NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)

HEADQUARTERS

SPACE TECHNOLOGY MISSION DIRECTORATE

300 E Street, SW

Washington, DC 20546-0001

UTILIZING PUBLIC - PRIVATE PARTNERSHIPS TO ADVANCE TIPPING POINT TECHNOLOGIES

APPENDIX

to

NASA Research Announcement (NRA): Space Technology - Research, Development, Demonstration, and Infusion - 2015 (SpaceTech–REDDI–2015), NNH15ZOA001N

APPENDIX NUMBER: NNH15ZOA001N-15STMD-001

Appendix Issued: *May 21, 2015*

Notices of Intent Due: *July 1, 2015* (5:00pm Eastern)

Proposals Due: *July 23, 2015* (5:00pm Eastern)

Catalog of Federal Domestic Assistance (CFDA) Number 43.012

OMB Approval Number 2700-0087

Offerors are reminded:

Per Section 4.3.1 of the umbrella NRA solicitation NNH15ZOA001N, all proposals submitted via email or any means other than NSPIRES 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, 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 NSPIRES is not a sufficient reason for NASA to consider a proposal submitted after the deadline."**

Summary of Key Information

Appendix Name: "Utilizing Public-Private Partnerships to Advance Tipping Point Technologies", hereafter called "Appendix" to the SpaceTech-REDDI-2015 NRA, hereafter called "NRA".

Goal/Intent: With this Appendix, the National Aeronautics and Space Administration (NASA) continues to embrace public-private partnerships to achieve its strategic goals for expanding capabilities and opportunities in space. A key aspect of NASA's strategy is to stimulate the commercial space industry while leveraging those same commercial capabilities through public-private partnerships to deliver technologies and capabilities needed for future NASA, other government agency, and commercial missions. With the recent increase of U.S. private sector companies interested in space applications, NASA is seeking commercial space technologies that are at a "tipping point" in their development. For the purpose of this Appendix, a space technology is at a tipping point if an investment in a ground development / demonstration or a flight demonstration will result in:

- a significant advancement of the technology's maturation,
- a high likelihood for utilization of the technology in a commercially fielded space application, and
- a significant improvement in the offerors' ability to successfully bring the space technology to market.

STMD is also releasing an Announcement of Collaborative Opportunity (ACO) that compliments the objectives of this Appendix. Both solicitations embrace public-private partnerships to expand capabilities and opportunities in space. More specifically, the ACO focuses on partnerships between NASA and industry through the award of non-reimbursable Space Act Agreements (SAAs) that will accelerate the availability and reduce costs for the development and infusion of emerging space system capabilities. In the ACO, NASA is seeking to provide technical expertise, test facilities, hardware, and software to aid industry partners in maturing capabilities that can enable or enhance space vehicle systems and/or mature other closely related subsystems. The technology topics listed in these two solicitations when taken together form a subset of the total field of topics that were considered by STMD for public-private partnership efforts to support commercial space interests. In selecting these topics for this year's solicitations, STMD considered responses received from the Tipping Point Request for Information (RFI), other recently released RFIs, as well as existing investments within NASA's technology portfolio for commercial space applications. It is STMD's intent to provide similar Tipping Point NRA and ACO opportunities for public-private partnerships on an annual basis.

Eligibility: Proposed efforts to this Appendix must be led by U.S. industry defined as for-profit businesses that are incorporated in the United States of America. NASA will not consider proposals that do not include a U.S. industry business as the lead proposer. Recent market research activities indicate that the U.S. commercial space sector offers promising “tipping point” technologies with commercialization potential that aligned with NASA goals and objectives. The offeror may propose any teaming arrangement (e.g. academia, non-profit, FFRDC, NASA civil servants, JPL) that optimizes affordability and the potential for rapid development and infusion of the space technology. Partnerships with NASA civil servants and Jet Propulsion Laboratory employees are strongly encouraged. **Only one proposal per topic per offeror is permitted. Proposals may NOT cross topics.**

Key Dates:

Release Date:	May 21, 2015
Virtual Industry Forum	June 17, 2015 (Target)
Notices of Intent Due:	July 1, 2015
Proposals Due:	July 23, 2015
Selection Announcement:	September 2015 (Target)
Award Date:	December 2015 (Target)

Virtual Industry Forum: NASA will host a virtual industry forum that will address key aspects of this Appendix. The date targeted for this forum is Wednesday June 17, 2015. The agenda for the virtual industry forum and all other related information and material will be posted on the following website: http://www.nasa.gov/feature/opportunities-to-foster-commercial-space-technologies. Offerors are encouraged to regularly refer to this website for updates and other information relative to this Appendix. Only those questions received by close of business on June 5, 2015 will be addressed at the forum. Questions regarding this Appendix should be submitted to **HQ-STMD-TippingPointAppendix@nasaprs.com**.

