please see ROSES *Summary of Solicitation* Section I(g) Order of Precedence, Table 1, and the *NASA Guidebook for Proposers*.
Submission medium	Electronic proposal submission is required; no hard copy is required or permitted. See also Section IV of the *ROSES Summary of Solicitation* and the *NASA Guidebook for Proposers*.
Web site for submission of proposal via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Web site for submission of proposal via Grants.gov	http://grants.gov (help desk available at support@grants.gov or (800) 518-4726)
Funding opportunity number for downloading an application package from Grants.gov	NNH19ZDA001N-TWSC
Funding Points of Contact	https://science.nasa.gov/researchers/sara/program-officers-list
Coordinating point of contact concerning this program	Mary F. Sladek Science Mission Directorate NASA Headquarters Washington, DC 20546-0001 Telephone: (202) 358-0861 Email: mary.f.sladek@nasa.gov

E.3 EXOPLANETS RESEARCH

NOTICE: Proposals are not solicited via this program element in ROSES-2019. This program was solicited a second time late in ROSES-2018 with due dates in calendar year 2019. Interested proposers should see the second solicitation of Exoplanets Research as program element E.5 of ROSES-18.

Proposals to this program will be taken by a two-step process in which the Notice of Intent is replaced by a required Step-1 proposal submitted by an organization Authorized Organizational Representative. No PDF upload is required or permitted for Step-1 proposals. Step-1 proposers must provide information in the Proposal Summary text box on the NSPIRES cover pages, and provide the list of team members. Only proposers who submit a Step-1 proposal are eligible to submit a Step-2 (full) proposal. See Section 3 for details.

1. Scope of Program

The Exoplanets Research Program (XRP) element solicits basic research proposals to conduct scientific investigations focused on extrasolar planets (exoplanets). Broad objectives of this program include, but are not limited to: the detection and characterization of other planetary systems; characterization of individual exoplanets, through exploration of their composition, dynamics, energetics, chemical behavior, etc.; and the origins of extrasolar planets. This program element is cross-divisional, and jointly managed by the four science divisions within the Science Mission Directorate.

Proposed investigations should do one or more of the following:

- Detect exoplanets and/or confirm exoplanet candidates
- Observationally characterize exoplanets, their atmospheres, or specific host star properties that directly impact our understanding of the exoplanetary system
- Explore the chemical and physical processes of exoplanets (including the state and evolution of their surfaces, interiors, and atmospheres);
- Improve understanding of the origins of exoplanetary systems.

This call supports observational, laboratory, and theoretical studies (including modeling) that focus on improving our understanding of exoplanetary systems. Proposed investigations should have significant impact on the study of exoplanets, by: 1) collecting new data that delivers unique insight into the nature of exoplanetary systems and 2) improving the interpretation of data on exoplanetary systems, through collection and interpretation of laboratory data for comparison to observations and/or providing observationally testable theory. All such investigations will be judged, in part, on how the proposed studies will support past and current NASA missions and/or how they will facilitate the formulation and development of future NASA missions and strategic exoplanet programs. Proposals should demonstrate relevance to NASA by describing the benefit for NASA missions, with specific past, current, or future missions or programs identified.

Ground-based observations are supported by XRP, and may be made at any ground-based facility, public or private, including those supported by NASA. If new observations are to be made, the facility and all instrumentation specific to the investigation must be in scientific operation at the time of submission of the proposal, and the proposal must state whether or not observing time to support the proposed investigation has been awarded. Proposals must provide evidence of current instrument performance and data quality.

Proposed investigations with a main focus on stellar objects or brown dwarfs are in scope, but should demonstrate convincingly that the research investigation will advance exoplanet science.

Investigations with laboratory, theoretical, or modeling components should clearly describe how results will support and/or be tested by observational data.

All XRP proposals will be evaluated, in part, on their significance to and impact on the advancement of exoplanet science. Proposals that have a near-term impact (within 5 years) are particularly encouraged. All proposals must include plans for scientific data analysis, public archiving of data (see Section 3.3), and for publication of results.

Investigations that combine two or more divisional disciplines to investigate exoplanet properties (Astrophysics, Planetary Science, Heliophysics, and Earth Science) are especially encouraged.

2. Programmatic Information

2.1 Clarifications and Exclusions

The Exoplanet Research Program is intended to encompass the majority of research investigations where exoplanets are the primary focus. However, there remains some overlap with other ROSES program elements resulting in the following exclusions:

Studies of the formation of planetary systems that are focused on increased understanding of our own Solar System, should be submitted to Emerging Worlds (program element C.2).

Observational, theoretical, and archival proposals focused upon the detection of technosignatures are within scope of the XRP, except for archival proposals that exploit data within a NASA public domain archive. Such proposals should be submitted to the Astrophysics Data Analysis Program (ADAP) element of ROSES (element D.2).

Observational proposals focused on detecting, validating, or characterizing potentially habitable planets fall within the scope of the XRP. Observational proposals focused on supporting the detection of biosignatures using current or future telescopes also fall within the scope of the XRP. Theoretical or laboratory investigations focused on the studies defining, understanding or characterizing biosignatures generally fall in the scope of the Exobiology Program (C.5), and theoretical or laboratory investigations focused on the environmental conditions needed for life generally fall in the scope of the Habitable Worlds Program (E.4). For programs that have overlap between these areas, consultation with an XRP, HW, and/or ExoBio Program Officer is encouraged.

Investigations with a primary focus on analysis of data from a NASA public domain archive (including the Kepler and TESS missions) are not solicited in this program element. Such proposals should be submitted to ADAP. Should a proposal submitted to XRP contain an archival data analysis component, a clear justification should be made for why the proposal is not compliant with ADAP.

Proposed investigations containing major work elements of collecting and analyzing data from currently operating or future space missions that have Guest Investigator programs (e.g. TESS, Hubble, Webb, etc.) will not be considered for grant funding through XRP. Such investigations should respond directly to the Guest Investigator programs of the relevant missions.

Investigations with the primary objective of maintaining and operating observing facilities, or developing, commissioning, or determining the integrated performance of instrumentation are not solicited in this program.

Proposals that are substantively identical to proposals submitted to another program element within ROSES will not be accepted for review in XRP.

2.2 Facilities Available to Proposers

Those investigators whose research requires high-performance computing should refer to the *Summary of Solicitation*, Section I(d), "NASA-provided High-End Computing Resources." This section describes the opportunity for successful proposers to XRP to apply for computing time on either of two NASA computing facilities at the Goddard Space Flight Center's Computational and Information Sciences and Technology Office or at the Ames Research Center's Advanced Supercomputing Division.

2.3 Early Career Programs

Details of the new Planetary Science Early Career Award (ECA) program are given in program element C.19. The aim of this program is to support research and professional development of outstanding early-career scientists, and to help stimulate research careers in areas supported by the Planetary Sciences Division. This program is an ECA-participating ROSES program element.

2.4 Duration of Awards

We anticipate that most proposals will seek three years of funding. Proposals for fewer than three years are encouraged for projects that can be completed on shorter timescales. Four-year proposals are allowed but must justify the need for the longer duration.

2.5 Selecting Officials

Selections from XRP will be jointly made by the Resource and Analysis Leads of the divisions within the Science Mission Directorate.

2.6 Research Coordination Networks

PIs of proposals selected for funding from this program element may be eligible to become members of the Steering Committees of the newly-established Research Coordination Networks (RCNs) if the proposed investigation is aligned with the goals of an RCN. Relevance to an RCN is not an evaluation criterion for proposals to this program element, and eligibility for participation in an RCN does not indicate that additional research funding will be provided. The currently active RCNs are:

- NExSS: a research coordination network that brings together scientists from many disciplines to investigate the diversity of exoplanets and to learn how their history, geology, and climate interact to create the conditions for life. (For more information see https://nexss.info/.)
- NfoLD: a research coordination network that brings together scientists from many disciplines to investigate life detection research, including biosignature creation and preservation, as well as related technology development. (For more information see https://nfold.org.)

3. The Two-Step Submission Process

To facilitate the early recruitment of a conflict-free review panel, and to ensure proposals are submitted to the appropriate program, XRP will use a two-step proposal submission process (see Section IV.(b)vii of the ROSES *Summary of Solicitation*).

A Step-1 proposal is required and must be submitted electronically by the PI's Authorized Organizational Representative (AOR). No budget is required. Only proposers who submit a Step-1 proposal are eligible to submit a Step-2 proposal. Full (Step-2) proposals must broadly contain the same scientific goals proposed in the Step-1 proposal. The Step-1 proposal title and PI cannot be adjusted. To add funded investigators between the Step-1 and Step-2 proposals, proposers must write to the point(s) of contact below and cc sara@nasa.gov at least four weeks in advance of the Step-2 due date. Submission of the Step-1 proposal does not obligate the proposer to submit a Step-2 (full) proposal later.

3.1 Step-1 Proposal

Proposers should refer to the "Instructions for Submitting a Step-1 Proposal" under "Other Documents" on the NASA Solicitation and Proposal Integrated Review and Evaluation System (NSPIRES) web page for this program. The Step-1 proposal should identify the PI and team members on the proposal. The Scientific-Technical-Management section of the Step-1 proposal is restricted to the 4,000-character text box on the NSPIRES web interface cover pages and should include a description of the science goals and objectives to be addressed by the proposal, a brief description of the methodology to be used to address the science goals and objectives, and the relevance of the proposed research to this call. The Step-1 proposal may be used to determine whether the proposal was submitted to the correct program element. No evaluation of intrinsic merit will be done on Step-1 proposals.

The proposal is entered directly into a text field in NSPIRES, and no attachment is required or permitted. Proposers will be notified when they are able to submit their Step-2 proposals. NSPIRES will notify proposers whether their Step-1 proposal is encouraged or not, at which point they will be able to create Step-2 proposals.

3.2 Step-2 Proposal

Proposers should refer to the document entitled "How to submit a Step-2 proposal" under "Other Documents" on the NSPIRES page for this program. The process for preparation and submission of the Step-2 (full) proposals is essentially identical to that associated with any other ROSES proposal. This is a reminder that all proposals submitted to ROSES must strictly conform to the formatting rules in Section IV of the *Summary of Solicitation* and the *NASA Guidebook for Proposers*. Those that violate the rules may be rejected without review. In previous years, problems with the following aspects of formatting proposals have been noted. Proposers should pay particular attention to:

- Length of the Scientific/Technical/Management section: 15 pages
- Margins: 1 inch on all sides, with a standard page size of 8.5 × 11 inches.
- Font: The *NASA Guidebook for Proposers* requires that you use a 12-point or larger font. The selected font must meet the requirement of having, on average, no more than 15 characters per inch (e.g., Times New Roman and Arial). You may not adjust the character spacing or otherwise condense a font from its default appearance.
- Line spacing: Font and line-spacing settings should produce text that contains no more than 5.5 lines per inch. Do not adjust line-spacing settings for your selected font below single-spaced.
- Figure captions: Must follow the same font and spacing rules as the main text.
- Figures and tables: For text in figures and tables, font and spacing rules listed above do not apply, but all text must be judged to be legible to reviewers without magnification above 100%. Do not place expository text in tables or figures in order to gain space.

3.3 Data Management Plan

In order to maximize the impact of NASA-funded science, all XRP investigations must include a Data Management Plan (DMP). The intent is to ensure broad and timely availability of data to the community and a clear plan for the long-term access to the data. Data management plans are to be submitted via the NSPIRES cover pages in response to the DMP question.

4. Points of contact

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E.4 HABITABLE WORLDS

NOTICE: Proposals to this program will be taken by a two-step process in which the Notice of Intent is replaced by a required Step-1 proposal submitted by an organization Authorized Organizational Representative. No PDF upload is required or permitted for the Step-1 proposal. Step-1 proposers merely must fill in the Proposal Summary text box on the NSPIRES cover pages. Only proposers who submit a Step-1 proposal are eligible to submit a Step-2 (full) proposal. See Section 3 for details.

1. Scope of Program

The goal of the Habitable Worlds program is to use knowledge of the history of the Earth and the life upon it as a guide for determining the processes and conditions that create and maintain habitable environments and to search for ancient and contemporary habitable environments and explore the possibility of extant life beyond the Earth.

NASA's Habitable Worlds Program includes elements of the Astrobiology Program, the Mars Exploration Program, the Outer Planets Program (all in the Planetary Science Division), Exoplanet research in the Astrophysics Division, and Living With a Star in Heliophysics. A common goal of these programs is to identify the characteristics and the distribution of potentially habitable environments in the Solar System and beyond. This research is conducted in the context of NASA’s ongoing exploration of our stellar neighborhood and the identification of biosignatures for *in situ* and remote sensing applications. For further information on the science scope of Astrobiology, please refer to the Astrobiology roadmap, which can be found on the Astrobiology web page http://astrobiology.nasa.gov/. Information on the habitability-related goals of the Mars Exploration Program can be found in the "*Mars Science Goals, Objectives, Investigations and Priorities: 2010*" document, available on the Mars Exploration Program Analysis Group web page (http://mepag.jpl.nasa.gov). For the Outer Planets Program, refer to the document "*Scientific Goals and Pathways for Exploration of the Outer Solar System*," found on the Outer Planets Assessment Group web site (http://www.lpi.usra.edu/opag).

