SMALL SPACECRAFT TECHNOLOGY PROGRAM
SMALLSAT TECHNOLOGY PARTNERSHIPS APPENDIX

to

(SpaceTech–REDDI–2017), NNH17ZOA001N

APPENDIX NUMBER: NNH17ZOA001N-17STP_E1

Appendix Issued: July 17, 2017
(amended July 27, 2017)(includes previous amendment(s))

Mandatory Notices of Intent Due: August 21, 2017 (5:00pm Eastern)
Proposals Due: September 20, 2017 (5:00pm Eastern)

Catalog of Federal Domestic Assistance (CFDA) Number 43.012
OMB Approval Number 2700-0092
Proposers are reminded:

Per Section 4.3.1 of the STMD umbrella NRA solicitation, STMD-REDDI-17 NNH17ZOA001N, all proposals submitted via email or any means other than NSPIRES or Grants.gov will not be accepted. Additionally, this section states:

“All proposals submitted in response to this solicitation must be submitted in electronic form by the **Authorized Organizational Representative (AOR)** at the proposing principal investigator’s (PIs) organization who is authorized to make such a submission; electronic submission of the proposal by the AOR serves as the required original signature by an authorized official of the proposing organization. No hard copy of the proposal will be accepted.

The proposal submission process is complex and involves multiple steps to be carried out by all participants in the proposal. Therefore, proposers are strongly encouraged to familiarize themselves with the system and begin the submittal process early, well in advance of the deadline. While every effort is made to ensure the reliability and accessibility of submission systems and to provide a help center via e-mail and telephone, difficulties may arise at any point, including the user’s own equipment. **Difficulty in registering or using NSPIRES or Grants.gov is not a sufficient reason for NASA to consider a proposal submitted after the deadline.**”
SUMMARY OF KEY INFORMATION

Appendix Name: “Smallsat Technology Partnerships”, hereafter called “appendix” to the SpaceTech-REDDI-2017 umbrella NRA, hereafter called “umbrella NRA”.

Goal/Intent: This appendix supports the development and/or demonstration of new technologies and capabilities for small spacecraft by U.S. colleges and universities in collaboration with NASA through award of cooperative agreements. Projects may be for ground-based technology development or development of spacecraft or payloads for suborbital, balloon or orbital space flight technology demonstrations.

Eligibility: Eligibility is limited to U.S. college and university teams, including faculty, undergraduate and/or graduate students. The Principle Investigator (PI) submitting a proposal and leading a university team shall be affiliated with a U.S. college or university (including community colleges), accredited in and having a campus located in the U.S.

Partnering between the university team and a NASA Center or Jet Propulsion Laboratory (JPL) is required in all funded Smallsat Technology Partnership projects. The NASA team member must be either a civil servant or a member of the technical staff from JPL. NASA contractors (except for JPL employees) may not be funded partners or collaborators on Smallsat Technology Partnership projects.

Each proposal submitted for this appendix must be limited to a single Technology Topic Area and the PI must specify the Technology Topic Area when proposing. An individual is limited to being the PI on a single proposal. A team member, including any individual who is the PI on another proposal, may be a team member on more than one proposal. NASA civil servants and/or JPL employees may be team members on more than one proposal. Proposing U.S. colleges or universities may submit more than one proposal, provided that, if selected, the proposer can carry out all proposed efforts.

Key Dates:

Appendix Issued: July 17, 2017
Mandatory Notices of Intent Due: August 21, 2017 (5:00 PM Eastern)
Proposals Due: September 20, 2017 (5:00 PM Eastern)
Selections Announced: November 2017 (Target)
Awards Issued: January 2018 (Target)


Technology Readiness Level (TRL): Unless otherwise stated in the individual Technology Topic Area, technologies must be at least TRL 3 at proposal submission. For general guidance, NASA TRL definitions are referenced in the SpaceTech-REDDI umbrella NRA and are included as Attachment 1 of this appendix.
Award Details:

Award Type: Cooperative agreements will be issued to the selected college or university partner. The cooperative agreement award resulting from this appendix will be between NASA and the primary proposing U.S. college or university. Cost sharing is not required.

Award Duration: Maximum period of performance is two years, with continuation to the second year contingent on progress achieved during the first year and the availability of funds.

Anticipated Number of Awards: Approximately 5 awards total across all Technology Topic Areas. NASA reserves the right to alter the number of awards based on funding availability and quality of proposals received in response to this appendix.

Anticipated Award Amounts: Maximum of $200,000 each year for up to two years ($400,000 maximum) per award. In addition, a NASA civil servant or JPL employee labor allocation of up to 0.5 full-time equivalent (FTE) per award, per year will be available to support NASA involvement. Proposal teams can request up to $25,000 of procurement funding for the second year of a project to cover NASA expenses in the collaboration. This procurement funding for the second year can be used to purchase hardware, applied to the use of NASA test facilities, or for other uses that directly support this effort. There is no NASA procurement funding for the first year. NASA reserves the right to negotiate the scope and magnitude of the proposed effort, cost/price terms, and any other terms, as appropriate with selected proposers.

Selection Official: Space Technology Mission Directorate Associate Administrator or designee.

Questions and Comments: Questions pertaining to this appendix should be submitted via email to the Small Spacecraft Technology Program Executive, Christopher Baker, or the NASA Procurement POC, Rachel Khattab, at this email HQ-STMD-SST-Partnerships@nasaprs.com (the same email address for both), no later than later than September 6, 2017. Questions of a general nature will be added to the FAQs for this appendix and posted on NSPIRES. Please refer to the NSPIRES site for FAQ updates.
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1. SOLICITED RESEARCH/TECHNOLOGY DESCRIPTION

1.1 Introduction/Overview

The Small Spacecraft Technology program within the NASA Space Technology Mission Directorate (STMD) is chartered to enable mission capabilities that are more rapid, more transformative, and more affordable than previously achievable. To that end, the Small Spacecraft Technology program seeks to:

- Enable and demonstrate new mission architectures that small spacecraft are uniquely suited for.
- Expand the capability of small spacecraft to execute missions at new destinations and in challenging new environments.
- Enable the augmentation of existing assets and future missions with supporting small spacecraft.

