

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)
HEADQUARTERS
SPACE TECHNOLOGY MISSION DIRECTORATE
300 E Street, SW
Washington, DC 20546-0001

**SMALL SPACECRAFT TECHNOLOGY PROGRAM
SMALLSAT TECHNOLOGY PARTNERSHIPS APPENDIX**

to

NASA Research Announcement (NRA): Space Technology - Research,
Development, Demonstration, and Infusion - 2019
(SpaceTech-REDDI-2019), 80HQTR19NOA01

APPENDIX NUMBER: 80HQTR19NOA01-20STP-S1

Appendix Issued: September 11, 2019
Notices of Intent Due: October 4, 2019 (5:00pm Eastern)
Proposals Due: November 6, 2019 (5:00pm Eastern)

Catalog of Federal Domestic Assistance (CFDA) Number 43.012
OMB Approval Number 2700-0092

Per Section 4.3.1 of the SpaceTech-REDDI umbrella NRA solicitation, all 80HQTR19NOA01 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. Proposals submitted via email or any means other than NSPIRES or Grants.gov will not be accepted.”

“The proposal submission process is complex and involves multiple steps to be carried out by all participants in the proposal. Therefore, offerors 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 proposal submission systems (either NSPIRES or Grants.gov) is not a sufficient reason for NASA to consider a proposal submitted after the deadline.**”

NASA support service contractors may have access to the mandatory Notices of Intent and subsequent proposal information. Information received in response to this solicitation that is marked ‘Proprietary’ will be handled and protected accordingly. NASA support service contractors are obligated to protect third-party proprietary information. By submitting a Notice of Intent and subsequent proposal, the responder is deemed to have consented to release of proprietary information to such NASA support service contractors.

Summary of Key Information

Appendix Name: “Smallsat Technology Partnerships”, hereafter called “appendix” to the **SpaceTech-REDDI-2019** 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 Principal 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 topic 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. Proposing U.S. colleges or universities or NASA centers may submit more than one proposal, provided that, if selected, the offeror can carry out all proposed efforts.

Key Dates:

Appendix Issued	September 11, 2019
Notices of Intent Due	October 4, 2019 (5:00 PM Eastern)
Proposals Due	November 6, 2019 (5:00 PM Eastern)
Selections Announced	January 22, 2020 (Target)
Awards Issued	March 25, 2020 (Target)

Proposal Submission & Selection Process: Competitive proposals with independent peer review.

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 in Attachment 2 of the SpaceTech-REDDI umbrella NRA.

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 of the basic STP cooperative agreement is two years, with continuation to the second year contingent on progress achieved during the first year and the availability of funds.

Small Spacecraft Technology (SST) program may approve requests within a limited time period of the STP effort for a funded extension of the basic STP cooperative agreement to cover specific activities in support of a technology demonstration flight, if the STP project is selected for subsequent launch through CubeSat Launch Initiative (CSLI) or Flight Opportunity Program (FOP). The funded extension may extend the cooperative agreement up to an additional 12 months (subject to qualifying conditions described in Section 1.5 below).

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 also request up to \$25,000 of procurement funding for the NASA partner at the second year of a project to cover NASA expenses in the collaboration. This procurement funding may be used by the NASA partner to purchase hardware or for use of NASA test facilities that support the partnership. There is no NASA procurement funding for the first year. Subject to approval, STP projects that are selected for a subsequent flight demonstration through CSLI or FOP may receive supplemental funds, through a funded extension of the basic cooperative agreement, to support the launch as described in Section 1.5 below. 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 offerors.

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 NASA Grant Officer, Beatrice Morales, Beatrice.M.Morales@nasa.gov no later than later than October 11, 2019 (5:00 Eastern). 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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Small Spacecraft Technology Program Smallsat Technology Partnerships

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 the execution of missions at much lower cost than previously possible.
- Substantially reduce the time required for development of spacecraft, from authority to proceed until initial launch capability.
- 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 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

David Voracek, david.f.voracek@nasa.gov, 661.276.2463

Armstrong has NASA expertise in areas that include suborbital flight testing.

Glenn Research Center

Cleveland, OH

Tim Smith, timothy.d.smith@nasa.gov, 216.977.7546

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 in areas that include communications and navigation, robotics, avionics technology, and instrument development.