Theoretical and experimental studies will be considered, as well as quantitative terrestrial field experiments that improve scientific understanding of how *in situ* measurements at analog sites can or will improve our understanding of the potential for the environment to support life. Research areas include, but are not limited to, the presence of water and/or exotic solvents, sources of energy for life, presence of organics and their reactivity, and water body physics and chemistry as they pertain to habitability and habitability over time, as well as space weather signatures that may be indicative of impacts to planetary habitability. The target bodies for this program element include, but are not limited to:

- Mars - the astrobiological potential of past or present environments on or in the Martian surface or subsurface.

• Icy Worlds - the astrobiological potential of icy worlds in the outer Solar System, including Europa, Ganymede, Enceladus, and Titan.

• Habitable Exoplanets and/or their moons - A potentially habitable exoplanet implies a planet with conditions roughly comparable to those of Earth (i.e., an Earth analog) and thus potentially favorable to the presence of life.

2. Programmatic Information

Proposals are sought for new projects within the scope of the Habitable Worlds. Proposals submitted in response to this Program Element should be for new work that is not currently supported by the program or for investigations that would extend to their next logical phase those tasks that have been funded in the Astrobiology, Mars Fundamental Research, Living with a Star, Exoplanet Research and Outer Planets (or other) programs.

The Habitable Worlds element will be administered primarily by the Planetary Science Division. As such, this solicitation is governed by information contained in program element C.1. However, highly-rated proposals of strong programmatic relevance to the Astrophysics or Heliophysics Division will be considered for funding by the Astrophysics or Heliophysics Division, respectively. The Astrophysics Division will consider supporting investigations that are focused upon the characterization of potentially habitable exoplanets and their atmospheres in order to:

- inform targeting and/or operational choices for current NASA Astrophysics missions, or
- provide targeting, operational, and/or formulation data for future NASA Astrophysics observatories.

2.1 Relevance Statement Requirement

Step-2 Proposals to this program element must discuss relevance in a (4000-character maximum) text box on the cover pages via the NSPIRES web interface for this program element. This section is outside of the 15-page Scientific/Technical/Management Section and the relocation of the relevance discussion does not decrease that 15-page limit. This requirement supersedes the *NASA Guidebook for Proposers* and the *ROSES Summary of Solicitation*, and the omission of this section is sufficient reason for a proposal to be returned without review.

The relevance discussion must explicitly refer to this program element and the section of the solicitation to which the proposal is responsive. If the proposed work is close in scope to research covered by any other program element, this discussion must also justify why it is more relevant to this program element than that other program element. This discussion may not be used to address the proposal's intrinsic merit, budget justification, or any other factor that remains in the 15-page main body, or any other section, of the proposal.

2.2 Program Exclusions

Proposals focused on the formation of complex organic molecules in space and their delivery to planetary surfaces in the Solar System should be submitted to C.2 Emerging Worlds. Proposals focused on the formation and stability of habitable planets should be submitted to either C.2 Emerging Worlds or E.3 Exoplanet Research Program, depending on the nature of the study. Refer to those solicitations for more information.

Biosignature studies of samples from sites thought to be analogs of other planetary environments that might potentially harbor life should be directed to C.5 Exobiology. Models of environments in which organic chemical synthesis could occur and the forms in which prebiotic organic matter has been preserved in planetary materials should be directed to C.5 Exobiology. Work to understand the phylogeny, physiology, and adaptations of extant terrestrial organisms to extreme environments should be directed to C.5 Exobiology.

Field-based investigations focused on exploring the relevant environments on Earth in order to develop a sound technical and scientific basis to conduct planetary research on other Solar System bodies should be directed to C.14 PSTAR (Planetary Science and Technology from Analog Research) program.

Through its data analysis programs, C.7 New Frontiers Data Analysis Program (NFDAP), C.8 Lunar Data Analysis Program (LDAP), C.9 Mars Data Analysis Program (MDAP), C.10 Cassini Data Analysis Program (CDAP), and C.11 Discovery Data Analysis Program (DDAP), the Planetary Science Division solicits proposals for work that are primarily analysis of planetary mission data. This program element does not accept proposals that are eligible for submission to one of those data analysis programs. If a proposal is not appropriate for one of the data analysis programs, but does fit within the bounds of this program, then it should be submitted to this program.

2.3 Pilot Studies

Proposals for one to two-year pilot studies to demonstrate or develop a new technique or a new application of an established technique will be considered. Such proposals may also include the demonstration of a technique new to the proposer, but not new to the field in general.

2.4 Instrumentation: Construction or Upgrade

Proposers to Habitable Worlds are eligible to request funds for major equipment under the Planetary Major Equipment and Facilities (PMEF) program. See program element C.17 for information on how to append a PMEF request to a regular Habitable Worlds research proposal or submit a stand-alone PMEF proposal to supplement an existing Habitable Worlds award.

2.5 Development of Instruments

This solicitation does not request proposals for the development of advanced instrument concepts and technologies as precursors to astrobiology flight instruments. Such proposals may be submitted to C.12 Planetary Instrument Concepts for the Advancement of Solar System Observations (PICASSO) Program, for technology readiness levels (TRLs) 1-3 or C.13 Maturation of Instruments for Solar System Exploration (MatISSE) Program for TRLs 4-6. Proposals for science-driven field campaigns that are expected to produce new science results, as well as new operational or technological capabilities, should be submitted to the C.14 Planetary Science and Technology Analogs Research (PSTAR) program.

2.6 Nexus of Exoplanet System Science

Although Habitable Worlds solicits proposals aimed at habitability of any planet, including those within the Solar System, PIs of proposals selected for funding from this program element that cover a research topic related to the habitability of, or search for life on, exoplanets specifically are eligible to be part of the Nexus of Exoplanet System Science (NExSS). Relevance to NExSS is not an evaluation criterion for proposals to this program element. Eligibility for participation in NExSS does not indicate that additional funding will be provided; NExSS is a research coordination network that brings together scientists from many disciplines that study planets beyond our Solar System. For more information see https://nexss.info/.

2.7 Duration and Size of Awards

NASA anticipates that most proposals will seek three years of funding. Proposals for less than three years are encouraged for projects that can be completed on shorter timescales. In rare cases, funding for the proposed fourth year may be provided, if the need for the longer duration is sufficiently well justified. The appropriateness of the proposed funding period will be reviewed, and adjustments may be requested. Programmatic balance may limit the opportunities for funding in some areas.

The average size of awards resulting from Step-2 proposals submitted to Habitable Worlds was ~$150-175 K per year per award, but with a wide range, depending on the nature of the work proposed. Proposers are encouraged to request what they actually need to conduct the research proposed.

2.8 Planetary Science Early Career Award

Details of the new Planetary Science Early Career Award (ECA) program are given in program element C.19. The aim of this program is to support research and professional development of outstanding early-career scientists, and to help stimulate research careers in areas supported by the Planetary Sciences Division. This program is an ECA-participating ROSES program element. Proposals from eligible PIs, or Science PIs if applicable, selected from this program in 2019 may become the 'parent award' for future ECA proposals (i.e., in 2020 or later).

2.9 Antarctica

The Habitable Worlds Program is no longer accepting proposals for work in Antarctica.

2.10 Resources: Information, Data, and Facilities

For proposals that contain mission data analysis, planetary spacecraft mission data to be used in proposed investigations must be available in the Planetary Data System (PDS) or equivalent publicly accessible archive at least 30 days prior to the Step-2 proposal due date. Spacecraft data that have not been obtained yet (i.e., future mission data) or those that have not been accepted for distribution in approved archives are not eligible for use in investigations. Regardless of the archive(s) used, if the data to be analyzed have issues that might represent an obstacle to analysis, the proposers must demonstrate clearly and satisfactorily how such potential difficulties will be overcome. Investigators funded by spacecraft missions who wish to apply must demonstrate clearly how the proposed research does not overlap and is not redundant with data analysis, duties, or responsibilities already funded by their respective mission(s). Please see C.1, The Planetary Science Division Research Program Overview, for more information.

2.10.1 Facilities and Data Sources Available to Proposers

Proposers are advised to read C.1 Planetary Science Division Research Program Overview for information on facilities and data sources that are available to supported investigators. If their use is anticipated, this should be discussed and justified in the submitted proposals (especially note the provision for such discussion in the proposal section entitled Facilities and Equipment). Also note that, per the directions in the *NASA Guidebook for Proposers*, a letter of support may be required from any facility required for the proposed effort.

2.10.2 Geologic Maps

Proposers who plan investigations involving geologic mapping should consult program element C.1, Section 3.8, for guidance on submission and requirements for publication of U.S. Geological Survey (USGS) maps. The scientific goal of such a geologic map product should be clearly explained and justified.

2.11 NASA Postdoctoral Program Fellows

Grantees in the program are eligible to serve as mentors to NASA Postdoctoral Program (NPP) Fellows. The tenure of a Fellow must begin before the end of the award, but may extend beyond it. Proposals from potential Fellows must be submitted through the standard NPP process. This Program expects to select no more than two Fellows this year. More information about the NASA Postdoctoral Program may be found at http://npp.usra.edu/.

2.12 Data Management Plans

Proposals submitted to this program element must include a Data Management Plan (DMP, see program element C.1, Section 3.6). This must be placed in a special section, not to exceed two pages in length, immediately following the References and Citations section for the Scientific/Technical/Management portion of the proposal.

3. The Two-Step Submission Process

To facilitate the early recruitment of a conflict-free review panel and to ensure proposals are submitted to the appropriate program, this program uses a two-step proposal submission process (see Section IV. (b) vii of the ROSES *Summary of Solicitation*).

A Step-1 proposal is required and must be submitted electronically by the Authorized Organizational Representative (AOR). No budget is required. Only proposers who submit a Step-1 proposal are eligible to submit a Step-2 proposal. Full (Step-2) proposals must broadly contain the same scientific goals proposed in the Step-1 proposal. The Principal Investigator (PI) cannot be adjusted and proposers that want to add funded investigators between the Step-1 and Step-2 proposals must inform the point(s) of contact below and cc sara@nasa.gov at least two weeks in advance of the Step-2 due date. Submission of the Step-1 proposal does not obligate the proposer to submit a Step-2 (full) proposal later.

3.1 Step-1 Proposal

Proposers should refer to the "Instructions for Submitting a Step-1 Proposal" under "Other Documents" on the NASA Solicitation and Proposal Integrated Review and Evaluation System (NSPIRES) page for this program. The Scientific-Technical-Management section of the Step-1 proposal is restricted to the 4000-character Proposal Summary text box on the NSPIRES web interface cover pages and should include a description of the science goals and objectives to be addressed by the proposal, a brief description of the methodology to be used to address the science goals and objectives, and the relevance of the proposed research to this call. The Step-1 proposal may be used to determine whether the proposal has been submitted to the appropriate program element. No evaluation of intrinsic merit will be performed on Step-1 proposals.

NSPIRES will notify proposers whether their Step-1proposal has been designated as encouraged or not, at which point they will be able to create Step-2 proposals.

3.2 Step-2 Proposal

This is a reminder that all proposals submitted to ROSES must strictly conform to the formatting rules in Section IV of this announcement and the *NASA Guidebook for Proposers*. Those that violate the rules may be rejected without review. In previous years, problems with the formatting of the Scientific/Technical/Management section proposals have been noted. Please pay particular attention to:

- Length: 15 pages
- Margins: 1 inch on all sides, with a standard page size of 8.5 × 11 inches.
- Font: The *NASA Guidebook for Proposers* requires that proposers use a 12-point or larger font. The selected font must meet the requirement of having, on average, no more than 15 characters per inch (e.g., Times New Roman and Arial). Proposers may not adjust the character spacing or otherwise condense a font from its default appearance.
- Line spacing: Font and line-spacing settings should produce text that contains no more than 5.5 lines per inch. Do not adjust line-spacing settings for your selected font below single-spaced.
- Figure captions: must follow the same font and spacing rules as the main text.
- Figures and tables: for text in figures and tables, font and spacing rules listed above do not apply, but all text must be judged to be legible to reviewers without magnification above 100%. Do not place expository text in tables or figures in order to gain space.

4. Summary of Key Information

Expected program budget for first year of new awards	~$2M
Number of new awards pending adequate proposals of merit	See Section 2.7
Maximum duration of awards	4 years; shorter-term proposals (1-3 years) are typical; fourth year must be explicitly and scientifically justified.
Due date for Step-1 proposals	See Tables 2 and 3 of this ROSES NRA

Due date for Step-2 proposals	See Tables 2 and 3 of this ROSES NRA
Planning date for start of investigation	6 months after proposal due date.
Page limit for the central Science/Technical/ Management section of proposal	15 pp; see also Table 1 of the ROSES *Summary of Solicitation* and the *NASA Guidebook for Proposers*.
Relevance	This program is relevant to Planetary Science, Heliophysics, and Astrophysics Divisions questions and goals in the NASA Science Plan. Proposals that are relevant to this program are, by definition, relevant to NASA.
General information and overview of this solicitation	See the *ROSES Summary of Solicitation*.
Detailed instructions for the preparation and submission of proposals	Please see *ROSES Summary of Solicitation* Section I(g) Order of Precedence, Table 1 and the *NASA Guidebook for Proposers*.
Submission medium	Electronic proposal submission is required; no hard copy is required or permitted.
Web site for submission of proposals via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Web site for submission of proposals via Grants.gov	http://grants.gov (help desk available at support@grants.gov or (800) 518-4726)
Funding opportunity number for downloading an application package from Grants.gov	NNH19ZDA001N-HW
NASA points of contact concerning this program	Mitch Schulte Planetary Science Division NASA Headquarters Washington, DC 20546 Telephone: (202) 358-2127 Email: mitchell.d.schulte@nasa.gov Mary Voytek Planetary Science Division NASA Headquarters Washington, DC 20546 Telephone: (202) 358-1577 Email: mary.voytek-1@nasa.gov Continued…

NASA points of contact concerning this program, continued	Martin Still Astrophysics Division NASA Headquarters Washington, DC 20546 Telephone: (202) 358-4462 Email: Martin.Still@nasa.gov Galen Fowler Heliophysics Division NASA Headquarters Washington, DC 20546 Telephone: (202) 358-0039 Email: galen.fowler@nasa.gov

E.5 APPLIED INFORMATION SYSTEMS RESEARCH

NOTICE: March 18, 2020. This amendment delays the Step-2 proposal due date for this program element to April 17, 2020.