The Small Spacecraft Technology program seeks development projects and demonstration missions that are small, affordable, rapid, and transformative. All efforts will focus on small spacecraft capabilities that are relevant to NASA’s missions in science and exploration, including those with crosscutting applications to the needs of the broader small spacecraft community in industry, academia, and other government agencies.

Definition of Small Spacecraft

For the purpose of this appendix, small spacecraft are defined as those with a mass of 180 kg or less and capable of being launched into space as an auxiliary or secondary payload. Although the term “smallsats” is used as a synonym, small spacecraft are not limited to Earth orbiting satellites, but might also include interplanetary spacecraft, planetary re-entry vehicles, and landing craft.

More information about the STMD Small Spacecraft Technology program is available online at: www.nasa.gov/smallsats.

1.2 Appendix Goals and Objectives

The Smallsat Technology Partnerships appendix is issued by the Small Spacecraft Technology program to:

- Engage the unique talents and fresh perspectives of the university community to develop new technologies and capabilities for small spacecraft.
- Share NASA experience and expertise in relevant university projects.
• Increase support to university efforts in small spacecraft technology through funding and collaboration with NASA, to foster a new generation of innovators for NASA and the nation.

• Engage NASA personnel across the agency in the rapid, agile, and cost-conscious small spacecraft development approaches that have evolved in the university community.

The goals of this appendix include collaboration with university teams that have experience in small spacecraft development and also extension of support to colleges and universities that have little or no previous involvement in this field. Colleges and universities with experience in small spacecraft development are encouraged to team with other college and universities to address these dual goals.

1.3 NASA Partnership Requirements

Collaboration with a NASA Center or NASA’s Jet Propulsion Laboratory (JPL) is a requirement for this appendix. College and university teams are required to coordinate with a NASA Center or JPL during the proposal development phase and to establish a collaborative partnership arrangement with NASA or JPL prior to the submission of their proposal. In order to develop a partnership, university teams preparing proposals should contact NASA personnel through the points of contact listed below. Areas of relevant expertise for each NASA Center and JPL are listed along with the points of contact.

**NASA Center Points of Contact**

Ames Research Center  
Moffett Field, CA  
Chad Frost, chad@nasa.gov, 650.604.1798  
Ames has NASA expertise in areas that include aerosciences, autonomy, small spacecraft technology, and instrument development.

Armstrong Flight Research Center  
Edwards, CA  
John Carter, john.f.carter@nasa.gov, 661.276.2025  
Armstrong has NASA expertise in areas that include suborbital flight testing.

Glenn Research Center  
Cleveland, OH  
Frederick Elliott, frederick.w.elliott@nasa.gov, 216.433.2322  
Glenn has NASA expertise in areas that include power technology, electric propulsion systems, and cryogenic fluid systems.

Goddard Space Flight Center  
Greenbelt, MD  
Michael Johnson, michael.a.johnson@nasa.gov, 301.286.5386
Goddard has NASA expertise areas that include in communications and navigation, robotics, avionics technology, and instrument development.

Jet Propulsion Laboratory
Pasadena, CA
Neil Murphy, neil.murphy@jpl.nasa.gov, 818.354.8718
JPL has NASA expertise in areas that include communications and navigation, robotics, avionics technology, and instrument development.

Johnson Space Center
Houston, TX
Mark Dillard, mark.a.dillard@nasa.gov 281.244.8640
Johnson has NASA expertise in areas that include crewed systems, in situ resource utilization technology, and robotics.

Kennedy Space Center
Kennedy Space Center, FL
Robert Ashley, robert.l.ashley@nasa.gov, 321.867.6037
Kennedy has NASA expertise in areas that include ground systems, launch services, and payload processing.

Langley Research Center
Hampton, VA
Julie Fowler, julie.l.fowler@nasa.gov, 757.864.4396
Langley has NASA expertise in areas that include aerosciences, entry decent and landing, vehicle structures and materials technology, and instrument development.

Marshall Space Flight Center
Huntsville, AL
John Dankanich, john.dankanich@nasa.gov, 256.544.3441
Marshall has NASA expertise in areas that include chemical propulsion, advanced manufacturing, cryogenic fluid systems, and instrument development.

Stennis Space Center
Stennis Space Center, MS
Ramona Travis, ramona.e.travis@nasa.gov, 228.688.3832
Stennis has NASA expertise in areas that include rocket propulsion testing.

For additional information, the following website lists all of the NASA Centers and provides links to individual websites for each Center that describe the work that they do. See: http://www.nasa.gov/about/sites/index.html

The NASA team member(s) must be either a civil servant or a member(s) of the technical staff from JPL. NASA contractors (except for JPL employees) may not be funded partners or collaborators on Smallsat Technology Partnerships projects. Establishing a partnership with NASA or JPL collaborators is the responsibility of the
university proposer. Teams that fail to establish a partnership will not receive a cooperative agreement award. Commitments made by NASA or JPL as part of proposal preparation shall only be valid if the proposal is selected and a cooperative agreement is established.

NASA Centers and JPL may exercise their own discretion in considering potential partnerships based on the level of interest and availability of appropriate expertise at their Center. NASA Centers and JPL may limit their proposed collaborations to technical fields for which their Center has specific experience, expertise, and future interest and to topic areas that are consistent with their Center’s core competencies.

Responsibilities and commitments of the NASA or JPL partner shall be clearly indicated in the proposal, including: specific project milestones, deliverable end-items, services to be performed (such as analysis, test, etc.), provision of government-furnished equipment, or provision of government-operated facilities (such as test labs).