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

Technology Readiness Level (TRL): TRL information per topic is available in Section 2.0 below. For general guidance, NASA TRL definitions are referenced in the SpaceTech-REDDI umbrella NRA and can be found at: http://nodis3.gsfc.nasa.gov/displayDir.cfm?Internal_ID=N_PR_7123_001B_&page_name=AppendixE&search_term=7123.1b

Award Details:

Award Type: Firm-Fixed Priced contracts with milestone payments. All awards will require a corporate and/or customer contribution of at least 25% of the total proposed firm-fixed price. Offerors are required to develop their technical approach and price proposal in distinct and severable phases (e.g. pre-flight phase and flight phase). Specific instructions on project phasing are contained in Section 4.0 – Proposal Submission Information and in the Technology Topic Attachments to this Appendix. Note: In certain unusual circumstances NASA may elect to award cost type contracts (e.g. complex ground demonstration or flight demonstration projects that involve significant risk).

Award Duration: Maximum period of performance is dependent on the proposal topic and is defined in the Table under Section 2.1 below and the availability of funds.

Anticipated Number and Amount of Awards: NASA reserves the right to select for award multiple, one, or none of the proposals in response to this Appendix. NASA reserves the right to negotiate with selected offerors the scope and magnitude of the proposed effort, cost/price terms, and any other terms, as appropriate. The overall anticipated number of awards and the amount of each award is outlined in Section 2.0 of this Appendix. Awards under the Appendix are subject to the availability of funding.

Selection Official: Space Technology Mission Directorate (STMD) Associate Administrator

Questions and Comments: Questions and Comments: Questions and comments about anything pertaining to this Appendix, including the Virtual Industry Forum, should be submitted via email to: **HQ-STMD-TippingPointAppendix@nasaprs.com**

NOTE: *Questions of a general nature will be added to the FAQs for this Appendix. The FAQs will be located under "Other Documents" on the NSPIRES page associated with this Appendix.*

Referenced Documents: See Section 9.0 of the NRA

TABLE OF CONTENTS

Utilizing Public – Private Partnerships to Advance Tipping Point Technologies

1.0 SOLICITED RESEARCH/TECHNOLOGY DESCRIPTION

1.1 Introduction/Overview

The Space Technology Mission Directorate (STMD) is responsible for developing the crosscutting, pioneering, new technologies and capabilities needed by the agency to achieve its current and future missions. STMD rapidly innovates, develops, demonstrates, and infuses revolutionary, high-payoff technologies through transparent, collaborative partnerships, expanding the boundaries of the aerospace enterprise. STMD employs a merit-based competition model with a portfolio approach, spanning a range of discipline areas and technology readiness levels.

This Appendix is seeking proposals for space technology development and demonstration projects executed through fixed price contracts with milestone payments. The intent is that contracts resulting from this Appendix will enable public-private partnerships managed by Programs within the Space Technology Mission Directorate. STMD will assign selected projects to STMD Programs at time of award. It is anticipated that projects awarded from this Appendix will be assigned to the Game Changing Development (GCD) Program, the Flight Opportunities (FO) Program, the Small Spacecraft Technology (SST) Program, or the Technology Demonstration Missions (TDM) Program. More information about the NASA Space Technology Mission Directorate and STMD Programs can be found at:
http://www.nasa.gov/directorates/spacetech/about_us/index.html

1.2 Appendix Goals and Objectives

With this Appendix, the National Aeronautics and Space Administration (NASA) continues to embrace public-private partnerships to achieve its strategic goals for expanding capabilities and opportunities in space. A key aspect of NASA's strategy is to stimulate the commercial space industry while leveraging those same commercial capabilities through public-private partnerships to deliver technologies and capabilities needed for future NASA, other government agency, and commercial missions. With the recent increase of U.S. private sector companies interested in space applications, NASA is seeking commercial space technologies that are at a "tipping point" in their development cycle. For the purpose of this Appendix, a space technology is at a tipping point if an investment in a ground development/demonstration or a flight demonstration will result in a significant advancement of the technology's maturation, a high likelihood for utilization of the technology in a commercial space application, and a significant improvement in the offerors' ability to successfully bring the space technology to market.

NASA is interested in advancing these new capabilities to a point that industry would complete and qualify them for market without further government investments. These technologies should provide a substantial benefit to both the commercial and government sectors once the validation/demonstration project completes. NASA does not envision supporting the final qualification and acceptance of operational systems, but instead views STMD's role as providing support for key system-level development and demonstration, beyond which industry could proceed without additional government investments.

This Appendix is seeking U.S. industry led proposals to advance “tipping point” space technologies, executed through fixed price contracts with milestone payments. Proposed efforts to this Appendix must be led by U.S. industry defined as for-profit businesses that are incorporated in the United States of America. NASA will not consider proposals that do not include a U.S. industry business as the lead proposer. The offeror may propose any teaming arrangement (e.g. academia, non-profit, FFRDC, NASA civil servants, JPL) optimizing the affordability as well as the potential for rapid development and infusion of the space technology. Awards resulting from this Appendix will enable public-private partnerships between U.S. industry and NASA. Partnerships with NASA civil servants and Jet Propulsion Laboratory employees are encouraged. To further ensure successful infusion of these space technologies, NASA is requiring that offerors provide corporate and/or customer contributions of at least 25% of the total proposed firm-fixed price.