Amended December 13, 2019. This Amendment releases final text and sets the due dates for this program element that was previously released as draft for community comment. NASA funding is currently under a continuing resolution, and funding of this program is contingent on the final FY20 Congressional authorization.

This program element uses a two-step proposal submission process described in Section 2.2 of C.1 The Planetary Science Research Program Overview.

1. Scope of Program

The purpose of the Applied Information Systems Research (AISR) program is to evolve advances in computer and information science and technology to enhance science productivity of the Science Mission Directorate (SMD). AISR seeks innovative ideas for applying advanced information and related technologies to increase life cycle effectiveness and efficiency of SMD programs. The focus this year of AISR is Autonomous Robotics Research for Ocean Worlds (ARROW).

1.1 Introduction

ARROW supports the research and development of functional and system-level autonomous capabilities for the surface exploration of Ocean Worlds, such as Europa, Enceladus, and Titan (Hendrix et al., 2019). The goal of the program is to develop autonomy software technologies to significantly increase the robustness and productivity of future Ocean Worlds lander missions including those to never-before-visited destinations with surface conditions and phenomena that may be largely, or completely, unknown a priori at the time of landing. Although ARROW does not itself solicit technology for a flight opportunity, proposers will be required to test and demonstrate the developed technology using testbeds (see Section 2.3) developed and supported by NASA.

One of NASA's primary goals is to identify and characterize potentially habitable environments in the Solar System and beyond. While the search for evidence of extant and extinct life, and conditions supporting life in the Solar System, has primarily focused on Mars, there is strong evidence that a number of outer Solar System moons (e.g., Europa, Enceladus, and Titan) harbor subsurface (interior) oceans. These Ocean Worlds may be the best places to search for extant life beyond Earth.

NASA is currently studying a Europa lander mission concept (2016) that likely contains similarities to possible missions for other Ocean Worlds. NASA's 2012 Europa Lander Report also describes a mission concept that may be similar to future Ocean Worlds missions. As a result, these mission concepts, especially their technology assumptions and resource constraints, can be used as a helpful guideline for focusing and targeting autonomy technology research and development.

NASA's 2016 mission concept envisions delivery of a lander with a total mass of approximately 300 kg to the surface of Europa. While this mission concept is anticipated to have a surface lifetime of less than 30 days using a power system consisting of solar panels and/or batteries, other mission concepts such as NASA's 2012 study are envisioned to have a longer duration enabled by nuclear power sources. Either way, the lander would provide the capability to deliver multiple surface and/or subsurface samples to instruments using a manipulator arm and other mechanisms.

1.2 Autonomy for Ocean Worlds Missions

The robotic exploration of Ocean Worlds is fraught with many challenges. Extremely low temperatures as well as high-radiation levels pose significant problems for reliable and long-duration mission operations. Lengthy communication delays, limited bandwidth, and the difficulty of maintaining communications links prevent the use of pervasive ground control supervision from Earth. Although future orbital missions, such as Europa Clipper, may provide high-resolution remote sensing, data and knowledge of Ocean World surface environments (including topography, surface composition, etc) is extremely limited or unknown. Spacecraft power will be restricted to on-board systems (batteries, etc.), which limits avionics performance and places a premium on efficient use and management of power.

Given these challenges, future Ocean Worlds lander missions will need to operate with significantly greater autonomy than the current state-of-the-art in robotic planetary surface exploration. In particular, autonomy that enables "fail-active" operation (continued operation without ground control intervention in the presence of sub-system faults, time-varying degradations, and unpredictable failures) is needed to achieve high productivity and to reduce risk.

To this end, ARROW specifically seeks functional and system-level autonomous capabilities for future Ocean Worlds lander missions that:

a) increase the productivity of surface science operations;
b) reduce the frequency of ground control contact and uplink/downlink command cycles necessary for surface science operations; and
c) enable autonomous adaptation to spacecraft faults, degradations, failures or other unexpected conditions.

Autonomous capabilities may include, but are not limited to, technologies that:

1) autonomously collect and transfer (using a manipulator arm) targeted samples collected from a surface having a range of topographies, varied material properties, and possibly abrupt changes;
2) autonomously adapt spacecraft activities to unpredictable faults due to operation in an unknown and uncertain environment;
3) autonomously react to unanticipated environmental stimuli (including dynamic effects from surface interaction);
4) autonomously operate for long durations with minimal ground control demand or interaction;
5) autonomously prioritize on-board operations to maximize mission life (e.g., efficient energy management) and/or science return; or

6) autonomously adapt to changes in system dynamics (e.g., manipulator performance) caused by degradation or failure (actuator wear, intermittent sensor noise, etc).

Proposals should focus on adapting or maturing technology that may have significant impact on the performance and resilience of robotic science operations on Ocean Worlds. Proposals are encouraged to address dealing with unexpected and unanticipated situations (the "known unknowns" and the "unknown unknowns"). Proposals are also highly encouraged to consider the practicality of incorporating the technical advances into flight missions (e.g., in terms of requirements on computational performance, data storage, verification and validation, etc.). Finally, proposals should describe how technical advances in the above areas could be applied to future NASA missions.

Only proposals to develop software will be accepted. Proposals for hardware development, including instruments and sensors, will be considered unresponsive and returned without review.

Proposals focused on adapting, or maturing, autonomy technology adapted from terrestrial applications are encouraged.

2 Programmatic Considerations

2.1 Eligibility and Teaming

Organizations of every type (domestic and foreign, Government and private, for-profit and not-for-profit) may submit proposals without restriction on teaming arrangements, with two exceptions: 1) personnel at the NASA Ames Research Center and NASA Jet Propulsion Laboratory working on the testbeds listed in Table 1 and 2) NASA may not fund projects that involve bilateral collaboration with the Peoples Republic of China (see Section IIIc of the *ROSES Summary of Solicitation*). Note that it is NASA policy that all research involving non-U.S. organizations will be conducted on the basis of no exchange of funds. Additional information on foreign participation can be found in the *NASA Guidebook for Proposers* (https://www.hq.nasa.gov/office/procurement/nraguidebook).

Team members must confirm participation online via NSPIRES. Please note that a proposal cannot be submitted if any listed team member has not confirmed their participation via NSPIRES. In addition, if partner organization(s) would provide access to a resource or facility not under the direct control of the team member, letter(s) of resource support must be provided from the partner organization (s).

2.2 Proposal Guidelines

Proposals must contain all of the elements described in Table 1 of the *ROSES Summary of Solicitation*.

To facilitate the early recruitment of a conflict-free review panel, this program will use the two-step proposal submission process described in Section 2 of C.1 The Planetary Science Division Research Program Overview. Proposers are reminded that Step-1 proposals are mandatory and must be submitted by the proposing organization.

Proposals must follow all formatting requirements that are described in C.1 The Planetary Science Division Research Program Overview and in the *ROSES Summary of Solicitation*.

All salary, fringe, and overhead are to be omitted from the main peer reviewed proposal PDF but are included in the NSPIRES web page budget and in the separately uploaded "total" budget file; see the FAQ regarding budget redaction.

2.3 Required use of Ocean World Testbeds

NASA has developed two testbeds, one virtual and one physical, to support the development and testing of new autonomy technologies for future Ocean Worlds lander missions. The testbeds provide simulation in hardware and software of a "generic" planetary lander equipped with a seven degree-of-freedom robotic manipulator and a variety of sensors.

Virtual Testbed: This software-based simulator emulates surface environmental conditions (e.g., lighting and surface material properties), robotic manipulator operation, and high-level lander systems. The simulator supports injection of faults and provides system introspection capabilities. The simulator is modeled on the Europa Lander mission, but could be configured for other lander missions and planetary bodies. The simulator will be provided as NASA Open Source software and requires Ubuntu Linux.

Physical Testbed: This hardware-based facility is located at the Jet Propulsion Laboratory (Pasadena, California) and emulates bodies with different gravities. The testbed includes a lander deck (with robotic manipulator) mounted on a six degree-of-freedom Stewart platform. The manipulator is equipped with a 6-axis force-torque sensor at its tool interface. Geotechnical instruments and sampling tools are provided as end effectors, which can be attached to the tool interface.

Both testbeds have a common software interface (application programming interface) for acquiring sensor data and commanding a manipulator arm, the mast, and the sensor suite. Sensor data available from the testbeds include arm joint and end effector position, measured end-effector forces and torques, and stereo camera images.

The virtual testbed will allow more complete modeling of the surface environment (illumination, topography out to the horizon, surface albedo, etc.), as well as broader spacecraft subsystems modeling (power system operational constraints, communication system operational constraints, flight like sensing systems, etc.). The virtual testbed will also allow rapid and broader modification of environmental and spacecraft parameters.

The physical testbed will provide higher-fidelity terrain interaction with tools and instruments than the virtual testbed. The physical testbed will also enable more realistic sensing constraints and higher-fidelity dynamics of manipulation / sampling to be studied. Significant modification of environmental conditions, however, will not be possible.

ARROW proposals must describe how the proposed work will make use of these testbeds. Proposals can choose to make use of the virtual testbed, the physical testbed, or a combination of the two. Use of both testbeds is encouraged, but not required. NASA will provide technical support (including bug fixes for the virtual testbed and integration assistance for the physical testbed) for the testbeds during the period of performance. Proposers should propose the full amount of time that they think they will need and specific dates for accommodation will be negotiated with NASA after award.

Proposers may contact the NASA points of contact listed in Table 1 of this program element, below, and additional information about these testbeds can be found on the Planetary Exploration Science Technology Office website.

Table 1. NASA Ocean World Autonomy Testbed Points of Contact

Ocean Worlds Autonomy Testbed	NASA Point of Contact
Virtual Testbed	Larry Edwards NASA Ames Research Center 650-604-4710 laurence.j.edwards@nasa.gov
Physical Testbed	Hari Nayar NASA Jet Propulsion Laboratory 818-393-2505 hdnayar@jpl.nasa.gov

2.4 Evaluation Criteria

The evaluation criteria for this opportunity are given in Section VI (a) of the *ROSES-2019 Summary of Solicitation* and the *Guidebook for Proposers*. In addition to those, the evaluation of proposals submitted to this program element will also consider the following factors.

The evaluation of Intrinsic Merit will consider:

- The impact on the performance, productivity, and resilience of robotic science capabilities, particularly "fail active" and handling of "unknown unknowns", on Ocean Worlds from the proposed activity.
- The practicality of incorporating the proposed technical advance into flight missions, particularly in terms of compatibility with current and near-term (i.e., next 5 to 10 years) flight computing, ease of performing verification and validation, and ease of integration into a range of missions.
- Whether the technical advance provides significant benefits at the system level, rather than simply improving low-level functions (e.g., actuator servo control).

The evaluation of Relevance will consider:

- The applicability of proposed autonomy technologies to advance the NASA Planetary Science Division's exploration goals for future Ocean Worlds missions, as described in the Planetary Science Decadal Survey, the Europa Lander Study Report, and the NASA Roadmap to Ocean Worlds with specific interest in the goals relevant to Europa surface missions.
- The extent to which the proposed activity makes effective use of at least one testbed described in Section 2.3 to characterize the efficacy of the autonomy technology.

Cost-sharing is welcome but not required and will not be evaluated by the peer review panel.

2.5 Reporting

Once awarded, all Progress Reporting deliverables applicable to this solicitation shall be submitted to the web-based Planetary Electronic Reporting System (ERS). A user account on ERS will be provided to the PI upon award. Due to NASA IT security requirements, all Principal Investigators (PIs) must register with the Identity Management and Account Exchange (IdMAX) system before a user account on ERS will be established. To create an IdMAX account, some personal information will be required. All submissions shall be made in PDF format.

The following deliverables shall be required and the proposed budget should provide for these reporting requirements.

2.5.1 *Semi-Annual Technical Reports*

Each six months during the performance period of the award, a Quarterly Technical Report is required including the project's technical status (technical accomplishments, technology development results, and results of tests and/or demonstrations) and schedule status (any variance from planned versus actual schedule, and tasks completed).

Reports shall be submitted in PDF, Microsoft Word, or Microsoft PowerPoint compatible file formats. A teleconference or brief meeting may be conducted between the NASA Program Officer and the PI to review and discuss each report. These reports are not expected to exceed 5 pages in length excluding figures and/or data.