**NASA Letter of Commitment**

For proposals submitted via NSPIRES, a NASA collaborator acknowledges his/her intended participation in the proposed effort by identifying himself/herself as a participant on the proposal’s cover page. Digitally signing off in NSPIRES indicates acceptance of this role and is a *preliminary* commitment by the Center to collaborate in the proposed effort. NASA employees should coordinate with their management prior to making a commitment to collaborate (management signature is not required). No further statement or letter of commitment is required when submitting via NSPIRES. Because Grants.gov does not support the electronic commitment of team members, statements of commitment from all team members, including NASA employees, must be provided as letters attached to the proposal application. See Appendix 4 of the umbrella NRA for more information. An example of the statement of commitment is as follows:

"I (we) acknowledge that I (we) am (are) identified by name as Co-Principal Investigator(s), Co-Investigator(s) [and/or Collaborator(s)] to the investigation, entitled <name of proposal>, that is submitted by <name of Principal Investigator> to the NASA funding announcement<alpha-numeric identifier>, and that I (we) intend to carry out all responsibilities identified for me (us) in this proposal. I (we) understand that the extent and justification of my (our) participation as stated in this proposal will be considered during peer review in determining in part the merits of this proposal. I (we) have read the entire proposal, including the management plan and budget, and I (we) agree that the proposal correctly describes my (our) commitment to the proposed investigation." For the purposes of conducting work for this investigation, my participating organization is <<insert name of organization>>.

Proposed use of government-furnished equipment, government-owned facilities, and government software must include a statement from the cognizant government official that the facilities and/or property will be available for the use intended by the proposing
team within the planned schedule. See Section 2.3.10 of the 2016 Proposer's Handbook.

NASA commitments/responsibilities are finalized after selection, through issuance of a cooperative agreement.

Since the prospective NASA and JPL partners will need time to coordinate approval and obtain the required statements of commitment and support, university proposers should contact them as early as possible during the proposal process.

1.4 Technology Topic Areas

Each proposal must address a single Technology Topic Area from among the topics listed in this section. NSPIRES will require the PI to identify the specific Technology Topic Area as part of the proposal submittal process. All submitted proposals will be grouped by Technology Topic Area and each proposal will only be evaluated within one topic area.

For all Technology Topic Areas the proposing team must define a reference science or exploration mission that requires the proposed technology or capability to accomplish using small spacecraft. The proposing team must identify specific gaps in the current state of the art relative to what is needed for the reference mission and use quantifiable performance targets to show that the proposed effort will bridge one or more of those gaps. Proposers are encouraged to refer to Achieving Science with CubeSats - Thinking Inside the Box published by the National Academies Press and the Small Spacecraft Technology State of the Art Report as a reference for current system capabilities.

https://www.nap.edu/catalog/23503/achieving-science-with-cubesats-thinking-inside-the-box

https://sst-soa.arc.nasa.gov

The following are not within the scope of this appendix: science investigations, operational science missions and conceptual design projects. Appropriate technologies for the topics in this appendix must have a starting TRL of at least 3 and no more than 6. For general guidance, NASA TRL definitions are referenced in the umbrella NRA and are included as Attachment 1 of this appendix.

The partnership team may propose to demonstrate the technology or capability in the laboratory environment or in a spaceflight demonstration that employs the technology or capability in at least a limited capacity (see below for other NASA opportunities that might enable flight demonstrations).
**Topic 1: Instrument Technologies for Small Spacecraft**

Missions executed by observatory-class large satellites for multi-spectral, high-resolution Earth or astronomical observations can be prohibitively expensive. More affordable small satellites do not have the form factor necessary to hold the large apertures needed to achieve high angular resolution and cannot support complex optical paths or suites of instruments for multi-spectral observations. Can Earth science, heliophysics, planetary or astronomy missions be executed in a unique way, or more affordably, using advanced sensors and new observing techniques on small spacecraft?

The goal of this topic is to develop new sensor or detector approaches that will enable small spacecraft to execute a terrestrial, planetary, astronomical, heliophysics or other science or exploration mission that either cannot be executed currently or requires a significant improvement in the current state-of-the-art sensors to achieve the science goals. Examples include disaggregated sensor suites on multiple small spacecraft flying in formation to permit the type of sensor fusion that can be accomplished on larger satellites, as well as the use of interferometry or synthetic aperture techniques or novel optical, electro-optical or image processing technologies to enable high-resolution data to be gathered by spacecraft form factors that preclude large apertures.

Efforts under this topic are to advance the state of the art in sensors, detectors, or optics of instruments and fusion or advanced processing of measurements from multiple instruments to enable new or more affordable science or exploration mission concepts with small spacecraft or ensembles of small spacecraft.

**Topic 2: Technologies That Enable Large Swarms of Small Spacecraft**

Constellations and swarms of 10 to 100 satellites or more can provide transformational science or make unique contributions to space exploration missions. For applications where high-cadence or multipoint measurements are essential for studying time-varying and distributed phenomena in areas such as heliophysics and Earth or planetary science, affordable small spacecraft swarms may be a solution. Ensembles of small spacecraft may also serve as planetary or deep space communications relays; augment, inspect, repair or decommission other assets; or operate cooperatively to contribute to exploration missions in unique ways. However, there are several barriers to implementing large swarms or swarms requiring tight formation control. For example, current state-of-practice implements control of satellite groups through commanding of individual spacecraft from the ground. However, operations costs become prohibitive when scaling this approach to swarms of 10 to 100 spacecraft. Additionally, safely maintaining configuration of a swarm in relatively close proximity - as may be required for fusion of sensor data across the swarm, interferometry, and other applications - requires rapid corrections and increases the complexity of operational logistics.