Jet Propulsion Laboratory

Pasadena, CA

Tom Cwik, thomas.a.cwik@jpl.nasa.gov, 818.354.4386

JPL has NASA expertise in areas that include communications and navigation, robotics, avionics technology, and instrument development.

Johnson Space Center

Houston, TX

Linda Ham, linda.j.ham@nasa.gov, 281.483.6881

Johnson has NASA expertise in areas that include crewed systems, in situ resource utilization technology, and robotics.

Kennedy Space Center

Kennedy Space Center, FL

Jose Nunez, jose.l.nunez@nasa.gov, 321.867.5922

Kennedy has NASA expertise in areas that include ground systems, launch services, and payload processing.

Langley Research Center

Hampton, VA

Carrie Rhoades, carrie.m.rhoades@nasa.gov, 757.864.8793

Chris Edwards, william.c.edwards@nasa.gov, 757.864.1555

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 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.

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 Section 4. Proposal Submission Information for further explanation of proposal requirements and example statement of commitment.

1.4 Technology Topic Areas

NASA will return humans to the moon by 2024 and thereafter establish a sustainable presence. Precursor missions of small spacecraft will blaze the trail for lunar exploration, and will establish infrastructure such as communications and navigation networks and as on-orbit inspection, assembly and repair services for larger structures and human habitats.

NASA will send small spacecraft to the moon as early as 2020 to establish a “beach head” with some of these services; however, advanced and add-on capabilities will be added incrementally by small spacecraft to support sustained human presence at the moon, on to Mars and other deep space destinations.

For this Small Spacecraft Technology (STP) solicitation, the proposing team will need to:

- Describe a specific capability or service needed for lunar exploration precursor missions, or for exploration infrastructure. The capability should be an extension or improvement over the performance of missions that NASA already plans to execute in the 2022 time frame. Explain how small spacecraft – or cooperative groups of small spacecraft – can offer a unique, cost-effective solution for the identified capability or service. Execution of the mission is not considered part of the proposed effort but the needed mission capabilities serve to gauge technology gaps and advancements to performance measures proposed.
- Identify one or more of the technology topics from the list below where the state-of-the-art (as projected for the 2022-23 time frame) will inhibit/prevent small spacecraft from achieving the previously described solution. Use quantitative measures where possible when describing the technology gap.
- Explain your proposed two-year development effort that leads to a solution that will fill the identified technology gap. Specify quantifiable Key Performance Parameters (KPP) or Measures of Performance (MOP) to serve as quantitative measure to contrast the performance of the projected 2022-23 state of the art compared to that needed for your solution. Explain how your proposed two-year development effort will raise the performance measure to approach the targeted value.
- 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 single, 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.

Topic 1. Lunar Communications and Navigation Network

Our lives have been transformed by ubiquitous access to mobile networked communications: we open an application, interact with any networked device on Earth, and rely on the network to take care of the rest. NASA’s vision is to extend this network service paradigm to the Moon and on to Mars. Orbiting, ground-based stationary and roving robotic and manned assets will soon be conducting sustained lunar operations. Disparate assets performing various services - whether supplied by NASA, U.S. commercial or academic entities or foreign national partners - need to interoperate with devices nearby, remotely or back on Earth. Towards this, NASA has created a highly extensible, open architecture lunar communications and navigation network concept known as LunaNet. An Earth-based ground system provides LunaNet access to terrestrial users. At the Moon, each satellite node serves as a network access point for lunar orbital and surface users, enabling the exchange of data units with any other

authorized and connected user on Earth or at the Moon. Similar to Earth's Internet, the user's ability to exchange self-contained data units without detailed procedures or technical knowledge about the enabling infrastructure is the defining characteristic of LunaNet. Assets will pass into and out of network when they start up or as they occasionally become obscured from line-of-sight by lunar surface features or by the geometries of their orbit, etc. and human operator intervention in network insertion or routing is not feasible. LunaNet achieves its primary internetworking function through the delay/disruption tolerant network (DTN) Bundle Protocol. The store-and-forward functions of Bundle Protocol ensure generalized, reliable and robust internetworking among LunaNet users and nodes, and provide the foundation for a solar system internet interconnecting nodes and networks at other planetary bodies or locations of interest. In addition to communications services, Position Navigation and Timing (PNT) services are crucially important to the LunaNet architecture, to support Lunar surface navigation, relative navigation between assets, orbit determination, and Human Location Services.