2.5.2 *Final Review and Final Report*

The PI shall provide a comprehensive Final Review at the completion of the activity. The Final Review must provide conclusions of the work performed, including performance analysis results of tests and/or demonstrations, and estimates of demonstrated improvements over the state of the art.

A written Final Report summarizing the final review shall be uploaded to the ERS system within ten days of the final review. In addition, for grantees, a copy of the written report shall be emailed to the NASA Shared Services Center (NSSC) at NSSC-Grant-Report@mail.nasa.gov.

PIs are also encouraged to broadly disseminate the results of their research activity at conferences and in journal publications.

2.6 Intellectual Property

Technology developed under this solicitation is encouraged to be distributed as open source for archival via GitHub (https://github.com/nasa) but because of NASA's interest in determining the applicability of commercial terrestrial autonomy technologies this is not required.

3. Summary of Key Information

Expected program budget for first year of new awards	$1.25M total for all awards for all years
Number of new awards pending adequate proposals of merit	~5 awards
Maximum duration of awards	2 years

Due date for Step-1 proposals	See Tables 2 and 3 of this ROSES NRA
Due date for Step-2 proposals	See Tables 2 and 3 of this ROSES NRA
Planning date for start of investigation	August 1, 2020
Page limit for the central Science/Technical/Management section of proposal	15 pp; see also Table 1 at the end of the *ROSES-2019 Summary of Solicitation* and the *NASA Guidebook for Proposers*.
Relevance	This program is relevant to the Earth Science questions and goals in the NASA Science Plan. Proposals that are relevant to this program are, by definition, relevant to NASA.
General information and overview of this solicitation	See the *ROSES-2019 Summary of Solicitation*.
General requirements for content of proposals	See Section 3 of the *NASA Guidebook for Proposers* and Section IV and Table 1 of *the ROSES-2019 Summary of Solicitation*.
Detailed instructions for the submission of proposals	See https://nspires.nasaprs.com/tutorials/ Sections 3.22-4.4 of the *NASA Guidebook for Proposers* and Section IV(b) of *the ROSES-2019 Summary of Solicitation*.
Submission medium	Electronic proposal submission is required; no hard copy is required or permitted.
Web site for submission of proposal via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Web site for submission of proposal via Grants.gov	http://grants.gov/ (help desk available at support@grants.gov or (800) 518-4726)
Funding opportunity number for downloading an application package from Grants.gov	NNH19ZDA001N-AISR
Point of contact concerning this program	Carolyn Mercer Planetary Science Division Science Mission Directorate National Aeronautics and Space Administration Washington, DC 20526-0001 Telephone: (216) 433-3411 Email: cmercer@nasa.gov

E.6 FUTURE INVESTIGATORS IN NASA EARTH AND SPACE SCIENCE AND TECHNOLOGY

NOTICE: Revised January 17, 2020. In this revision new text is in bold and deleted text is struck through in order to clarify the FINESST program element in ROSES-2019 as follows: 1) The Earth Science Division has a second funding point of contact: philip.m.larkin@nasa.gov. 2) The summary transcript from the optional pre-proposal teleconference held December 2, 2019, is available on NSPIRES under "Other Documents." 3) Section 3.2.2 "Data Management Plans"adds a "Clarifying Note" regarding why normally needed data resource support letters (RLS) are not necessary. 4) Section "4.1 FINESST Proposals" adds a page number placement and format sentence. 5) Section 4.1.6 "Budget Timeline and Narrative" provides another case to explain the content of special documentation and its formatting. 6) Under Section 4.1.8 "Proposal compliance" a reference to Section 3.17 "Statements of Commitment and Letters of Resource Support" in The 2018 Guidebook for Proposers Responding to A NASA Funding Announcement is added to clarify that FINESST does not invite affirmation, recommendation, or support letters, i.e., letters that endorse the Intrinsic Merit, including significance or impact, of a proposal or the Future Investigator. If such letters are submitted, they are included in the six (6) page limit for the Scientific/Technical/Management section or plan.

NOTICE: Amended November 1, 2019. This amendment adds this new program element to ROSES-2019. An optional pre-proposal teleconference will be held December 2, 2019, from 1:00-2:30 p.m. Eastern Time, see Section 1.1 for details. A Notice of Intent is not requested for this program element. Proposals are due by February 4, 2020.

1. Introduction and Funding Opportunity Description

The Future Investigators in NASA Earth and Space Science and Technology (FINESST) is a new program element in Research Opportunities in Space and Earth Sciences (ROSES)-2019. ROSES is an "omnibus" solicitation, having default guidelines and information in the *ROSES Summary of Solicitation* that apply to all of ROSES, including this program element. Through FINESST, the Science Mission Directorate (SMD) solicits proposals from accredited U.S. universities and other eligible organizations for graduate student-designed and performed research projects that contribute to SMD's science, technology and exploration goals.

The Future Investigator (FI, i.e., the student participant) shall have the primary initiative to define the proposed FINESST research project and must be the primary author, with input or supervision from the proposal's Principal Investigator (PI), as appropriate. In cases when the PI already has an ongoing research award from NASA, the research proposed under FINESST may address a similar topic, but the proposal should make clear how the proposed research goes beyond what NASA has already agreed to support.

In 2018, SMD released FINESST as a stand-alone, successor solicitation to the NASA Earth and Space Science Fellowship (NESSF); however, FINESST is not a fellowship. FINESST awards are research grants. If necessary, however, as described in Section 3.4 of the Grant and Cooperative Agreement Manual (GCAM) "Determining Whether to Issue a Grant or Cooperative Agreement", NASA may issue cooperative agreements to the submitting universities or other eligible institutions.

The titles of proposals that were selected by the participating divisions under the inaugural FINESST competition can be accessed on the NSPIRES page for FINESST-2019 by downloading the PDF files under the heading "Selections". In 2020, SMD estimates it will receive about ~1000 FINESST proposals and will select/award about 100. Dissimilar to FINESST-2019, in addition to the PI and FI names and institutions, abstracts of selected projects will be posted on the FINESST NSPIRES page.

A key criterion for proposal evaluation (See Section 5) and selection is the relevance of the proposed investigation to the Science Mission Directorate (SMD). Information on NASA's Strategic Goals and Objectives and SMD's high-level objectives is in 2018 NASA Strategic Plan. Detailed plans/objectives that correspond to the science divisions of SMD: Heliophysics, Earth Science, Planetary Science, and Astrophysics appear in Chapter 4 of the 2014 NASA Science Plan. All FINESST proposals must address one or more goal(s) and objective(s) relevant to at least one SMD division.

The proposal must present a well-defined research problem/activity and a justification of its scientific significance to NASA, as well as a detailed approach for its solution/conduct. Proposals should explain how the research is relevant to the particular SMD division that will review the proposal. The proposal should refer to a specific research topic(s) solicited by a Division (e.g., but not limited to, the program or program elements listed in Table 3 of ROSES).

Proposal submission requires choosing just one reviewing division. However, proposals that are relevant to more than one division are welcome. If, prior to a proposal's review, NASA determines that a submitted proposal belongs to a different division, then it may suggest that the proposal be sent to another division for review. Alternatively, NASA may choose to reassign the proposal without consulting the proposer and notify the proposer later.

1.1 Pre-Proposal Teleconference (Optional)

On a no-advance-reservation, first-to-dial-in basis callers can attend the pre-proposal teleconference. Email HQ-FINESST@mail.nasa.gov any teleconference agenda suggestions and questions using "December 2019 Telecon" in the email's subject line on or before November 25, 2019.

The optional pre-proposal teleconference on December 2, 2019, begins 1:00 p.m. and ends 2:30 p.m. Eastern Time. SMD will post the teleconference charts no later than noon Eastern Time on the teleconference day under “Other Documents” on FINESST's NSPIRES page.

An operator will add callers in listen-only mode and on-hold music will play until the FINESST leaders start the conference. If there is time to take caller questions, the operator who moderates will provide instructions during the call. Caution: to preserve anonymity callers, callers must not disclose their names or institutions. If a caller can't join the call for any reason, e.g., scheduling conflict, number of callers exceeds capacity, see Section 1.2 "Record/Replay of the Pre-Proposal Telecon".

No earlier than 30 minutes prior to the start time, call 1-888-324-3185 (U.S.-only Toll Free) or 1-630-395-0272 (U.S. Toll) and use Participant Passcode: 8018549. Restrictions may prevent the use of a toll-free number from a mobile or free-phone or from telephones outside the U.S.

For TTY-equipped callers or other types of relay services no earlier than 30 minutes before the start of the teleconference, call 711 and provide the same conference call number 1-888-324-3185 (U.S.-only Toll Free) or 1-630-395-0272 (U.S. Toll) and Participant Passcode: 8018549.

1.2 Record/Replay of the Pre-Proposal Telecon (Optional)

Unless the recording quality prevents it, e.g., poor sound, concerns about loss of caller anonymity, etc., audio-only, on-demand replays of the pre-proposal teleconference should be available by 6:00 p.m. Eastern Time starting on December 2. No later than 9:00 p.m. Eastern on January 30, 2020, on-demand replays will end. For the FINESST pre-proposal telecon replay call numbers 800-947-6790 (Toll Free) or 402-220-4622 (Toll) and enter Passcode: 120219.

Reminders: Restrictions may prevent the use of toll-free replay number from a mobile or free-phone or from telephones outside the U.S. For relay services call 711 and provide the FINESST pre-proposal telecon replay call numbers.

NSPIRES ~~will~~ post**ed** a written summary of the recorded call under "Other Documents" ~~no later than 45 days following the teleconference~~ **on January 16, 2020. [revised January 17, 2020]**

2. Scope of Program: Division Research Overviews

This section presents a partial overview of the research funded by SMD's science divisions that review FINESST proposals. Proposers may refer to the list of research program element(s) solicited by a particular division(s) in Table 3 of this year's ROSES solicitation to get an indication of topics that are covered by each division. This list is not exhaustive since it changes from year to year. If a particular program element is listed as "not solicited this year", TBD, or even absent this year, that topic is still in scope for FINESST. For example, despite the fact that ROSES-2019 does not solicit Biodiversity as program element A.7, a potential proposer to FINESST with an interest in that research may propose it to Earth Science. Similarly, though the DSCOVR Science Team doesn't appear on the list this year at all, Deep Space Climate Observatory data is still of interest to Earth Science. If the proposed project would be relevant to more than one division (e.g., exoplanets) then please note this in the abstract and specify those other divisions.

2.1 Earth Science Research Program

Earth Science proposers must review ROSES-2019 A.1 Earth Science Research Overview for complete information.

The Earth Science Research Program, managed by the Earth Science Division (ESD) of the Science Mission Directorate (https://science.nasa.gov/earth-science), contributes to NASA's mission, in particular, Strategic Objective 1.1: "Understanding The Sun, Earth, Solar System, And Universe" (from the 2018 NASA Strategic Plan). This strategic objective involves the following key questions:

- How is the global Earth system changing?
- What causes these changes in the Earth system?
- How will the Earth system change in the future?
- How can Earth system science provide societal benefit?

The ESD welcomes proposals that relate to: Research and Analysis, Applied Sciences, Earth Science Technology Office, and Flight. ESD encourages proposals that place particular emphasis on the utilization of unique NASA capabilities in studies of the Earth.

Do not submit to the Earth Science Division proposals on these topics:

- molecular biology, biochemistry, development, physiology, or evolution of living organisms, without a direct utilization of remote sensing approaches or global/regional modeling which makes use of remote sensing data, or
- efforts in laboratory and/or theoretical chemistry that are not directly related to remote sensing and/or computational modeling of atmospheric gas phase and particulate composition, or
- social science research that is not directly linked to NASA observations and/or models.

Proposers should examine the relevance to other SMD programs in FINESST (e.g., astrobiology in the Planetary Science Research Program) or graduate research opportunities funded elsewhere at NASA, e.g., the Space Technology Mission Directorate, etc., or outside NASA.

2.2 Heliophysics Research Program

Heliophysics proposers must review ROSES-2019 B.1 Heliophysics Research Program Overview for complete information.

Chapter 4.1 of the *SMD Science Plan 2014* available at http://science.nasa.gov/about-us/science-strategy/ describes the Heliophysics research program. The NASA Strategic Objective for Heliophysics is to understand the Sun, Earth, Solar System, and Universe. In pursuit of this objective, and with guidance from the National Research Council's most recent decadal survey, *Solar and Space Physics, A Science for a Technological Society* (download free PDF), key questions are:

- What causes the Sun to vary?
- How do the geospace, planetary space environments, and the heliosphere respond?
- What are the impacts on humanity?

The research program supports theory, modeling, and data analysis utilizing remote sensing and *in situ* measurements. The program also supports investigations of the physics of magnetospheres, including their formation and fundamental interactions with plasmas, fields, and particles and the physics of the terrestrial mesosphere, thermosphere, ionosphere, and auroras, including the coupling of these phenomena to the lower atmosphere and magnetosphere. For further information, consult *Our Dynamic Space Environment: Heliophysics Science and Technology Roadmap for 2014-2033* (download PDF).

2.3 Planetary Science Research Program

Planetary Science proposers must review ROSES-2019 C.1 Planetary Science Research Program Overview for complete information.