Enabling swarms within affordable operations costs requires that the swarm be operated as a cooperative entity using swarm-level commanding from the ground rather than the current practice of controlling individual spacecraft. This requires moving
functions currently provided by ground controllers or ground assets into swarm itself, enabling the swarm to independently perform functions such as maintaining or adjusting its configuration to achieve the ground-commanded goal. Additionally, basic operations become increasingly more complex with large or tightly controlled swarms. The goal of this topic is to develop new technologies and capabilities to enable affordable large constellations and swarms. The core technologies enabling swarms are a mixture of mature in-space, mature on-the-ground, and new to-be-developed:

- **Knowledge** – members of the satellite swarm must know their positions and movements, especially relative to other swarm members, with precision required to maintain the swarm configuration while avoiding unplanned contact
- **Communications** – efficient transfer of commands, controls, timing, or sensor information to and from all the spacecraft in the swarm
- **Control** – simultaneous and coordinated configuration/reconfiguration of the swarm, orientation, direction of coordinated tasks and mutual targets of swarm observations
- **Ground operations** – efficient and economical command, situation awareness, and data retrieval and processing
- **Propulsion/station keeping** – transport of the swarm to the desired orbital configuration, rendezvous for cooperative operations, and maintenance or change of orbits and orientation as mission needs require and evolve.

The proposing team is encouraged to leverage existing government or private sector work in the area of orbital, airborne, or ground based swarm operations and other relevant work.

**Topic 3: Technologies That Enable Deep Space Small Spacecraft Missions**

In the near future, mission designers will rely on small spacecraft to implement science and exploration missions more affordably and by using unique architectures comprised of groups of cooperative small spacecraft. Manned and robotic exploration of lunar and deep space destinations may require many types of precursor exploratory probes as well as supporting infrastructure. Some of these precursor missions and infrastructure may utilize small spacecraft as the primary method of execution or to augment the capabilities of large missions and facilities. In a supporting role, small spacecraft may serve communications relays, observation platforms, navigational aids, or as tender spacecraft that provide inspection or other services for larger assets in transit or in a state of dormancy. Small spacecraft may also be used to directly execute rapid and affordable lunar, Martian, NEO, or other deep space missions. However, current performance and operational limitations of small spacecraft are obstacles to their use in deep space missions.

Affordable small spacecraft have limitations in attitude determination and control outside Earth’s magnetosphere, position and trajectory determination when out of reach of GPS, power and propulsion capabilities for operations beyond 1 AU, long-range direct or relayed data communications, as well as thermal management and cost effective
radiation tolerance outside of the more benign LEO environment. The goal of this topic is to develop new technologies and capabilities to enable deep space missions with small spacecraft while maintaining the affordability of small spacecraft systems.

1.5 Flight Demonstration Opportunities

The partnership team may propose to demonstrate the technology or capability in the laboratory environment or in a spaceflight demonstration that employs the technology or capability in at least a limited capacity (e.g. using a limited number of spacecraft to test a system designed for disaggregated or swarm applications or testing a technology designed for deep space in LEO). Although separate and distinct from this appendix, other NASA opportunities exist that might enable flight demonstrations of technologies or capabilities developed under awards from this appendix. These other NASA opportunities include:

- **CubeSat Launch Initiative**: Projects that involve development of CubeSats may propose to the NASA CubeSat Launch Initiative for an orbital flight opportunity at no additional cost to the project. [Link](https://www.nasa.gov/directorates/heo/home/CubeSats_initiative.html)

- **Flight Opportunities Program**: Projects may propose to NASA’s Flight Opportunities program, and if selected under that program, receive suborbital and balloon flight opportunities at no additional cost to the project. [Link](http://www.nasa.gov/directorates/spacetech/flight_opportunities/index.html)

- **International Space Station (ISS) Research, Development, and Demonstration Opportunities**: The ISS provides proposers with a national laboratory resource with unique environments for the development of space technologies. Although ISS utilization is not required in this solicitation, if the proposer intends to use ISS, the following guidance is provided. The ISS program provides transportation to and from the ISS and standard experiment integration activities free of charge to approved, sponsored technology development investigations. Research, development, and demonstration opportunities include accommodation inside the pressurized habitable volume of the station, on external platforms outside the station, and accommodation within resupply/cargo vehicle pressurized and unpressurized volumes. Deployable options are also available.

More information on accommodations for ISS research, development, and demonstration can be found in the ISS Utilization Reference Guide as well as in the series of Researcher’s Guide publications.


[Link](http://www.nasa.gov/mission_pages/station/research/researcher_guide)
For submissions proposing to utilize the ISS or its commercial launch assets please contact the ISS Research Integration Office to obtain a letter of feasibility well in advance of your proposal submission. For STMD and other NASA funded efforts including both scientific and general engineering research, development, or demonstration proposals, the ISS point of contact is:

Dr. George C. Nelson: Manager, ISS Technology and Science Research Office, 281.244.8514, george.nelson-1@nasa.gov

2. AWARD INFORMATION

2.1 Funding and Period of Performance Information

**Award Type:** Cooperative agreements will be issued to the selected college or university partner. The cooperative agreement award resulting from this appendix will be between NASA and the primary proposing U.S. college or university. Cost sharing is not required.

**Award Duration:** Maximum period of performance is two years, with continuation to the second year contingent on progress achieved during the first year and the availability of funds.

**Anticipated Number of Awards:** Approximately 5 awards total across all Technology Topic Areas. NASA reserves the right to alter the number of awards based on funding availability and quality of proposals received in response to this appendix.

**Anticipated Award Amounts:** Maximum of $200,000 each year for up to two years ($400,000 maximum) per award. In addition, a NASA civil servant or JPL employee labor allocation of up to 0.5 full-time equivalent (FTE) per award, per year will be available to support NASA involvement. Proposal teams can request up to $25,000 of procurement funding for the second year of a project to cover NASA expenses in the collaboration. This procurement funding for the second year can be used to purchase hardware, applied to the use of NASA test facilities, or for other uses that directly support this effort. There is no NASA procurement funding for the first year. NASA reserves the right to negotiate the scope and magnitude of the proposed effort, cost/price terms, and any other terms, as appropriate with selected proposers.
<table>
<thead>
<tr>
<th>Award Information</th>
<th>First Year</th>
<th>Second Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Period of Performance</td>
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<td>up to 12 months</td>
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<tr>
<td>University Team Award</td>
<td>up to $200,000</td>
<td>up to $200,000</td>
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<td>Available NASA Civil Servant or JPL Labor Allocation</td>
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<td>up to 0.5 FTE</td>
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<tr>
<td>NASA or JPL Procurement Allocation</td>
<td>none</td>
<td>up to $25,000</td>
</tr>
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2.2 **Availability of Funds for Awards**

The Government’s obligation to make award(s) is contingent upon the availability of the appropriated funds from which to make payments, and the receipt of high quality proposals that are determined acceptable for NASA award under this appendix. NASA reserves the right to alter the number of awards, as outlined in Section 2.1, based on funding availability and quality of proposals received in response to this appendix. NASA reserves the right to negotiate the scope and magnitude of the proposed effort, cost/price terms, and any other terms, as appropriate with selected proposers.