NASA is exploring plans to deploy one or more communications relay spacecraft in the 2021-2022 time frame. Small spacecraft will implement aspects of LunaNet services, and all small spacecraft must meet interoperability requirements to take advantage of the LunaNet architecture. Future small spacecraft will extend and enhance LunaNet navigation and communications capabilities for a sustained lunar presence.

STP proposals should describe a Smallsat mission or use-case for LunaNet and specify a Key Performance Parameter or Measure of Performance for that mission. Describe the two-year STP approach to development and testing of technologies compatible with or extending the LunaNet architecture. Characteristics of interest for a LunaNet CubeSat Node:

1. Number of simultaneous communications links
2. Data rate capabilities of the links
3. Link performance (link margin, reliability, etc.)
4. DTN Relay Storage Capability/Capacity
5. Family of Position, Navigation, and Timing (PNT) services

The proposer should identify solutions to technology gaps, add-ons and enhancements to LunaNet that they propose to develop under their two-year STP effort that can be readily transitioned for deployment as additional service nodes soon after LunaNet becomes operational. Proposed nodes shall provide at least two of the following services: data relay, navigational aid, or timing reference. In order to ensure compatibility with 12U spacecraft, the final configuration of the proposed communications / navigation technology should occupy no more than 3U of volume and 6kg of mass, but may presume deployable systems such as antennas or solar arrays consistent with a 12U spacecraft.

The following publications should be helpful for purposes of proposing solutions that are in line with the LunaNet architecture:

- <https://www.internationaldeepspacestandards.com>
- Space Communication Architecture Working Group (SCAWG) (2006) *NASA Space Communication and Navigation Architecture Recommendations for 2005-2030*
- Burleigh, Scott, Adrian Hooke, Leigh Torgerson, Kevin Fall, Vint Cerf, Bob Durst, Keith Scott, and Howard Weiss. "Delay-tolerant networking: an approach to interplanetary internet." *IEEE Communications Magazine* 41, no. 6 (2003): 128-136.
- Israel, David J., Gregory W. Heckler, and Robert J. Menrad. "Space mobile network: a near earth communications and navigation architecture." In 2016 *IEEE Aerospace Conference*, pp. 1-7. IEEE, 2016.
- J. Valdez, B. Ashman, C. Gramling, G. Heckler, "Navigation Architecture for a Space Mobile Network," *Proceedings of the 39th American Astronautical Society Guidance and Control Conference*, Breckenridge, CO, 5-10 February 2016.

Proposers should also be familiar with the following existing work, missions and references:

- Advanced Space Cislunar Autonomous Positioning System (CAPS) (SBIR) - <https://sbir.nasa.gov/SBIR/abstracts/17/sbir/phase1/SBIR-17-1-S3.04-9783.html>, <https://sbir.nasa.gov/SBIR/abstracts/17/sbir/phase2/SBIR-17-2-S3.04-9783.html>
- Space Communications and Navigation (SCaN) - <https://www.nasa.gov/directorates/heo/scan/index.html>

Topic 2: Smallsat Propulsion for Lunar Missions

Launch vehicle upper stages, kick-stages, or "parent" spacecraft may insert small spacecraft into translunar trajectories or into lunar orbit. Small spacecraft will require propulsion to insert themselves into optimal lunar orbits, and require propulsion for long-duration station-keeping or for orbital plane changes while in lunar orbit.

In addition to planned and proposed operations in lunar orbit, payloads on commercial lunar landers may return samples to Earth via small spacecraft with sufficient propulsion. The proposer should identify and propose solutions to technology gaps to enable the return to Earth from the lunar surface of up to 1kg sample using a spacecraft that is no more than 12U. Mission solutions may be direct to Earth or presume the use of either Gateway or ISS as a location where the sample can be transferred from one small spacecraft to another (each spacecraft can be up to 12U).