The Planetary Science Research Program, managed by the Planetary Science Division, sponsors research that addresses the broad strategic objective to "Ascertain the content, origin, and evolution of the Solar System and the potential for life elsewhere." To pursue this objective, the Planetary Science Division has five science goals that guide the focus of the division's science research and technology development activities. As described in Chapter 4.3 of the SMD 2014 Science Plan (https://science.nasa.gov/about-us/science-strategy), these are:

- Explore and observe the objects in the Solar System to understand how they formed and evolve.
- Advance the understanding of how the chemical and physical processes in the Solar System operate, interact and evolve.
- Explore and find locations where life could have existed or could exist today.
- Improve our understanding of the origin and evolution of life on Earth to guide our search for life elsewhere.
- Identify and characterize objects in the Solar System that pose threats to Earth or offer resources for human exploration.

The Planetary Research Program invites a wide range of planetary science and astrobiology investigations in order to address the goals above, but this program also supports research into:

- Investigations into the potential for both forward and backward contamination during planetary exploration, methods to minimize such contamination, and standards in these areas for spacecraft preparation and operating procedures;
- Investigations which enhance the scientific return of NASA Planetary Science Division missions through the analysis of data collected by those missions;
- Advancement of laboratory- or spacecraft-based (including small satellites, e.g., CubeSats) instrument technology that shows promise for use in scientific investigations on future planetary missions; and
- Analog studies, laboratory experiments, or fieldwork to increase our understanding of Solar System bodies or processes and/or to prepare for future missions.

2.4 Astrophysics Research Program

Astrophysics proposers must review the ROSES-2019 D.1 Astrophysics Research Program Overview for complete information.

The Astrophysics Research Program, managed by the Astrophysics Division, explores the Universe beyond our Solar System: from the search for planets and life in other stellar systems to the origin, evolution, structure, and destiny of the universe itself.

Investigations submitted to the Astrophysics research program should explicitly support past, present, or future NASA astrophysics missions. These investigations may include theory, simulation, data analysis, and technology development. The Astrophysics research program and missions are described in Chapter 4.4 of the SMD 2014 Science Plan available at https://science.nasa.gov/about-us/science-strategy.

3. FINESST Program Principles and Proposal Constraints

3.1 Eligibility and Restrictions on Submissions

Participation in ROSES-funded research by non-U.S. organizations in this program is welcome, but on a "no exchange of funds" basis. It is NASA policy that each international partner, its sponsoring agency, or its funding/sponsoring institution, covers its own research contributions (further information on foreign participation is provided in ROSES FAQ #14 on this topic and the *NASA Guidebook for Proposers*).

Normally, a higher education institution will submit the proposal; however, other institutions that may receive a grant and that have a relationship with an educational institution may submit a proposal as long as the FI is enrolled at an accredited U.S. higher education institution. The budget justification must provide evidence from the U.S. institution of the student's enrollment/good standing in an eligible degree program.

This call solicits proposals for a research project conducted by an individual Future Investigator (FI) who is or will be pursuing a Masters or PhD degree in an Earth or space sciences-related discipline from an accredited U.S. university. By the proposal due date, the student, known as a future investigator (FI), must have applied to, been admitted to, or be enrolled as a graduate student at an eligible, accredited U.S. university.

An FI may be a participant on only one submitted FINESST proposal at a time.

There must be a principal investigator (PI) at the submitting institution who will serve as the research mentor and acts as a champion for the FI by serving as guide, role model, teacher, etc., who supports the FI's research and professional development. The PI is determined based on the norms, policies, and practices of the proposing institution and the requirements of the proposed research. NASA does not advise or assist on who should be the PI.

A PI may submit more than one proposal to this program element (if it is on behalf of more than one student). See Section 3.2.

A PI may have FINESST and other (e.g., ROSES) proposals with overlapping tasks submitted at the same time. However, upon selection of either, the PI must alert both the funding FINESST program scientist and the other program manager. Proposals that overlap with previously submitted proposals still under consideration should acknowledge, e.g., in the budget justification, that funds are requested elsewhere. If NASA selects both the FINESST and non-FINESST proposals, the AOR/PI must inform the NASA managers so that budget negotiations/adjustments may ensue.

Although a proposing organization may submit more than one proposal to this solicitation, duplicative proposals from the same organization in the same year are not solicited and may be returned without review. However, the resubmission of a not-funded proposal from a prior competition is permitted and will treated the same as an entirely new submission.

A student currently or in the past supported by a NESSF award is not normally eligible for FINESST. Only students supported by NESSF for fewer than three years are eligible for support via FINESST and only up to a maximum of three years total support from NESSF and FINESST combined.

An FI who proposed to, but was not funded by, a prior FINESST or another solicitation such as NESSF is eligible to be included on a proposal in response to this program element. Similarly, a FI (or PI) who previously declined to accept NASA funding is eligible.

Since a FINESST award requires a significant commitment, an FI whose time is already funded by another award is not eligible to propose to this opportunity.

Students in the first or second year of a multi-year fellowship (such as from National Science Foundation or another source) that provides stipend and tuition beyond September 2020 are discouraged from participating in this FINESST solicitation.

During the period that a FINESST proposal is under consideration or during the period of performance of a FINESST grant, the funded institution's Authorized Organization Representative (AOR) must inform NASA if the student has accepted any Federal fellowship or traineeship that 1) provides stipend and other participant support costs, e.g., tuition *and* 2) is longer than three months in duration. In an instance when such a proposal is selected, NASA may require a revised budget and, if appropriate, a revised proposal for any active award to ensure that the FI can devote sufficient time to the FINESST research.

Since FINESST is a research grant and not a fellowship, there are no deferments, reserves, or tenure years. Only after selection or award are requests for a period of performance change potentially allowable. The funding program's technical officer in conjunction with the NASA Shared Service's Center (NSSC) handles/decides such requests on a case-by-case basis.

In accordance with 2 CFR 200 and a recipient's institutional policies, students funded by a FINESST grant may be eligible to pursue other employment, e.g., teaching, consulting, etc., or receive stipend support from another source if it does not conflict with or preclude conducting the FINESST research.

NASA recognizes and supports the benefits of having diverse and inclusive scientific, engineering, and technology communities. FIs (and PIs) with disabilities and/or from underrepresented minority groups are urged to propose. No proposal shall be denied consideration on the grounds of race, color, age, ethnicity, national origin, religion, pregnancy, sexual orientation, gender identity, sex, marital status, disability, or status as of a team member as a U.S. Veteran.

3.1.1 Limitations on Participants and Research Conducted in Designated Countries

In accordance with language in Appropriation Acts that restrict NASA from funding certain projects involving the People's Republic of China (PRC), NASA is "prohibited from funding any work that involves the bilateral participation, collaboration, or coordination with China or any Chinese-owned company or entity, whether funded or performed under a no exchange of funds arrangement." Proposing organizations will be required to certify compliance with regarding this NASA PRC funding restriction. Prospective FINESST PIs or/and FIs affiliated with PRC institutions may not be eligible. See https://science.nasa.gov/researchers/sara/faqs/prc-faq-roses/ for the ROSES FAQ on this subject.

The purpose of FINESST is to provide support primarily for fundamental research and/or technology development projects that normally would not expect to be subject to export control. However, should the FI's proposed research project fall under International Traffic in Arms Regulations (ITAR) or Export Administration Regulations (EAR), then only U.S. persons may be participants, and proposers must identify the parts of the proposal that contain ITAR material as instructed in Appendix A of the *NASA Guidebook for Proposers*.

Proposals that would involve research or collaboration outside the United States in "Designated Countries" that also are "State Sponsors of Terrorism" will be subject to additional levels of review by the Office of International and Interagency Relations (OIIR) that may result in a proposal being denied. NASA's "Designated Country (DC) List" is hosted on the NASA Export Control website at https://www.nasa.gov/oiir/export-control. The relevant part of the list is Column II, i.e., Countries determined by the Department of State to support Terrorism. The DC list is updated regularly; therefore, please consult the website to ensure use of the most up-to-date list. Otherwise, beyond the standard restrictions that prevent subawards to non-U.S. institutions, there are no restrictions on international collaboration. The FINESST program does not allow subawards/contracts.

NASA Centers and other Federal entities that do not grant degrees are not eligible institutions for FINESST awards. Federal civil servants who lack status or a qualifying affiliation at an eligible degree-awarding institution may not serve as Principal Investigators. Federal civil servants who are eligible to propose through an eligible institution may serve as PIs.

Regarding participation from a NASA Center, NASA civil servants must avoid any perception of or potentially real conflict of interest (COI). Civil servants who want to appear as a Collaborator or Co-Investigator in a FINESST proposal must follow the policies and procedures in place at their employing center or facility and, if applicable or necessary, refer questions to their Center's General Counsel. No Co-Investigators, including civil servants will be funded through this program.

3.2 Data Limitations and Requirements

3.2.1 *Data Eligibility*

Spacecraft mission data to be used in proposed work must be available in a publicly accessible archive (e.g., https://earthdata.nasa.gov/, http://spdf.gsfc.nasa.gov/, https://science.nasa.gov/astrophysics/astrophysics-data-centers, https://pds.nasa.gov/, and http://umbra.nascom.nasa.gov/) at least 30 days prior to the proposal due date.

Proposals that require spacecraft mission data that has not been public for at least 30 days prior to the full proposal due date are not compliant and may be returned without review or declined after review, no matter the peer review score. Proposals that can proceed with public data, i.e., are not reliant on future data, but would make use of future data if/when it comes along during the duration of the award are acceptable. Proposers should make it clear that the project would be improved by future data, but such data is not necessary.

The data eligibility requirement applies only to spacecraft mission data, not to other kinds of data, such as airborne campaigns, field campaigns, fieldwork, etc., that are collected as part of the proposed research. Proposing to use any kind of data that has not yet been collected is a risk but not prohibited. If a project is completely dependent on "risky" data, e.g., not acquired, not publicly available, etc., that could prevent selection and/or be noted as a proposal weakness.

3.2.2 *Data Management Plans*

In keeping with the NASA Plan for Increasing Access to Results of Federally Funded Research, a Data Management Plan (DMP), or an explanation of why one is not needed given the nature of the work proposed, is required to be contained by the NSPIRES coversheet. The DMP is not part of the proposal page limit, but it is limited to two, 4000-character plain text boxes on the NSPIRES web pages associated with the proposal. The goal of the policy is to ensure the public release of data that is generated as a result of federally funded research programs like this one. Thus, proposers should plan that all data will be made available by the end of the award, with certain notable exceptions: work that is proprietary or may affect U.S. economic competitiveness; work that results in personally identifiable human subjects research data; export-controlled data; controlled unclassified information data; national security classified data; and SBIR/STTR contracts. The point of the DMP is to ensure that the proposer plans in advance what data will be made public and that time is allocated to that important task. A DMP should answer these types of questions:

1. What data types, volumes, formats, and (e.g., where relevant) data standards?
2. Where does the project intend to make these data available?
3. When will these data be made available?
4. Who will do archiving and what experience do they have with this kind of data, archive, etc.?

Regardless of what the DMP submitted with the proposal says, grantees must still meet the mandatory minimum requirement that the data behind figures and tables in peer-reviewed publications be available electronically at the time of release, ideally in supplementary material with the article. See the ROSES DMP FAQs.

Clarifying Note: Third-party resource support letters to archive the data, permissions from data owners/authors, data licenses, or any other scenario are not required. Simply state in the DMP who has agreed to what. A data resource support letter(s) may be submitted with the FINESST budget. For additional guidance, see Section 4.1.6 “Budget Timeline and Narrative.” Reminder: Do not

add resource support letters from any collaborator or team member listed under Section VI of the NSPIRES cover page and who acknowledges commitment via NSPIRES. When a data collaborator directly confirms in NSPIRES, that is sufficient resource commitment to the FINESST project. [revised January 17, 2020]

3.2.3 *Archiving Manuscript Versions of Publications*

In keeping with the NASA Plan for Increasing Access to Results of Federally Funded Research, awards deriving from ROSES, including this FINESST program, include terms and conditions requiring that as accepted manuscript versions of peer-reviewed publications (hereafter "manuscripts") that result from ROSES awards be uploaded into NASA's part of the PubMed Central (PMC) repository called NASA PubSpace. The Federal Register notice on this subject specifies that manuscripts be deposited within one year of completion of the peer review process. Please note that not doing so may delay or prevent awarding of funds. This applies only to peer reviewed manuscripts. Patents, publications that contain material governed by personal privacy, export control, proprietary restrictions, or national security law or regulations will not be covered by this requirement. For more details on public access to scientific publications and digital scientific data resulting from NASA-funded research, please see: https://www.nasa.gov/open/researchaccess.

4. Proposal Preparation and Submission

The FI (student) must be the primary author of the proposal's research project description and personal statement.

Proposals are due: 11:59 p.m. Eastern Time, February 4, 2020.

All proposals must be submitted in electronic format only. For those unfamiliar with NSPIRES, instructions, tutorials, and FAQs for submitting electronic proposals are located at https://nspires.nasaprs.com/tutorials/index.html. If you already know how to submit an NSPIRES proposal, just go to the NSPIRES page for this FINESST element of ROSES and click on the appropriate "Create" button. Proposers must complete the NSPIRES cover pages, including the FINESST Program Specific Data questions, such as filling out the text box for the Data Management Plan, described above.

When creating the proposal one must choose the division (see Section 2) to which the proposal will be submitted. If the proposed project would be relevant to more than one division (e.g., exoplanets) then please note this in the abstract and specify those other divisions.