2.3 **Award Reporting Requirements / Meetings / Deliverables**

The following reports and presentations will be required from all teams selected for award. All university and NASA collaborators should contribute to the preparation of materials, but the university PI is responsible for all submissions.

- **Monthly Status Quad Chart**
  Due 15 days after the end of each month.

- **Quarterly Reports**
  Due 15 days after the end of each three-month period beginning from the project start date. Two or more pages describing the status of the project with publically releasable text and images for NASA websites and publications.

- **Project Annual Report and Project Final Report**
  Project Annual Report is due one year after the project start date and Project Final Report is due at project completion. If those two dates are less than three months apart, only a Project Final Report is required. The primary university PI and the NASA partner shall co-author the Project Annual and Final Reports. The reports must include a complete summary of accomplishments and the relevant design documentation, test data, results, and analyses, including recommendations and conclusions based on the experience and results.
obtained. The final report should include algorithms, tables, graphs, diagrams, plots, images, and drawings in sufficient detail to explain comprehensively the results achieved under the Cooperative Agreement. This report shall comply with the requirements stated in NPR 2200.2C “Requirements for Documentation, Approval, and Dissemination of NASA Scientific and Technical Information”.

- **NF 1679 Disclosure of Invention and New Technology Forms**, as applicable. The University Team is required to participate with their NASA partner in the completion of NF 1679 Disclosure of Invention and New Technology forms filed with a NASA Commercialization Office for each invention and new technology developed as part of the project.

The Small Spacecraft Technology program will provide templates and instructions for submitting the above reports electronically.

The meetings listed below are required of all project teams. Awardees may elect to hold meetings at the university, at the NASA Center, or via teleconference. Choice of physical location or teleconference for meetings and reviews may be negotiated after selection.

- **Kickoff Meeting** within 15 days of project start date
- **Quarterly Reviews**

Under this appendix, no deliverables from the university team to NASA are required beyond the reports, meetings, and reviews stated above. However, in some instances, a project team may arrange to transfer spacecraft or other equipment to NASA for inclusion in a flight or ground demonstration conducted by NASA or others.

2.4 **Successor Proposals and Resubmission**

No change from umbrella NRA.

2.5 **Use and Disclosure of Research Resulting from Awards**

No change from umbrella NRA.

2.6 **Intellectual Property Resulting from Awards**

No change from umbrella NRA.

2.7 **Cost-Sharing or Matching**

No change from umbrella NRA.
2.8 **International Traffic in Arms Regulations (ITAR) and Export Administration Regulations (EAR) Requirements**

No change from umbrella NRA.

3. **ELIGIBILITY INFORMATION**

3.1 **Eligibility and Limitation of Number of Proposals**

Eligibility is limited to U.S. college and university teams, including faculty, undergraduate and/or graduate students. The Principle Investigator (PI) submitting a proposal and leading a university team shall be affiliated with a U.S. college or university (including community colleges), accredited in and having a campus located in the U.S.

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Each proposal submitted for this appendix must be limited to a single Technology Topic Area and the PI must specify the Technology Topic Area when proposing. An individual is limited to being the PI on a single proposal. A team member, including any individual who is the PI on another proposal, may be a team member on more than one proposal. NASA civil servants and/or JPL employees may be team members on more than one proposal. Proposing U.S. colleges or universities may submit more than one proposal, provided that, if selected, the proposer can carry out all proposed efforts.

3.2 **Other Eligibility Limitations**

No change from umbrella NRA.

3.3 **Foreign Participation**

Proposals will only be accepted from teams affiliated with a U.S. college or university accredited in and having a campus located in the United States. University teams may include non-U.S. persons, but proposers are reminded of ITAR and EAR requirements.

3.4 **China Funding Restriction**

No change from umbrella NRA.
4. PROPOSAL SUBMISSION INFORMATION

The following information supplements, where applicable, the information provided in Section 4.1 through 4.6 of the NRA:

- Proposers shall submit proposals via NSPIRES or Grants.gov. See 4.3.1 of the NRA.

- Mandatory Notice of Intent (NOI) to Propose: For this appendix, a mandatory Notice of Intent (NOI) to propose is required for proposal submission. The information contained in an NOI is used to expedite the proposal review activities. Material in an NOI will be protected to the extent allowed by law and will be treated as confidential, nonbinding for the proposer, and will be used for NASA planning purposes only. An NOI is submitted electronically by entering the requested information at: http://nspires.nasaprs.com/. Grants.gov does not provide NOI capability; therefore, an NOI must be submitted via NSPIRES regardless of whether the proposal will be submitted via NSPIRES or Grants.gov. Interested proposers must register with NSPIRES before they can prepare an NOI. Note that NOIs may be submitted within NSPIRES directly by the PI; no action by an organization’s AOR is required to submit an NOI. Within NSPIRES, space is provided for the PI to provide the following NOI information:

  1. A full title of the anticipated proposal (which should not exceed 254 characters).
  2. The Technology Topic Area being applied to from the list of topics provided in this appendix.
  3. A brief description of the proposed effort (which should not exceed 4,000 characters).
  4. The name of the proposal lead. NOTE: Proposal lead must have previously accessed and registered in NSPIRES.
  5. The names of any Co-Investigators and/or Collaborators as may be known by the time the NOI is submitted. In order to enter such names, such team members must have previously accessed and registered in NSPIRES themselves; a PI cannot do this for them.
  6. The NASA Center the PI intends to team with. The PI should be in contact with the point of contact at the NASA Center identified. If known at the time the NOI is submitted, include a NASA team member in the Co-Investigators and/or Collaborators and specify their NASA Center affiliation. A NASA Center intended for collaboration must be identified. However, a NASA team member is not required to be identified in the NOI.