Commercial propulsion systems/subsystems exist on the market, each with relative merits for respective applications. The STP proposal should be aimed at radical improvements to existing solutions in aspects of: efficiency, reliability, manufacturability or functionality; or aimed at innovative alternatives to existing available propulsion technologies. Proposals must describe a reference mission and gaps in the current state-of-the-art propulsion technology. Cite the existing versus the targeted Key Performance Parameters (KPP) or Measures of Performance (MOP), contrasting the values for state of the art versus the proposed propulsion technology. Desired

characteristics for small spacecraft propulsion include increased specific impulse, high total impulse, and increased dV, hybrid (e.g. electric and cold gas) propulsion, or other innovations. Some key technical challenges may include: propulsion solutions that use solid, liquid, or low-pressure gaseous propellants that are compliant with published secondary payload restrictions and can be stored in an integrated state for at least 12 months without significant performance degradation.

Topic 3: Advanced Electrical Power Subsystem and Thermal Management Technology

In the near future, small spacecraft may serve as orbiting or landed precursor assets or may comprise part of a sustainable infrastructure for lunar exploration missions, operating either alone or as an integral part of a larger system. Sufficient power generation, power storage and power distribution are desired for small spacecraft to operate high-powered radio and payloads instruments, while eclipsed or – for landed spacecraft - while operating in permanently shadowed areas of the lunar surface. In addition to the usual challenges of having to manage heat generated by processors and high-powered communications subsystems, the thermal environment encountered in cislunar and lunar surface missions presents new challenges to small spacecraft that previously have been designed to operate in Low Earth Orbit. In cislunar space, small spacecraft must deal with both the extreme cold when pointed at black sky, as well as reflected heat from Earth and lunar albedo. Landed spacecraft may have to operate for long durations in permanently shadowed areas of the lunar poles, where cold may adversely affect batteries and electronics. Power subsystem components such as solar panels may incorporate thermal control mechanisms for radiating the heat generated by large electrical loads. Conversely, advanced technologies for efficient heat sources may be required.

Proposers must describe a reference mission and identify gaps in current capabilities of state-of-the-art electrical power subsystems or thermal management technology, citing Key Performance Parameters (KPP) or Measures of Performance (MOP). Successful proposals will describe how the investigation will result in elevation of the TRL and KPP/MOP towards values that will enable future mission success.

Proposers are encouraged to refer to the Small Spacecraft Technology State of the Art Report as a reference for current system capabilities.

See: <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. See Attachment 2 of the NRA umbrella for TRL Descriptions.

1.5 Flight Demonstration Opportunities

All partnership teams should propose to demonstrate progress toward targeted KPP or MOP values for the technology they develop under this STP within the two-year basic

period of performance, at least in the laboratory environment. Optionally, partnership teams may choose to propose to demonstrate their STP-developed technology through CubeSat Launch Initiative (CSLI) or Flight Opportunities Program (FOP).

Funded Extensions to Support Flight Demonstration Activities

To support CSLI or FOP flight demonstration activities, STP projects may, within a limited time period of the basic STP effort, request through the STP Cooperative Agreement Technical Officer a funded extension of their cooperative agreement. If selected for launch by CSLI or FOP, the SST program may grant an extension of the STP cooperative agreement by up to 12 months and may award additional funds to the STP project to support the proposed integration, launch cost, operations and limited post-flight analysis. Amount of additional funds will be determined at negotiation of the proposed STP cooperative agreement extension. Approval of the funded extension would be contingent on satisfactory performance throughout the STP cooperative agreement two-year period of performance, and on the availability of funding resources.

The STP project must submit a funded extension request to the STP Cooperative Agreement Technical Officer at least three months in advance of the expiration date of their cooperative agreement. The Cooperative Agreement extension request must state to which program – CSLI or FOP or both – the flight demonstration is proposed. The request for funded extension must include: the objectives and measurable success criteria of the flight demonstration(s), the milestone schedule and work to be performed leading to, during, and after the flight demonstration, and the additional funds requested. If the STP project requests suborbital flight services from a qualified flight provider currently under contract through NASA's Flight Opportunities program, the STP project must show that the proposed flight service provider is well suited to execute the flight(s) and must provide a cost and schedule quote from the flight provider.

SST program shall not grant a cooperative agreement funded extension before the STP project is selected by CSLI for launch (in the case of CSLI launch) or approved for flight through FOP (in case of FOP launch)

CubeSat Launch Initiative: NASA's CSLI provides access to space for CubeSats developed by NASA Centers and programs, educational institutions and non-profit organizations to conduct research in the areas of science, exploration, technology development, education or operations. STP projects that involve development of CubeSats are encouraged to propose to the annual NASA CSLI solicitation for an orbital flight opportunity.