4.1 FINESST Proposals

The contents of the proposal must include the elements listed below, clearly identified, starting on a new page, and appearing in the order below in a single PDF file. **Page numbers are permitted in headers and footers, and no format style, letters, numbers, or combination is specified [revised January 17, 2020]**. Main body text of proposals and captions must use an easily read font of no more than 15 characters per horizontal inch (typical of 12-point Times New Roman) and no more than 5.5 lines per vertical inch (*i.e.,* single-spaced). There must be at least one-inch margins on all sides, and the proposal must be sized for U.S. letter size (8.5x11) paper. Non-compliant proposals may be returned without review. FINESST proposals do not require current and Pending Support, nor a Summary Table of Work Effort. In addition to (and after) the table of contents, the content of the proposal is as follows:

4.1.1 *Personal Statement*

This section must contain a personal statement of up to two pages authored by the FI that addresses the research readiness criterion from Section 5.1 and

a. Outlines the FI's goals, expertise, attributes, any relevant barriers to study and/or research encountered and steps taken to overcome any such barriers, etc.
b. Highlights any relevant academic or other experiences prior to proposal submission, e.g., undergraduate studies, or other degree(s), graduate study already completed, etc.
c. Provides a graduate study timeline that at minimum states the degree type (Ph.D/M.Sc. or both) and the start and completion dates estimates.

This section may total no more than two pages, conforming to formatting requirements (line spacing etc.) in Section 4.

4.1.2 *Science/Technical/Management Section*

This section describes the proposed research project and may include figures and tables as appropriate. This section, excluding citations, may total no more than six (6) pages conforming to formatting requirements in Section 4. The project description should include the following elements:

a. A well-defined problem with a justification of its scientific significance and a detailed approach for its resolution.
b. A statement describing the relevance of the proposed work to the appropriate SMD Division and a program within that division. Note: If the research is relevant to more than one division/program, please identify the other division(s).
c. A description of the approach to be taken to address the chosen problem.
d. A period of performance or timeline for the proposed project listing anticipated accomplishments and major milestones, including planned publications.

4.1.3 *References/Citations and Acknowledgements*

Citations and/or endnotes must directly follow the project description and are not included in the research description's 6-page limit. Provide all references and citations for the 6-page project description using easily understandable, standard abbreviations for journals and complete names for books. Providing URLs is done at the proposer’s own risk. Reviewers are not obligated to follow any links.

Though this FINESST element does not specify what is "allowed content" for either References/citations nor the Acknowledgements, it should not include technical information that belongs in the project description. The *Guidebook for Proposers Responding to A NASA Funding Announcement* explains restrictions and preferences for bibliographies and appendices.

In an acknowledgement statement of up to 150 words, describe the FI and PI or any other team member roles in preparing the proposal. This statement must affirm that the proposal is the work of the FI. It is acceptable for an FI to receive editorial and/graphic support from a writing center, copy editor, colleagues, and peers to improve the proposal (e.g., grammar, clarity, structure), but this help should be acknowledged, if applicable.

4.1.4 *Curriculum Vitae (CV) for the PI (mentor) and the FI*

The PI's and FI's CV or resume are mandatory and limited to two pages each. Any mentors beyond the PI may be given the role of (unfunded) Co-Is or collaborators, depending on their level of involvement. The CV is optional for any Co-I(s). Do not provide CVs for collaborators.

4.1.5 *Mentoring plan or agreement*

The Mentoring Plan/Agreement should not exceed 2-pages**.** Both the FI and PI prepare and sign this agreement that may include more than one mentor; however, having additional mentors does not extend the page limit. Non-PI mentors do not have to be at the submitting institution. It is optional to include mentors beyond the PI, but if they are named, they must be added to the NSPIRES cover page as team members.

At minimum, the Mentoring Plan must include a statement that the FI and PI have committed to the accomplishment of the research project. The content, format, and organization of mentoring plan are at the discretion of PI-FI team.

If the submitting institution has a standard Mentor-Mentee checklist, plan, agreement, template, etc., and it is longer than 2-pages, uses font size, margins, etc., that do conform to this solicitation, then the institution’s standard is acceptable.

The plan’s purpose is to provide the FI with a plan for developing skills and acquiring knowledge and experiences necessary to complete the research project and should address the research readiness criterion from Section 5.1. This mentoring plan does not need to re-state information provided in response to sections 4.1.1-4.1.4. The mentor(s) may explain in the mentoring plan why the mentor has agreed to support this FI’s research.

If the proposing institution has no mentorship standards, policies, forms, templates etc., then see Explanatory Note E: Mentoring Plan/Agreement: An Introduction for PI-FI Teams

4.1.6 *Budget Timeline and Narrative*

This section should not exceed 2-pages, excluding any special documentation that, for example, may be required from a non-profit that is not an education organization that the proposed FI is enrolled/in good standing in an eligible degree program at a university. **Another example of special documentation allowed by ROSES and Section 3.17 in the *Proposer's Guidebook's* are "Letters of Resource Support" ROSES Table 1 explains: "A letter of support is required from the owner of any facility or resource that is not under the direct control of the PI or a Co-I acknowledging that the facility or resource is available for the proposed use during the proposed period." If possible, use the FINESST format requirements for special documents such as, but not limited to, Resource Support Letters (RSL) [revised January 17, 2020].**

Propose a budget start date and end date. However, given NASA's review schedule and other limitations, the start date cannot be much earlier than September 1. In general, the latest proposed start date is one year (approximately) from this solicitation's February due date. NASA reserves the right to change the requested start date/end date for the award's period of performance.

Propose a timeline that makes sense for the research project month-by-month, quarterly, semester, etc. The budget timeline must include a brief budget justification narrative that explains the proposed allocation of funds across eligible participant support categories, e.g., what is the stipend? What is for the FI's activities as a mentee, e.g., travel, subscriptions, workshop registrations, society memberships, etc.? What, if any, amount is requested for tuition or similar funds for the university? When the university is committing to reduce or waive tuition and fees for the student, specify that amount in the budget justification. See Section 10 Explanatory Note B - Limitations on FINESST Budget Categories.

Students funded by a FINESST grant may receive funding from other sources for expenses not covered by this award (e.g., to purchase equipment). FIs may take a hiatus to pursue other activities such as internships, family leave, military leave, etc. When a student is on hiatus for any period after the funding has been awarded, the student will not receive a FINESST stipend, and the institution shall not draw down/spend the FINESST stipend funds during the FI's hiatus.

FINESST funds may be requested to support an FI's tuition; fees (allowable under 2 CFR 200 and consistent with university policy); travel in support of the research investigation or to conferences, symposia, or collaborative meetings; text books or other instructional supports; expendable laboratory supplies; page charges for journal articles; printing of a thesis; or health insurance policy, see Section 10.2 Explanatory Note B-Limitations on FINESST Budget Categories.

4.1.7 *Optional High-End Computing Appendix*

The High-End Computing (HEC) program (https://www.hec.nasa.gov/) provides a specialized computational infrastructure to support NASA's research community. Proposers to FINESST may apply for HEC resources to support their research by uploading an Appendix as a separate PDF file, so do not include it in the main proposal

PDF file. See Section 10.1, Explanatory Note A, below for details on how to pursue this option.

4.1.8 *Proposal compliance*

- Proposals containing unsolicited appendices/attachments may be declared noncompliant.
- Do not include undergraduate or graduate transcripts for the FI. This is a research grant not a fellowship.
- Proposals not submitted by the required deadlines, and/or that do not meet the eligibility, page length, formatting and/or other requirements as listed in the funding announcement may be returned without review.
- Team members beyond the FI and PI are permitted in cases where needed, e.g., to show a second mentor. NASA wants to know who will be participating on the project in order to manage organizational conflict of interest during peer review, but, in general, additional team members do not give any advantage nor may they be funded via FINESST.
- All team members must be listed on the NSPIRES cover page. Please note that a proposal cannot be submitted if any listed team member, including unfunded collaborators, do not log into NSPIRES and confirm their role on the proposal.
- **FINESST does not invite recommendations or support letters. A recommendation letter is a type of "letter of affirmation," i.e., letters that endorse the Intrinsic Merit, including significance or impact, of a proposal. If letters of affirmation are submitted, they may not be submitted as an appendix; they are counted and included within the six (6) page Scientific/Technical/Management section. For full details see Section 3.17 “Statements of Commitment and Letters of Resource Support” of The 2018 Guidebook for Proposers Responding to A NASA Funding Announcement. [revised January 17, 2020]**

4.2 Confirmation of Proposal Submission and Late Proposals

Proposals must be complete and submitted electronically by 11:59 p.m. Eastern Time on the due date given in Tables 2 and 3 of ROSES. NSPIRES generates an automatic acknowledgement when any proposal is submitted. When the FINESST solicitation completely shuts down on NSPIRES, the proposer is prevented from finishing a submission. If the institution did not receive an email confirming submission of a proposal, check spam filters and junk boxes. If unable to locate the email acknowledgement, contact the NSPIRES Help Desk or log in directly to NSPIRES to check a submission status.

NSPIRES marks FINESST proposals submitted after the due date or deadline as "late". Late proposals will be handled in accordance with the SMD Policy on Late Proposals. SMD does not pre-approve the submission of a late proposal. The decision to submit a late proposal is solely that of the proposer, and it is then NASA’s decision whether to accept it or not. Late proposals are rarely accepted, except in cases of problems with NSPIRES. The FINESST program scientists/administrators are not empowered to authorize the submission of a late proposal.

5. Proposal Evaluation and Selection

5.1 Review

NASA Headquarters Science Mission Directorate scientist(s) and program managers/executives, or their designees, conduct proposal evaluations through one or a combination of the following methods: individual reviews, virtual panels, or face-to-face panels. Reviewers can be from the external community including scientists at NASA Centers. While reviewers may not be experts in every subtopic or discipline within the FI's proposed research field, the reviewers will be experts in the broader research.

If SMD determines that a proposal has been submitted to the wrong division prior to review, then it may give permission for a proposal to be reassigned to another SMD division or shared for additional review.

For a detailed description of standard NASA review processes for proposals, including qualitative rating definitions, see APPENDIX D of the most recent *NASA Guidebook for Proposers* (also known as *Guidebook for Proposers Responding to a NASA Research Announcement* and *Guidebook for Proposers Responding to a NASA Funding Announcement*) available at: https://www.hq.nasa.gov/office/procurement/nraguidebook/.

The standard proposal review process includes for each review criterion a narrative assessment of a proposal's strengths and weakness. For detailed information, see the *ROSES-19 Summary of Solicitation* Section VI. "PROPOSAL REVIEW INFORMATION."

This program element has criteria that differ from the default presented in the ROSES Summary of Solicitation. The criteria for evaluation of FINESST proposals are:

(a) The scientific merit of proposed research project. Assessing the scientific merit of the proposed research includes:

1. The compelling nature of the research topic.
2. The exhibited depth of understanding of the research topic.
3. The expected impact of the research, should it succeed.
4. The feasibility of the proposed research plan, including the availability of resources for successful completion of the project.
5. The robustness of the research plan to anticipated setbacks.

(b) The relevance of the proposed research or technology development to SMD's objectives in Earth and/or space science as described in Section 2: Division Research Overviews. Proposals must be specific about how the proposed research is relevant to the particular division/program that will review the proposal. Note: peer reviewers may comment on relevance, but the funding SMD Division makes the ultimate determination on relevance.

(c) Research readiness assessment.

This criterion focuses on how the FI's research design, approach, attitudes, or perceptions correlate to their actual research skills/capabilities as described in the:

1. FI's personal statement.

2. The PI-FI Mentoring Plan/Agreement.
3. The FI's curriculum vitae/resume.
4. The PI's curriculum vitae/resume.

Reviewers evaluating research readiness may be asked to consider the following questions: Does the FI's record of performance demonstrate an ability to excel and to learn? Does the choice of research mentor(s) complement the proposed research project? Has the FI been involved in any activities within or outside of academia that make them particularly capable of conducting the proposed research? Will the proposed mentoring activities advance the FINESST research and enable access to resources, prepare the FI to apply for NASA opportunities, and/or in other ways facilitate the FI's growth as a new professional?

(d) Cost reasonableness.

FINESST grants are limited cost category awards. NASA personnel will look at the split between stipend and other participant support costs (see Section 6).

5.2 Selection

The Directors of the Science Divisions of SMD at NASA Headquarters or their designees make the respective award selections. The Selection Officials will select proposals as judged against the evaluation criteria in Section 5.1, divisional objectives, and those in this announcement, programmatic considerations, and the available financial resources.

Many proposals will receive scores that make them fundable but may not be selected for programmatic reasons, e.g., either because the proposed work is redundant with another FINESST project, or the topic is deemed by NASA to be of lower priority for funding/selection. Other programmatic considerations include and are not limited to balance across subdisciplines and institution types, technologies, methodologies, data accessibility, etc.

At the conclusion of the review/selection process, an NSPIRES email will be sent to the PI and the university asking them to log into the NSPIRES. PIs/organization representatives are responsible to download NASA letters and feedback and share with the FI. Abstracts of selected proposals will be publicly posted on the NSPIRES page for FINESST.