- Summary Chart: Provide a single 8.5 x 11 page summary chart that will be used to represent your proposal during the review process. Please closely follow the template provided in Attachment 2.
The chart is intended to provide a quick sense of the proposed effort and should stand alone (i.e., not require the full proposal to be understood). It should not include any proprietary or sensitive data as NASA may make it available to the public after awards are announced and may post it on the STMD website.

- **Proposal Cover Page, Program Specific Data (PSD):** This Appendix contains PSD questions. See section 4.3.4, 4.3.4.1 of the NRA and NSPIRES instructions.

- **Required Certifications:** See 4.3.4.1 of the NRA

The **Proposal** shall include the following, in the order listed:

<table>
<thead>
<tr>
<th>Proposal Section</th>
<th>Maximum Page Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Table of Contents</td>
<td>1</td>
</tr>
<tr>
<td>2. Relevance and Impact</td>
<td>up to 4</td>
</tr>
<tr>
<td>3. Technical and Management Approach</td>
<td>up to 4</td>
</tr>
<tr>
<td>4. Schedule Summary</td>
<td>1</td>
</tr>
<tr>
<td>5. Budget Summary (Table)</td>
<td>1</td>
</tr>
<tr>
<td>6. Budget Justification</td>
<td>as needed</td>
</tr>
<tr>
<td>7. Letters of Commitment and Statements of Support</td>
<td>as needed</td>
</tr>
</tbody>
</table>

**NOTE:** Reviewers will not consider any content in excess of the page limits specified in the table above.

1. **Table of Contents:**

Proposers should include a one-page Table of Contents that provides a guide to the organization and contents of the proposal.

2. **Relevance and Impact:**

Describe a reference scientific or space exploration mission that is consistent with NASA’s goals. Identify one or more technology or capability gaps in the current state of the art for small spacecraft that prevents the accomplishment of the reference mission. Describe how the mission could be implemented with small spacecraft if those gaps are addressed. Propose a technology or capability advancement that would bridge one or more of the gaps and is consistent with one of the Technology Topic Areas. Describe how the proposed technology or capability will bridge the targeted gap(s) and is also broadly relevant to NASA or the larger space community.
Use quantitative measures, such as figures of merit, with supporting data to describe the current state of the art and how the proposed technology or capability will improve upon that state of the art. Potential figures of merit include but are not limited to: volume, mass, power (produced or consumed), cost (non-recurring and recurring), capacity, efficiency, specific fuel consumption, accuracy and precision, signal to noise ratio, operating lifetime, reliability, tolerance to radiation or single event upsets, tolerance to temperature extremes and cycles, etc. Identify the threshold (minimum) performance required and the desired target performance for the proposed technology or capability. Explain how this performance will enable or significantly enhance the execution of the reference mission and other science or exploration missions.

Describe any plans for infusion of the technology or capability into a space mission, commercialization, or other follow on work if the project is successful. Describe any near term plans for testing the technology or capability through orbital or suborbital testing. Flight testing of the technology or capability is not required, but a path to such testing is desired.

3. Technical and Management Approach:

Describe the technology or capability to be developed in the proposed project and explain the scientific or engineering principles that underlie that technology or capability. Describe the overall technical approach to implementing project. Describe any significant technical challenges or risks anticipated in developing and/or demonstrating the proposed technology or capability and explain the mitigation plans for those challenges and risks. Briefly describe the steps and milestones (including any major tests and demonstrations) in the project from start through completion. The description of the technical approach and milestones should demonstrate that the proposed effort is sound, complete and feasible within the resources and schedule of the project, and provides a reasonable pathway to project success.

Provide evidence to support that the TRL of the technology or capability at the time of proposal submission the meets minimum requirements identified in the chosen Technology Topic Area and that the proposed effort will increase the TRL of the technology or capability.

Describe the approach used in managing and coordinating project activities. Identify the roles, responsibilities, and contributions of the proposing university, the NASA partner, and any additional partners. Provide a brief description of the experience and expertise of the key team members. Identify any prior or current work that demonstrates that the combined team has the competencies needed to execute the project. Describe any equipment and facilities needed by the project and indicate the availability of these facilities or equipment, or the strategy for gaining access to them. Proposed use of government-furnished equipment or government-owned facilities must include a statement of support from the cognizant government official that the facilities and/or property will be available for the use intended by the project within the planned schedule.
4. **Schedule Summary:**

Provide a schedule chart for the full duration of the project including all major milestones and activities described in the Technical and Management Approach. Assume a start date no earlier than January 15, 2018.

5. **Budget Summary:**

Complete and include the following table.

<table>
<thead>
<tr>
<th>Budget</th>
<th>1st Year</th>
<th>2nd Year (if applicable)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Requested University Funding</td>
<td><em>in dollars</em></td>
<td><em>in dollars</em></td>
</tr>
<tr>
<td>NASA Labor Allocation*</td>
<td><em>in FTE</em></td>
<td><em>in FTE</em></td>
</tr>
<tr>
<td>NASA Procurement</td>
<td><em>N/A</em></td>
<td><em>in dollars</em></td>
</tr>
<tr>
<td>Additional Contributions</td>
<td><em>in dollars and/or FTE</em></td>
<td><em>in dollars and/or FTE</em></td>
</tr>
<tr>
<td>Total Cost</td>
<td><em>in dollars</em></td>
<td><em>in dollars</em></td>
</tr>
</tbody>
</table>

* Although JPL employees are not NASA civil servants please indicate the equivalent of the FTE level for their participation in this table. The table should not include NASA and JPL labor costs in dollars.