See above for requesting a possible funded extension of the basic STP cooperative agreement to support proposed integration, launch cost, and operations.

SST program can facilitate the independent Feasibility Review that is required by CSLI prior to proposal submittal to CSLI and may provide a letter demonstrating

financial support if required. An STP project's STP cooperative agreement may also be used as an indicator of merit for a CSLI proposal.

The STP project may use any STP funds to cover additional launch costs not already covered by CSLI (such as for costs to launch a CubeSat larger in size than 3U).

For further information on CSLI see:

https://www.nasa.gov/directorates/heo/home/CubeSats_initiative.html

Links to past and current CSLI announcements of opportunities are at:

<https://www.nasa.gov/content/announcement-of-opportunity-for-cubesat-launch-initiative>

Flight Opportunities Program: The goal of NASA's Flight Opportunities program is to demonstrate space exploration and utilization technologies in relevant space-like environments using currently available U.S. commercial suborbital rockets, rocket-powered lander vehicles, high-altitude balloons, and aircraft following reduced-gravity flight profiles.

Projects are encouraged to demonstrate the technology developed under their STP effort on a suborbital flight. If the STP project requests suborbital flight services from a qualified flight provider currently under contract through NASA's Flight Opportunities program, the STP project must show that the proposed flight service provider is well suited to execute the flight(s) and must provide a cost and schedule quote from the flight provider.

See above for the possibility of a funded extension of the basic STP cooperative agreement to support proposed integration, launch cost, and operations.

SST program will assess the technical feasibility of the request, and if the funded extension is approved funds may be used to purchase suborbital flight services from a qualified flight provider currently under contract through NASA's Flight Opportunities program and to cover pre- and post-flight preparations and operations. STP projects are not required to submit a proposal in response to an open Flight Opportunities solicitation.

For a list of suborbital vehicles and services that are under contract to NASA through the Flight Opportunities program see:

<https://www.nasa.gov/directorates/spacetech/flightopportunities/flightproviders>

For spaceflight demonstration of technologies other than CubeSats, STP projects are encouraged to investigate NASA International Space Station (ISS) opportunities. Although separate and distinct from this appendix, researchers would propose technology demonstrations (other than CubeSats) separately under that program. An

STP cooperative agreement funded extension is not offered for ISS flight demonstrations.

International Space Station (ISS) Research, Development, and Demonstration Opportunities:

The ISS provides offerors with a national laboratory resource with unique environments for the development of space technologies. 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.

<https://www.nasa.gov/sites/default/files/atoms/files/np-2015-05-022-jsc-iss-guide-2015-update-111015-508c.pdf>

http://www.nasa.gov/mission_pages/station/research/researcher_guide

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 of the basic STP cooperative agreement is two years, with continuation to the second year contingent on progress achieved during the first year and the availability of funds.

SST program may approve requests within a limited time period of the STP effort for a funded extension of the basic STP cooperative agreement to cover specific activities in support of an orbital or suborbital technology demonstration flight, if the project has also been selected for subsequent launch through CSLI or FOP. The funded extension may

extend the cooperative agreement up to an additional 12 months (subject to qualifying conditions described in Section 1.5 above).

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 also request up to \$25,000 of procurement funding for the NASA partner at the second year of a project to cover NASA expenses in the collaboration. This procurement funding may be used by the NASA partner to purchase hardware or for use of NASA test facilities that support the partnership. There is no NASA procurement funding for the first year. Subject to approval, STP projects that are selected for an orbital or suborbital flight demonstration through CSLI or FOP may receive supplemental funds, through a funded extension of the basic cooperative agreement, to support the launch as described in Section 1.5 above. 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 offerors.

Award Information	First Year	Second Year
Period of Performance	up to 12 months	up to 12 months
University Team Award	up to \$200,000	up to \$200,000
Available NASA Civil Servant or JPL Labor Allocation	up to 0.5 FTE	up to 0.5 FTE
NASA or JPL Procurement Allocation	none	up to \$25,000

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 2200.2D** "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 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** by telecon conducted in conjunction with each of the other current STP teams.

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 Section 2.3 in the umbrella NRA.

2.5 Use and Disclosure of Research Resulting from Awards

No change from Section 2.4 in the umbrella NRA.

2.6 Intellectual Property Resulting from Awards

No change from Section 2.5 in the umbrella NRA.

