C.3 SOLAR SYSTEM WORKINGS

NOTICE: This Program Element requires an explicit statement of relevance, which will be collected in a mandatory (4000-character) text box on the cover pages via the NSPIRES web interface. See Section 3, below.

This Program Element continues to use a two-step proposal submission process described in Section 2 of Appendix C.1.

The calls for the Planetary Science Division's Data Analysis Programs have been clarified and, in some cases, slightly expanded in ROSES-2016. Proposers are expected to read the DAP solicitations before submitting to this Program Element any proposal that uses planetary mission data.

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. A wide range of investigations will be covered, including theoretical studies, analytical and numerical modeling, sample-based studies of extraterrestrial materials, field work, laboratory studies, and data synthesis relevant to the physical and chemical processes affecting planetary systems.

1. Scope of Program

The Solar System Workings program solicits proposals for innovative scientific research related to understanding the atmospheric, climatological, dynamical, geologic, physical, and chemical processes occurring within the Solar System. This 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 include data synthesis, 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, or theoretical 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 nonexhaustive list of areas of research called for in this solicitation 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 time scales.
- 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 nongravitational 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.
  - *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

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 the Emerging Worlds Program (Program Element C.2). 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 (Program Element E.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), listed below. Solar System Workings 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.

- *Moon*: Proposals using data from recent lunar missions may be appropriate for the Lunar Data Analysis Program (see Program Element C.8).
- *Mars*: Proposals using Mars mission data may be appropriate for the Mars Data Analysis Program (see Program Element C.9).
- *Cassini*: Proposals using data from the Cassini mission may be appropriate for the Cassini Data Analysis Program (see Program Element C.10).

- *Discovery*: Proposals that use Discovery mission data may be appropriate for the Discovery Data Analysis Program (see Program Element C.11).
- *New Frontiers*: Proposals that use New Frontiers mission data may be appropriate for the New Frontiers Data Analysis Program (see Program Element C.19).

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. Most proposals to develop general theories or models of planets or planetary systems, as well as those focused on understanding exoplanetary systems, should be submitted to the Exoplanet Research Program (Program Element E.3).

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 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 the Planetary Data Archiving, Restoration, and Tools (PDART) Program (Program Element C.7).

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 Duration of Awards

Typical proposals to Solar System Workings seek three years of funding or fewer. Please refer to Appendix C.1, Section 3.2, 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 duration, may also be proposed.

2.3 Additional Funding for Relevant Instrumentation Construction or Upgrade

Proposers to Solar System Workings are eligible to request funds for Planetary Major Equipment (PME). See Program Element C.17 for information on how to append a PME request to a regular Solar Systems Workings research proposal or submit a stand-alone PME proposal to supplement an existing Solar System Workings award.

2.4 Planetary Science Division Early Career Fellowship Program

Proposals to this Program Element may include an application for Early Career Fellowships (ECF). See Program Element C.16 for a description of the application and evaluation process.

2.5 Relevance Statement Requirement

Step-2 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 Section 2.3.5 of 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. Proposal Submission Process

This Program Element uses the two-step proposal submission process outlined 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 in Chapter 2 of the *NASA Guidebook for Proposers*. Note that these requirements have been updated in 2016. 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 Appendix C.1, Section 3.3. 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 Appendix 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 Section 2.3 of the *NASA Guidebook for Proposers*, a letter of support may be required from any facility required for the proposed effort.

4.3 Data Management Plans (DMPs)

Proposals submitted to this Program Element must include a Data Management Plan (see Appendix C.1, Section 3.5). 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 Appendix C.1, Section 3.6, 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 Access to the Antarctic

Proposals to this Program Element must follow the rules given in Appendix C.1, Section 3.7, when requesting access to Antarctica.

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 Step-1 proposals	See Tables 2 and 3 in the *Summary of Solicitation* of this NRA.
Due date for Step-2 proposals	See Tables 2 and 3 in the *Summary of Solicitation* of this 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 Chapter 2 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. See Section 2.6 of this solicitation for special relevance requirements.
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 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	NNH16ZDA001N-SSW
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