At its own discretion, a participating NASA Center may provide additional FTE contributions and/or additional procurements (not covered by STMD). In such cases, these resources should be summarized in this proposal section. Similarly, at their own discretion, university teams may offer to contribute resources at no cost to the project. Such contributions should be summarized in this proposal section as well.

6. **Budget Justification**

Each proposal shall provide a budget justification for the proposed effort and shall be supported by appropriate narrative material and budget details in compliance with the instructions in the umbrella NRA and the 2016 version of the NASA Guidebook for Proposers [http://www.hq.nasa.gov/office/procurement/nraguidebook/](http://www.hq.nasa.gov/office/procurement/nraguidebook/)

Describe the basis for the estimates. The totals of the detailed budget justification must match the budget summary specified in proposal Section 5.

See specifically Section 2.3.11 of the 2016 version of the NASA Guidebook for Proposers and Sections 4.3.5 and 4.3.6 of the umbrella NRA. However, this appendix requires that NASA civil servants and JPL employees are stated as a percentage of FTE only. Fully burdened civil servant and JPL employee labor costs are not required.
See also Exhibit F - Examples of Costs Categories from 2 CFR 200 Subpart E in the NASA Grant and Cooperative Agreement Manual dated 5/24/2017 https://prod.nais.nasa.gov/cgibin/nais/nasa_ref.cgi

Each proposal shall provide a Table of Personnel and Work Effort in compliance with Section 2.3.13 of the 2016 version of the NASA Guidebook for Proposers.

7. Letters of Commitment and Statements of Support:

For proposals submitted via NSPIRES, a NASA collaborator acknowledges his/her intended participation in the proposed effort by identifying himself/herself as a participant on the proposal's cover page. Digitally signing off in NSPIRES indicates acceptance of this role and is a preliminary commitment by the Center to collaborate in the proposed effort. NASA employees should coordinate with their management prior to making a commitment to collaborate (management signature is not required). No further statement or letter of commitment is required when submitting via NSPIRES. Because Grants.gov does not support the electronic commitment of team members, statements of commitment from all team members, including NASA employees, must be provided as letters attached to the proposal application. See Appendix 4 of the umbrella NRA for more information.

Proposed use of government-furnished equipment, government-owned facilities, and government software must include a statement from the cognizant government official that the facilities and/or property will be available for the use intended by the proposing team within the planned schedule.

Since the prospective NASA and JPL partners will need time to coordinate approval and obtain the required letters of commitment and statements of support, university proposers should contact them as early as possible during the proposal process.

5. PROPOSAL REVIEW INFORMATION

The following information supplements, where applicable, the information provided in Section 5.1 through 5.6 of the NRA. If any criteria in this appendix conflict with any other part of the umbrella NRA, the criteria identified in this appendix take precedence.

5.1 Compliance Review

No change from umbrella NRA.

5.2 Evaluation Criteria

The evaluation criteria considered in evaluating proposals under this Appendix are listed below. The criteria are weighted as follows:
Relevance and Impact (45%):

The reference science or exploration mission is consistent with NASA’s goals and the extent to which the technology or capability proposed is broadly relevant to NASA or the larger space community. The extent to which technology or capability gaps to achieving the reference mission are identified and the reference mission could be feasibly implemented with small spacecraft if those gaps are addressed. The extent to which the proposed work bridges one or more of the identified technology gaps and the extent to which the proposed work is critical for enabling the reference mission. The proposed work is relevant to the solicited topic area of this appendix.

The overall impact of the proposed work and the extent to which evidence is provided that the project would meaningfully improve performance relative to the current state-of-the-art in small spacecraft technology or capabilities (proposers are advised to use quantifiable figure of merit comparisons with supporting data). The extent to which the work would enable or significantly enhance the execution of the reference mission and other science or exploration missions.

The proposal provides a high-level plan for mission infusion, commercialization, or other follow on potential and the extent to which to the proposed effort has a near term pathway to orbital or suborbital testing. The extent to which a path to flight testing the technology or capability was presented.

Technical and Management Approach (45%):

The extent to which the technology or capability is clearly described and explains the scientific or engineering principles that underlie the technology or capability. The overall merit of the technical approach and the extent to which the proposed activities and milestones represent concrete and specific deliverables or steps to accomplishing the objectives of the effort within the period of performance and available funding. The scientific and engineering basis of any new technology is sound and the extent to which major technical challenges and risks are clearly identified with feasible mitigation strategies proposed. The extent to which evidence supporting that the starting TRL is appropriate for the topic area is provided and that the proposed activities will increase the TRL.

The overall merit of the management approach and the extent to which the roles and responsibilities for all participating organizations, including the NASA partner, are clearly described and address the competences, facilities, and equipment needed to execute the project. Needed equipment, facilities and other hardware identified and available.

Cost (10%):

Budgets will be reviewed for compliance with the stated guidelines and reasonableness.
5.3 Selection Announcement and Award Dates

No change from umbrella NRA, except as noted below:

Debriefings: The PI submitting a proposal may request a written summary of the peer review panel evaluation via the NSPIRES system. This is the only debriefing that will be provided.

6. AWARD ADMINISTRATION INFORMATION

No change from umbrella NRA.

7. POINTS OF CONTACT FOR FURTHER INFORMATION

No change from umbrella NRA, except as noted below:

Questions pertaining to this appendix should be submitted via email to the Small Spacecraft Technology Program Executive, Christopher Baker, or the NASA Procurement POC, Rachel Khattab, at this email HQ-STMD-SST-Partnerships@nasaprs.com (the same email address for both), no later than later than September 6, 2017. Questions of a general nature will be added to the FAQs for this appendix and posted on NSPIRES. Please refer to the NSPIRES site for FAQ updates.

8. ANCILLARY INFORMATION

No change from umbrella NRA.

9. REFERENCES

No change from umbrella NRA.