2.7 Cost-Sharing or Matching

No change from Section 3.6 in the umbrella NRA.

2.8 International Traffic in Arms Regulations (ITAR) and Export Administration Regulations (EAR) Requirements

No change from Section 3.8 in the 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 Principal 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.

3.2 Other Eligibility Limitations

No change from Section 3.2 in the 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 Section 3.3 and 4.3.7 in the 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 by October 4, 2019 (5:00 p.m. Eastern) 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 offerors 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 proposed 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(s) 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 1 of this Appendix. 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, nor be marked as proprietary, as NASA may make it available to the public after awards are announced and may post it on the STMD website.**

- **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. Budget information does not need to be completed on the cover page, but should be included in the proposal as noted below.
- **Required Certifications:** See 4.3.4 in the umbrella NRA

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

	Proposal Section	Maximum Page Length
1.	Table of Contents	1
2.	Relevance and Impact	up to 4
3.	Technical and Management Approach	up to 4
4.	Schedule Summary	1
5.	Budget Summary (Table)	1

6.	Budget Justification	as needed
7.	Letters of Commitment and Statements of Support	as needed

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:

Each proposal must address a single Technology Topic Area from among the topics listed in Section 1.4 above. NSPIRES will require the PI to identify the single, specific Technology Topic Area (of Section 1.4 above) 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 this Small Spacecraft Technology (STP) solicitation, the proposing team will need to:

- Describe a specific capability or service needed for lunar exploration precursor missions, or for exploration infrastructure. The capability should be an extension or improvement over the performance of missions that NASA already plans to execute in the 2022 time frame. Explain how small spacecraft – or cooperative groups of small spacecraft – can offer a unique, cost-effective solution for the identified capability or service. Execution of the mission is not considered part of the proposed effort but the needed mission capabilities serve to gauge technology gaps and advancements to performance measures proposed.
- Identify one or more of the technology topics from the list where the state-of-the-art (as projected for the 2022-23 time frame) will inhibit/prevent small spacecraft from achieving the previously described solution. Use quantitative measures where possible when describing the technology gap.
- Explain your proposed two-year development effort that leads to a solution that will fill the identified technology gap. Specify quantifiable key performance parameters / measure of performance Key Performance Measurements (KPP) or Measure of Performance (MOP) to serve as quantitative measure to contrast the performance of the projected 2022-23 state of the art compared to that needed for your solution. Explain how your proposed two-year development effort will raise the performance measure to approach the targeted value.

Describe any plans for infusion of the technology or capability into a future space mission, commercialization, or other follow-on work if the project is successful.

All partnership teams should propose to demonstrate progress toward targeted KPP or MOP values for the technology they develop under this STP within the two-year basic period of performance, at least in the laboratory environment.

Flight testing of the technology or capability is not required, but a path to such testing is desired. Optionally, partnership teams may choose to propose to demonstrate their STP-developed technology through CSLI or FOP. Describe any plans for testing the technology or capability through orbital or suborbital testing.

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 the 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. Include brief description of technical measurement, test or demonstration intended to verify that the proposed quantitative measures of performance / key performance parameter has been improved or that the targeted performance has been achieved.

Provide evidence to support that the TRL of the technology or capability at the time of proposal submission 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. 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 March 25, 2020.

Proposals are encouraged, but not required, to propose planned technology demonstration flights, and if so should show relevant milestones.

Note that after award of the STP cooperative agreement, Small Spacecraft Technology (SST) program may approve requests within a limited time period of the STP effort for a funded extension of the basic STP cooperative agreement to cover specific activities in support of a technology demonstration flight, if the STP project is selected for subsequent launch through CubeSat Launch Initiative (CSLI) or Flight Opportunity Program (FOP). The funded extension may extend the cooperative agreement up to an additional 12 months (subject to qualifying conditions described in Section 1.5 above).

5. Budget Summary:

Complete and include the following table.

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

* 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 Section 3.18 and Appendix C of the **2018** version

of the NASA Guidebook for Proposers

<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 also Section 4.3.6 in the umbrella NRA. However, this appendix requires that NASA civil servants and JPL employees are stated as a percentage of FTE only. Proposers shall not provide fully burdened civil servant and JPL employee labor costs.