6. Award Information and Restrictions

Unless otherwise specified in the proposal, the default start date of all new awards is September 1, 2020. A NASA grant officer at the NASA Shared Services Center (NSSC) in Mississippi will conduct a pre-award review of risk associated with the proposer (*i.e.,* submitting university or non-profit) as required by 2 CFR 200.205.

FINESST supports an independent research project performed by a Future Investigator (FI). The PI and the FI are to work with the university Office of Sponsored Research or its equivalent to determine the appropriate allocation in each budget category.

The maximum amount of a FINESST award is $45,000 per 12-months and up to $135,000 total for a period of performance maximum of 36 months (not including a hiatus, if applicable).

SMD suggests a student stipend of $35,000 per 12 months; however, the stipend should be comparable with the institution's prevailing rate**.** When the FI's level of effort will be less than 12 months, and when a $35,000 stipend is the institution's normal prevailing rate, then the institution normally prorates the FINESST stipend in the budget.

The FINESST grant can fund up to a three-year research project, contingent upon availability of funds and satisfactory progress as demonstrated through the annual progress report from the university. If the NSSC implements the change of a period of performance as an administrative supplement or amendment, the duration or project's period of performance may exceed three calendar years or 36 months. For example, SMD will accommodate reasonable requests for a hiatus (to pause and later resume the research project and hence costing the FINESST grant), e.g., for family, medical, or military leave or for the student to gain other experiences (e.g., teaching, conducting fieldwork). Awardees may seek a No-Cost Extension Request at https://www.nssc.nasa.gov/nocostextension.

An FI supported for fewer than three years while obtaining a Masters may continue as a student participant on the FINESST grant while they pursue a PhD at the awarded institution. Even after completing a terminal degree, if acceptable to the awarded institution, the FI may remain at the grantee institution to continue the research. Not all projects require the maximum amount available in the period of performance. Proposers should lay out the proposal's budget justification as explained in 4.1.7 *Budget Timeline and Narrative*.

If, prior to the award's expiration date, a student departs the university, or ceases to perform the research project without a reasonable justification and expectation of return to the project, the university must communicate promptly to NASA. See Section 10 Explanatory Note D - Change of Original FINESST Student.

If the PI needs to be changed, then the standard NASA policies in the Grants and Cooperative Agreement Manual (GCAM) apply.

Students, faculty or staff in programs receiving NASA financial assistance, such as grant awards from this program, may raise allegations of discrimination, including harassment, by contacting the NASA Office of Diversity and Equal Opportunity. Find information on filing a complaint through ODEO at https://missionstem.nasa.gov/filing-a-complaint.html.

FINESST awards can follow a student to a new institution. FIs who have had less than the 3 years of FINESST funding are eligible to be on a proposal from the new institution with a new PI. The Science Mission Directorate may consider funding the FINESST student on a single source proposal, i.e., a non-competitive, invitation-only mechanism or, if timing permits, ask that a follow-on or transfer proposal be submitted to an open FINESST solicitation.

These decisions are made on a case-by-case basis with approval required from the funding SMD Division's Selecting Official and the NASA Shared Services Center. For example, when only the student is transferring and not the PI to a new institution, e.g., to start a PhD program or due to family reasons, etc., then the student, PI, and AOR must email HQ-FINESST@mail.nasa.gov, or if an Earth awardee claire.i.macaulay@nasa.gov, and the FINESST award's technical officer to determine whether funding is available. Send such requests as soon as they arise, and allow at least six (6) months for NASA processing.

7. Reporting Requirements and Intellectual Property

In accordance with any award terms and conditions provided by the NSSC at the time of award, a progress report must be emailed annually by March 15. If an adequate progress report is not received, then the NSSC will not send funds. See Section 10. Explanatory Note C - Elements of a FINESST Progress Report for the email addresses.

Expenditures under any NASA grants, including FINESST, are subject to inspection and audit during the period of the grant and for three (3) years thereafter. Records at the awarded institution must be maintained in sufficient detail to evidence prudent management and to facilitate the preparation of the required reports for determining whether expenditures are being/were made for the purposes for which the funds were granted.

Reporting requirements consistent with 2 CFR 200 will be specified by the official grant sent to the university upon issuance of the award, see Exhibit E – Required Publications and Reports of the NASA Grant and Cooperative Agreement Manual (accessible from https://prod.nais.nasa.gov/pub/pub_library/srba/index.html).

Award recipients may be subject to reporting requirements under the NASA Plan for Increasing Access to the Results of Scientific Research, including submitting peer-reviewed manuscripts and metadata to a designated repository (currently PubMed Central) and reporting publications with progress reports. For more details on public access to scientific publications and digital scientific data resulting from NASA-funded research, please see: https://www.nasa.gov/open/researchaccess. Any such requirements will be identified in the Notice of Award from the NSSC.

For information about data rights and other aspects of intellectual property such as invention rights resulting from awards, see the file entitled "Award and Intellectual Property Information" under the section called "Grant and Cooperative Agreement Guidance" at https://prod.nais.nasa.gov/pub/pub_library/srba/.

8. Collection of Demographic Information

NASA requests and collects demographic data from principal investigators and other NSPIRES users for the purpose of analyzing demographic differences associated with its award processes. Information collected will include name, gender, race, ethnicity, and disability status. Submission of the information is voluntary, confidential, and is not a precondition of award.

9. Points of Contact and Frequently Asked Questions

The Astrophysics, Earth Science, Heliophysics, and Planetary Science Divisions provide representatives to the SMD-wide FINESST Team. Members of the Deputy

Associate Administrator for Research (DAAR) team coordinate FINESST. Email questions to: HQ-FINESST@mail.nasa.gov.

ROSES-2019 E.6 FINESST questions and responses, with identifying information removed, will be posted on the NSPIRES page for this program under "Other documents".

10. Explanatory Notes

10.1 Explanatory Note A: NASA-Provided High-End Computing (HEC) Resources

SMD provides a specialized computational infrastructure to support its research community, managed on its behalf by NASA's High-End Computing (HEC) program (see the HEC website at https://www.hec.nasa.gov/). Two major computing facilities are offered, namely, the NASA Center for Climate Simulation (NCCS) at the Goddard Space Flight Center (GSFC), and the NASA Advanced Supercomputing (NAS) facility at the Ames Research Center (ARC).

The HEC program facilities maintain a range of computing systems with significant data storage resources. These offerings are summarized at https://www.hec.nasa.gov/about/overview.html. Augmentation and refreshment of these central systems occur on a periodic basis. The HEC program also provides assistance in code porting, performance tuning, scientific data visualization, and data transfer.

Any need for computing time and other HEC Program resources for the proposed research must be justified by completing a request for inclusion with a FINESST proposal (see sections i and ii below).

(i) Generate Request for HEC Resources

The purpose of this step is to inform FINESST reviewers at NASA of your computational needs, and if the FINESST proposal is selected, establish eligibility to use HEC resources. The PI (not the FI) completes and submits a request in the HEC Request Management System (RMS) at https://request.hec.nasa.gov or https://request.hec.nasa.gov/login?url=%2F. The form includes a written justification of how the computational resources would support the investigation as well as a multi-year resource-phasing plan, in annual increments, identifying the computing time and data storage requirements covering the duration of the proposed award period.

About the RMS User Interface: The RMS asks for information in six different sections. Some RMS items will capture responses in a text box and some items provided restricted or limited choices. When RMS asks:

1. NASA Sponsoring Directorate, select NASA Science Mission Directorate (SMD).
2. NASA Sponsoring Program, select the proposal's reviewing/funding division, e.g., Astrophysics Division (APD), etc.
3. Requested Start Date, type in 09/01/2020. Reminder: Normally FINESST start on this date, but if you have a different start date on your NSPIRES cover page, then use that date.
4. Project Duration (in years), select either 1 or 2 or 3.
5. Funding Type, select Research Opportunities in Space and Earth Science (ROSES).
6. Funding Year, select 2019

7. Funding Name, select Future Investigators in NASA Earth and Space Science and Technology (FINESST).
8. Funding Manager, select the name of funding division’s FINESST Program Scientist, i.e., Astrophysics (APD) = Evan Scannapieco, Earth (ESD) = Allison Leidner, Heliophysics (HPD) = Roshanak Hakimzadeh, and Planetary (PSD) = Lindsay Hays.

Computing time must be described in the request using Standard Billing Units (SBUs), a common unit of measurement employed by the HEC program for allocating and tracking computing usage across its various architectures. The RMS has a built-in calculator to help convert processor (CPU) hours to SBUs. SBU Conversion Factors are also available at https://www.hec.nasa.gov/user/policies/sbus.html, or proposers may contact HEC support staff for further assistance calculating SBUs. Contact information can be found at https://www.nas.nasa.gov/hecc/support/user_support.html for NAS User Support and https://www.nccs.nasa.gov for NCCS User Services Group.

If you are having difficulties using RMS and need technical support, then please email support@hec.nasa.gov and specify in the subject line "NNH19ZDA001N-FINESST HEC Request". Please allow 72 hours for a response before sending a second email.

(ii) Upload Request for HEC Resources

Save a PDF copy of your request after submitting it using the button provided in RMS. During the proposal submission in the NSPIRES system:

- Upload the PDF version of your computing time request as a separate file from your proposal and select "Appendix" as the document type when uploading.
- On the NSPIRES Cover Page
  - Check the box indicating that a request for HEC resources is included in the proposal, and
  - Enter the HEC Request Number (specified on the PDF). Reminder: Be sure to answer the HEC Program Specific Data questions with the NSPIRES Cover Page**.**

During the review of the proposed investigation, NASA will consider whether the computing time requested is an appropriate use of the highly constrained resources dedicated to FINESST.

Selection of your FINESST proposal does not guarantee that your HEC request is will be fully allocated; it means that your HEC request is eligible to progress to the next step for evaluation by the HEC Program (see section iii). While you are guaranteed some HEC time, it may differ from your request given resource constraints.

(iii) Allocation of HEC Resources

If your proposal is selected for funding, your HEC request will be evaluated by the HEC Allocation Authority. The HEC program will then issue letters identifying yearly allocations of HEC resources for the duration of the project, which again, may differ from your request due to limited availability of resources. However, PIs may submit requests to increase or decrease allocations of HEC resources if there are unexpected changes to computational needs. Requests for modifications must be submitted via RMS. Allocation in full cannot be guaranteed, but SMD will make every attempt to satisfy the needs in the context of the overall set of requirements, resource constraints, and science priorities.

To expedite initiation of new projects where PIs and/or users are foreign nationals (whose accounts will require additional documentation and longer processing), the HEC program will consider providing a minimal allocation to such projects that have been notified of pending funding soon after the PI submits an allocation request in RMS. PIs must provide the name of the FI participant (note that an FI is not a Co-I) who may use the account and identify foreign national status in the HEC request abstract.

For further information (no-how-to-use RMS questions) about NASA-provided High-End Computing resources, please contact Dr. Tsengdar Lee at Tsengdar.J.Lee@nasa.gov or 202-358-0860.

10.2 Explanatory Note B: Limitations on FINESST Budget Categories

FINESST research grants are limited to the cost categories identified in 2 CFR 200.75 Participant Support

- stipends
- subsistence allowances
- travel allowances
- registration fees paid to or on behalf of the student in connection with conferences

In general, NASA does not permit indirect costs (overhead) to be requested or recovered on participant support costs.

Because FINESST is not a fellowship, there is flexibility in what can be included as a reasonable, allowable, and allocable participant support cost, i.e., supplies, etc. However, because this particular program is limited solely to participant support costs, do not request indirect costs in the budget. Indirect costs are not an allowable, allocable, or reasonable cost under FINESST. NASA may return a non-compliant proposal that includes indirect costs without review.

Since a PI's, Co-I, or Collaborator's current employment includes compensation and continues whether or not the proposal is selected by NASA, no salary, travel, or other costs shall be requested from SMD for the PI's, Co-I's, or Collaborator's use.

While the purchase of equipment in excess of $5,000 is not permitted through FINESST awards, if an institution's policy permits the purchase of computers, digital devices, or materials, such as to support mentoring activities for the FI or to construct a CubeSat as a participant support cost without charging indirect, then these "other" charges are allowable.

FINESST budgets require a narrative justification in the proposal (about 1-2 pages) by three or four broad cost categories 1) FI stipend; 2) FI allowance(s), *e.g.,* travel, *etc.*; 3) University Fees/Tuition; and 4) Other.

Input these FI costs on the NSPIRES coversheet under letter E. Direct Costs- Participant/Trainee Support Cost. NSPIRES listed subcategories are 1) Tuition/Fees/Health Insurance, 2) Stipends, 3) Travel, 4) Subsistence, and 5) Other.

FINESST awards are limited to a single students, so the Number of Participants/Trainees on the NSPIRES cover sheet is never greater than one.

SMD suggests an FI's maximum stipend normally is $35,000 in any 12-month period. If an FI's stipend will be less (or more) than $35,000, then the amounts in the stipend and other participant support budget categories may be adjusted/exchanged. Normally, however, the FI's travel, registration fees, and other participant support costs do not exceed $10,000 in a 12-month period. Any request for partial year, i.e., a period of less than 12 months, should propose an appropriate prorate of the stipend and other costs.

In cases where the FINESST $45,000 is not enough to cover the standard cost of the student at the university for a 12-month period then, in order to cover the remaining FI costs, the university may choose to cover these additional expenses from other sources and show in the proposed budget the amount and source of the cost share. Alternatively, the proposal can plan that the FI take a hiatus to work on something funded by a non-FINESST source.