10. ATTACHMENTS
## ATTACHMENT 1

<table>
<thead>
<tr>
<th>TRL</th>
<th>Definition</th>
<th>Hardware Description</th>
<th>Software Description</th>
<th>Exit Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Basic principles observed and reported</td>
<td>Scientific knowledge generated underpinning hardware technology concepts/applications.</td>
<td>Scientific knowledge generated underpinning basic properties of software architecture and mathematical formulation.</td>
<td>Peer reviewed publication of research underlying the proposed concept/application.</td>
</tr>
<tr>
<td>2</td>
<td>Technology concept and/or application formulated</td>
<td>Invention begins, practical applications is identified but is speculative, no experimental proof or detailed analysis is available to support the conjecture.</td>
<td>Practical application is identified but is speculative; no experimental proof or detailed analysis is available to support the conjecture. Basic properties of algorithms, representations, and concepts defined. Basic principles coded. Experiments performed with synthetic data.</td>
<td>Documented description of the application/concept that addresses feasibility and benefit.</td>
</tr>
<tr>
<td>3</td>
<td>Analytical and experimental critical function and/or characteristic proof-of-concept</td>
<td>Analytical studies place the technology in an appropriate context and laboratory demonstrations, modeling and simulation validate analytical prediction.</td>
<td>Development of limited functionality to validate critical properties and predictions using non-integrated software components.</td>
<td>Documented analytical/experimental results validating predictions of key parameters.</td>
</tr>
<tr>
<td>4</td>
<td>Component and/or breadboard validation in laboratory environment.</td>
<td>A low fidelity system/component breadboard is built and operated to demonstrate basic functionality and critical test environments, and associated performance predictions are defined relative to final operating environment.</td>
<td>Key, functionality critical software components are integrated and functionally validated to establish interoperability and begin architecture development. Relevant environments defined and performance in the environment predicted.</td>
<td>Documented test performance demonstrating agreement with analytical predictions. Documented definition of relevant environment.</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th></th>
<th>Component and/or breadboard validation in relevant environment.</th>
<th>A medium fidelity system/component brassboard is built and operated to demonstrate overall performance in a simulated operational environment with realistic support elements that demonstrate overall performance in critical areas. Performance predictions are made for subsequent development phases.</th>
<th>End-to-end software elements implemented and interfaced with existing systems/simulations conforming to target environment. End-to-end software system tested in relevant environment, meeting predicted performance. Operational environment performance predicted. Prototype implementations developed.</th>
<th>Documented test performance demonstrating agreement with analytical predictions. Documented definition of scaling requirements.</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>System/sub-system model or prototype demonstration in a relevant environment.</td>
<td>A high fidelity system/component prototype that adequately addresses all critical scaling issues is built and operated in a relevant environment to demonstrate operations under critical environmental conditions.</td>
<td>Prototype implementations of the software demonstrated on full-scale, realistic problems. Partially integrated with existing hardware/software systems. Limited documentation available. Engineering feasibility fully demonstrated.</td>
<td>Documented test performance demonstrating agreement with analytical predictions.</td>
</tr>
<tr>
<td>6</td>
<td>System prototype demonstration in an operational environment.</td>
<td>A high fidelity engineering unit that adequately addresses all critical scaling issues is built and operated in a relevant environment to demonstrate performance in the actual operational environment and platform (ground, airborne, or space).</td>
<td>Prototype software exists having all key functionality available for demonstration and test. Well integrated with operational hardware/software systems demonstrating operational feasibility. Most software bugs removed. Limited documentation available.</td>
<td>Documented test performance demonstrating agreement with analytical predictions.</td>
</tr>
<tr>
<td>7</td>
<td></td>
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</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th></th>
<th>Actual system completed and &quot;flight qualified&quot; through test and demonstration.</th>
<th>The final product in its final configuration is successfully demonstrated through test and analysis for its intended operational environment and platform (ground, airborne, or space).</th>
<th>All software has been thoroughly debugged and fully integrated with all operational hardware and software systems. All user documentation, training documentation, and maintenance documentation completed. All functionality successfully demonstrated in simulated operational scenarios. Verification and validation completed.</th>
<th>Documented test performance verifying analytical predictions.</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td></td>
<td></td>
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<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Actual system flight proven through successful mission operations.</th>
<th>The final product is successfully operated in an actual mission.</th>
<th>All software has been thoroughly debugged and fully integrated with all operational hardware and software systems. All documentation has been completed. Sustaining software support is in place. System has been successfully operated in the operational environment.</th>
<th>Documented mission operational results.</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In cases of conflict between NASA directives concerning TRL definitions, NPR 7123.1 will take precedence.
ATTACHMENT 2

Summary Chart: A single 8.5 x 11 page summary chart (in landscape orientation) that will be used to represent the proposal during the review process.

The chart is intended to provide a quick sense of the proposed effort and should stand alone (i.e., not require the full proposal to be understood). It should not include any proprietary or sensitive data as NASA may make it available to the public after awards are announced and may post it on the STMD website.

<table>
<thead>
<tr>
<th>Title</th>
<th>Project Objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potential Impact</td>
<td></td>
</tr>
<tr>
<td>Technology Image</td>
<td></td>
</tr>
<tr>
<td>Technology Overview</td>
<td>Team Overview</td>
</tr>
</tbody>
</table>

- **Title** (Top): The proposal title.
- **Potential Impact** (Upper Left Quadrant): Brief summary of the projected overall impact of the proposed effort.
- **Technology Overview** (Lower Left Quadrant): Brief technology description including the starting TRL and projected TRL as a result of the proposed effort.
- **Project Objectives** (Upper Right Quadrant): Brief overview of the objectives of the effort with quantitative comparison between the proposed technology and the current state of the art.
- **Team Overview** (Lower Right Quadrant): The PI’s name and institution, and the names and affiliations of other key team members, including the NASA partner.
- **Technology Image** (Centered): Representative graphic (size may be varied to best illustrate/explain)