See also Appendix G - Examples of Costs Categories from 2 CFR 200 Subpart E in the NASA Grant and Cooperative Agreement Manual dated May 31, 2018
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 3.19 of the 2018 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.

Proposed use of government-furnished equipment, government-owned facilities, and government software must include a statement in the proposal 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.

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>>."

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. Evidence includes quantitative measures such as KPP(s) or MOP(s), 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. 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 the proposed effort has a near term pathway to orbital or suborbital testing.

The proposal includes a demonstration of progress toward KPP or MOP values for the technology developed within the two-year basic period of performance, at least in the laboratory environment. If a flight demonstration is optionally proposed, the extent to which the proposed flight demonstrates progress toward KPP or MOP values.

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 Review and Selection Process

No change from Sections 5.1 through 5.6 in the umbrella NRA.

5.4 Partial Selections

No change from Section 5.4 in the umbrella NRA.

5.5 Selection Announcement and Award Dates

No change from Section 5.5 in the 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 Section 6.0 in the umbrella NRA.

7. POINTS OF CONTACT FOR FURTHER INFORMATION

No change from Section 7.0 in the umbrella NRA, except as noted below:

Questions pertaining to this appendix should be submitted via email to the NASA Grant Officer, Beatrice Morales, Beatrice.M.Morales@nasa.gov no later than later than October 11, 2019 (5:00 Eastern). 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 Section 8.0 in the umbrella NRA.

9. REFERENCES

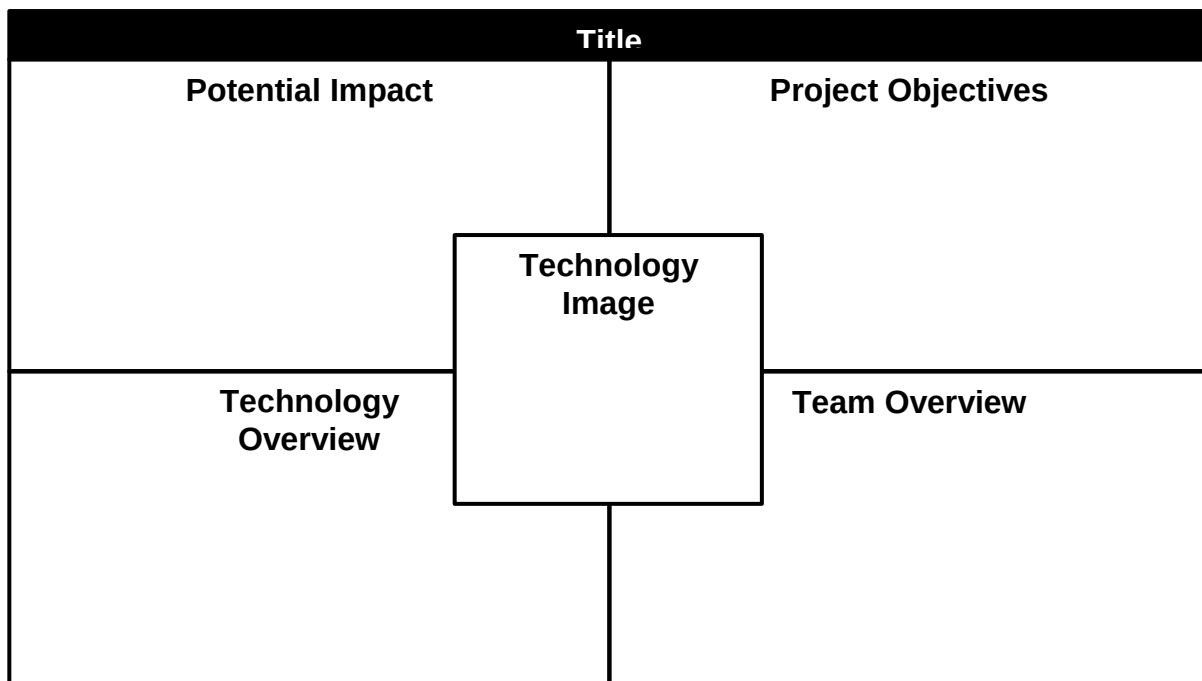
No change from Section 9.0 in the umbrella NRA.

10. ATTACHMENTS

ATTACHMENT 1

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, nor be marked as proprietary, as NASA may make it available to the public after awards are announced and may post it on the STMD website.**



- **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)