If NASA determines the proposal provides sufficient justification, then the amounts in the stipend and other budget categories are adjustable as long as the total amount requested does not exceed $45,000 in a 12-month period.

Changes to the period performance, including no cost extensions, will follow normal NASA grant procedures. The PI and FI are to work with the university's Office of Sponsored Research, or its equivalent, to determine the appropriate allocation in each budget category at the time of proposal and any subsequent changes to the budget post award in the annual progress report.

A proposed project's proposed start date, for example, may or may not be the same as its award date. A revised budget and revised detailed narrative justification may be requested before a selection or an award can be made. No commitment on the part of NASA should be inferred from technical or budgetary communications with a SMD civil servant, contractor, or JPL employee requesting budget revisions. Proposers are cautioned that only a NASA Grant/Contracting Officer from the NSSC may make commitments, obligations, or awards on behalf of NASA or authorize the expenditure of funds.

While the NSPIRES coversheet asks for cursory budget data, it is not a budget; therefore, it is necessary to address Section 4.1.6 Budget Timeline and Narrative. Proposed budgets, with narrative and any necessary supporting documentation, are a required section of the FINESST proposals and are subject to NASA procurement policies and negotiations.

10.3 Explanatory Note C: Elements of a FINESST Progress Report

As normal NASA grants under 2 CFR 200, this program requires only the standard mandatory minimum Research Performance Progress Report (RPPR). Progress reports are due annually by March 15. If March 15 falls on a non-work day, however, the next business day is a suitable email delivery/send date. The first progress report will be for a period of performance shorter than 12 months and due by March 15, 2021.

Progress Reports for Space Science: Email an annual progress report as a PDF attachment to NSSC-Grant-Report@mail.nasa.gov and the Space Science, (i.e., Astrophysics, Heliophysics, Planetary Science) technical officer identified on the NASA Form 1687, which is the first page of the grant award documents from the NSSC.

Progress Reports for Earth Science: Email the progress report as a PDF attachment to NSSC-Grant-Report@mail.nasa.gov and claire.i.macaulay@nasa.gov.

All FINESST progress report emails must have subject line that states 1) the NSSC-issued award number, 2) PI Name and 3) Institution Name. Failure to use and include the three items in the email subject line may significantly delay processing.

If for any reason, the organization will not be requesting continuation of a FINESST grant, a progress report should not be submitted. Instead, send an email to the award's 1) technical officer, 2) HQ-FINESST@mail.nasa.gov, 3) only applicable for Earth Science, the Earth Science FINESST administrative point of contact, and 4) the Grant's Officer at the NASA Shared Services Center (NSSC) to the effect that the project is ending early and a final report forthcoming to close out the award. Various final and closeout reports will be described in the NSSC award documentation.

Progress reports are short documents of approximately 2-4 pages, particularly for the first report. Progress reports are not new proposals. Progress report elements, excluding the optional high-end computing appendix, must be combined into a single PDF document and include the following, although each given section may be brief:

I. Administrative

- Name and address of the recipient's institution & Award Number
- Name of the Principal Investigator
- Name of the Future Investigator
- Award Title
- Type of Report: Choose one: Annual/Final
- Period covered by the report: <Month/Year to Month/Year>

II. Accomplishments

Start by reminding NASA what are the major goals and objectives of the project, and what did the FI do to progress toward those goals?

Did the FI do coursework or receive any professional development funded by the project? Provide an update toward completing a degree program with month/year completion date estimated. If no course work was planned or taken, state no coursework for this period.

III. Status/Changes/Issues/Updated Budget Narrative Justification (if applicable)

FI should discuss any stated goals not met or started.

If the PI/Institution got a warning/notification from the NSSC (e.g., "zero drawdown") because funds are not being spent, then the progress report should explain the lack of funds drawn down (e.g., because the student is on hiatus).

If not previously reported in writing to the NASA Shared Services Center and the awards technical officer at NASA Headquarters through other mechanisms, i.e., calls, emails, provide the following additional information:

Changes in approach and reason for change.
Actual or Anticipated problems or delays and actions or plans to resolve them.
Changes that have a significant impact on expenditures.

An updated budget justification narrative, if needed, especially if it is anticipated that the student may graduate, take a hiatus, or leave the program or university for any reason.

IV. Dissemination Activities (if applicable)

Have the results/activities been disseminated? For example, include a list of presentations, publications, videos with URLs, etc. Publications including web postings should acknowledge NASA support, including the FINESST program name and the NASA award number.

V. An Updated PI/FI mentoring plan/agreement (optional)

For example, if there will be a proposed PI change on the current FINESST award, explain that change to the mentoring plan and include a 2-page bio for the new PI requesting the change.

VI. Known Future Plans

Do the PI/FI anticipate a hiatus and/or no-cost extension?
If this is a final report, will the work continue post funding?
Is the FI remaining at the institution or moving on to new studies or a job offer, etc.?

VII. High-End Computing (if applicable)

If applicable, a progress report may include a new (or updated) request or modify high-end computing resources. If you are submitting a new HEC request, see Explanatory Note A of this solicitation for details. Be sure to allow enough time to compete the steps outlined in Explanatory Note A in order to create a new HEC appendix request for the progress report. A copy of a new HEC request should be provided as separate PDF file from FINESST award's progress report to the technical officer. The NSSC does not need a copy of the HEC request. If the project has an existing HEC-issued award and a modification is needed, please follow the guidance provided with the HEC award.

10.4 Explanatory Note D: Change of Original FINESST Student

In the event that an FI leaves the institution prior the completion of the research project or ceases to participate in the FINESST research for any other reason, NASA will determine how best to proceed.

The PI and FI should email the NASA program manager to let them know of the anticipated request so that the program manager can weigh in on the best course of action. On a case-by-case basis, NASA will formally consider a request for an FI change from the PI when the university's AOR emails a change request to the award's FINESST manager at HQ; the grants officer at the NSSC; and to HQ-FINESST@mail.nasa.gov.

An FI change request may propose that a masters or Ph.D. candidate, who is pursuing similar research, be named to expend the balance of the FINESST funds already with the institution. The request from the PI and the Office of Sponsored Research must include: 1) A statement (preferably from the original FI) indicating the date and reason for departure. 2) The successor FI's 2-page CV and mentoring plan. 3) Confirmation of the substitute student's status as a M.Sc. or Ph.D. candidate. 4) Specify what, if any, change is necessary to the period of performance and/or research scope. NASA will consider FI changes for administrative and/or merit-based reasons.

NASA review of such change requests includes, but is not limited to, scientific merit and continued relevance to NASA factors before deciding whether to approve. If approved, NASA may only allow a substitute student to use the current grant year funds and will not provide additional funds in future years. Caveat: Students who had three years of NESSF funding are not eligible to be named as an FI.

If the institution chooses not to propose a substitute FI, then the AOR still must email the award's program officer at HQ; grants officer at the NSSC; and HQ-FINESST@mail.nasa.gov with the news of the FI's departure and request an earlier end date to the period of performance. NASA will then proceed to grant close out.

10.5 Explanatory Note E: Mentoring Plan/Agreement: An Introduction for PI/FI Teams

Please verify whether your organization has mentorship resources or templates available. Go to your institution's website and search on key words, e.g., "mentor", "mentee", "mentor resources", etc., and communicate with your PI and organization about mentorship resources. If your proposing organization has mentorship information, please use it and refer to it. If your organization really has no mentorship plan, then adapting a mentoring plan designed originally for another purpose (such as a postdoctoral fellowship, NSF award) for use with FINESST is acceptable.

A mentoring plan or an agreement is not a confidential recommendation; rather, it sets respectful, reasonable expectations or goals and thus may help to foster a good working relationship that will further the FINESST research. It is to be hoped that the FINESST mentoring plan/agreement will set appropriate expectations for the working relationship early, be reviewed regularly, and be easily revisable, providing an opportunity for FIs to request adjustments that they may otherwise find uncomfortable bringing up with the PIs.

Through the mentoring plan, the PI and FI identify and work toward research career development goals designed to deepen the FI's understanding of the FINESST research, career pathways, broaden resource networks, and facilitate growth as new professionals. A non-exhaustive list of mentoring activities that a plan may include, but is not limited to: 1) training in the preparation of data, publications, presentations, etc.; 2) opportunities to collaborate with researchers from diverse backgrounds and/or disciplinary areas; and/or 3) responsible professional practices coaching.

A FINESST selection by NASA has the potential to be life changing for the FI as a graduate student and in the early career years that follow degree attainment. A FI's potential for success improves when the PI and the mentoring plan support the FI's research development and independence; recognizes when to refer an FI to other experts and resources; and provides the FI with regular, kind, clear, and honest input. For resources related to STEM mentoring, selected URLs include:

American Association for the Advancement of Science STEM Mentor Resources
Pathways to Science: Mentoring Manual
Committee on the Status of Women in Astronomy's Mentoring Page

10.6 Explanatory Note F FINESST Proposal Preparation: Item Check List, Page Limits and Number of PDF Files

All FINESST proposals must include the following materials in the following order. First, the system-generated Proposal Cover Page created by filling out the required fields such as name of the FI, electronic Commitments from Co-Is or any Collaborators, if any, answering the questions on the NSPIRES web page, e.g., providing the Data Management Plan, a research abstract suitable for public posting upon selection, etc. There is no page limit, NSPIRES will generate the required number of pages and automatically place this at the front of the proposal if the fields are filled out. There is no need to download the cover page and attach it to the uploaded PDF file.

Checklist of Items to be included in the single proposal PDF File (all page limits maximum, unless specified):

- Table of Contents - 1 page.
- Personal Statement (authored by the FI) - 2 pages.
- Science/Technical/Management Section (authored by the FI) 6 pages
  Including illustrations, tables, figures, and foldouts.
- References/Citations and Acknowledgements 1 page or more as needed.
  At minimum must include a statement that the proposal is the work of the FI.
- Resume/Curriculum Vitae (CV) For the PI and FI – 2 pages each.
- CV for Co-I(s): Optional – 1 page each.
- A PI-FI mentoring plan or agreement – 2 pages.
  Exception: If the submitting institution has a standard Mentor-Mentee checklist, plan, agreement, template, etc., and it is longer than 2-pages, uses font size, margins, etc., that do conform to this solicitation, then the institution's standard is acceptable.
- Budget Timeline and Narrative – 2 pages.
  Excluding any special documentation, e.g., when submitting institution is not an education organization, proof that the proposed FI is enrolled/in good standing in an eligible degree program at a university, etc.

Second PDF File - only when applicable

- Optional High-End Computing (HEC) Appendix, See Explanatory Note- A for details.

Unlike other ROSES elements, there is no need for a separately uploaded "Total Budget" file.

11. Summary of Key Information

Expected annual program budget for new awards	No dedicated budget; selected proposals will be funded by the relevant SMD program.

Number of new awards pending adequate proposals of merit	The number of proposals selected will be dependent on the number and quality of proposals submitted and on the availability of funds from the relevant SMD program.
Maximum duration of awards	3 years and see Section 6.
Due date for Notice of Intent to propose (NOI)	Not Applicable. Notices of Intent are not requested/accepted for this program element.
Due date for proposals	Proposals may be submitted at any time until 11:59 pm Eastern time on February 4, 2020.
Planning date for start of investigation	September 1, 2020
Page limit for the central Science/Technical/Management section of proposal	6 pp; see also Sections 4.1 and 10.6 of this program element.
Relevance	See Section 2. Proposals that are relevant to this program element are, by definition, relevant to NASA.
General information and overview of this solicitation	See the *ROSES Summary of Solicitation*. Grants and cooperative agreements will be subject to the policies and provisions identified in the regulations at 2 CFR (Code of Federal Regulations) 200, *NASA Grants and Cooperative Agreements Manual* (GCAM), and the *NASA Guidebook for Proposers*. In the case of any conflict, the order of precedence is as follows: regulations, NASA GCAM, this program element, the umbrella NRA, and then the *NASA Guidebook for Proposers*.
General requirements for content of proposals	See Section 3 of the *NASA Guidebook for Proposers* and Section IV and Table 1 of *the ROSES Summary of Solicitation*.
Detailed instructions for the submission of proposals	See https://nspires.nasaprs.com/tutorials/ Sections 3.22-4.4 of the *NASA Guidebook for Proposers* and Section IV(b) of *the ROSES Summary of Solicitation*.
Submission medium	Electronic proposal submission is required; no hard copy is required or permitted.
Web site for submission of proposal via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Web site for submission of proposal via Grants.gov	http://grants.gov (help desk available at support@grants.gov or (800) 518-4726)
Funding opportunity number for downloading a proposal package from Grants.gov	NNH19ZDA001N-FINESST

Funding Points of Contact **[new POC added January 17, 2020]**	Emails FINESST Program Scientists by Division: Earth Science: allison.k.leidner@nasa.gov **Earth Science: philip.m.larkin@nasa.gov** Planetary Science: lindsay.hays@nasa.gov Astrophysics: evan.scannapieco@nasa.gov Heliophysics: hakimzadeh@nasa.gov
Coordinating point of contact concerning this program	The HQ-FINESST Team Science Mission Directorate NASA Headquarters Washington, DC 20546-0001 Email: HQ-FINESST@mail.nasa.gov