1.3 Technology Topics

Topic 1: Robotic In-Space Manufacturing and Assembly of Spacecraft and Space Structures:

This topic, described in detail in Attachment 1, focuses on the technologies needed to assemble, aggregate, and/or manufacture large and/or complex systems in space without astronaut extravehicular activity (EVA). Presently, launch-shroud size, lift capacity, and launch loads/environments are factors that limit the size and capabilities of systems pre-assembled on the ground and deployed using a single launch. With advances in ultra-lightweight materials, robotics, and autonomy, in space manufacturing, assembly, and aggregation concepts are now at a tipping point. This disruptive capability could transform the traditional spacecraft-manufacturing model by enabling in-space creation of large spacecraft systems. No longer will developing, building, and qualifying a spacecraft focus so heavily on an integrated system that must survive launch loads and environments. Additionally, the capability portends greatly simplified integration and the ability to repurpose, upgrade, or reconfigure spacecraft assets in space. It is anticipated that these crosscutting technologies could also greatly reduce cost while increasing capabilities for both NASA and commercial space applications. For example, in-space assembly or manufacturing of large RF or optical reflectors, solar arrays, or entire spacecraft could transform the commercial communications satellite market as well as offer benefits to future NASA missions. The general technology areas of interest include but are not limited to (1) automated/robotic in-space assembly and construction technologies, (2) automated/robotic joining methods that offer reversible connections and reconfiguration for the aggregation/disaggregation of large space-based systems and (3) automated/robotic in-space manufacture of the required components for these systems. While a necessary element of a successful proposal may involve the identification and development of the discrete components or material involved in assembly, aggregation, or manufacture, the focus of the proposed effort must emphasize the design, development, and demonstration of the actual in-space system creation process. That is, the proposal must focus on how a spacecraft is built in space rather than what is used to build it.

Topic 2: Low Size, Weight, and Power (SWaP) Instruments for Remote Sensing Applications:

Space-based remote sensing is a major commercial space growth area with numerous constellations of primarily small spacecraft planned and beginning to come online. Recent announcements confirm significant market growth both in terms of new entrants and capability expansion. The growing market employs a range of electromagnetic sensors and geodetic detectors including panchromatic and multispectral imaging, GPS radio occultation, and other instruments to generate marketable datasets. As the foundations of commercial Earth observation are laid, more advanced and lower size, weight and power (SWaP) sensors/instruments including hyperspectral imagers, RADARs, LiDARs, radiometers, infrared devices, and gravimeters/gradiometers will offer additional marketable opportunities. If these sensors are delivered at sufficiently low power, low mass, and low size they can utilize small spacecraft platforms, enabling entirely new business plans due to the affordability of small spacecraft platforms. NASA and Other Government Agencies (OGAs) are also continually looking to develop sensors for new, innovative measurements and more efficient instruments for existing measurements to support planned earth, planetary, astrophysics, and heliophysics science mission objectives. Radical technological approaches to lowering SWaP while maintaining or improving gain and sensitivity have significant crosscutting application. This topic, detailed in Attachment 2, focuses on the development and/or demonstration of new low SWaP remote sensing instruments and components that are now at a tipping point and which have both commercial and NASA crosscutting potential.

Topic 3: Small Spacecraft Attitude Determination and Control (ADC) Sensors and Actuators:

Operational small spacecraft are increasingly at the center of business models that are expanding the space-based communications, navigation, and remote sensing markets. They are also supporting emerging commercial space markets as technology development platforms. NASA and other government agencies (OGAs) are leveraging small spacecraft to meet mission objectives. High performance, low cost and yet still reliable attitude determination and control (ADC) subsystems are one element limiting the infusion of more capable small spacecraft into mission designs. However, new ADC products applicable to small spacecraft are nearing a tipping point. New technology options driven by innovative low power and low size component and assembly techniques make adoption for operational small spacecraft applications a reasonable design alternative. This topic, detailed in Attachment 3, focuses on (1) low cost, high performance ADC sensors and (2) low cost, high reliability, non-propulsive ADC actuators. Potential investments include products that provide substantial performance increases while maintaining affordability, such as a sensor with radical improvements in inertial guidance precision to enable onboard autonomous navigation, or a low power momentum wheel with no friction/wear surfaces to reduce reliability/lifetime concerns.

Topic 4: Small Spacecraft Propulsion Systems:

Small spacecraft, largely due to their relatively low cost, have become ubiquitous in the expanding commercial space market. Previously used largely as platforms for technology development and education, they are finding increased utility in NASA science and exploration mission architectures. Small spacecraft enjoy increasing launch rates and more manageable launch costs but they are typically forced to fly as secondary payloads, restricting their orbital elements such as inclination, altitude, and local time of the ascending node. Similarly, while commercial small satellites now generate revenue, their range of applications and return on investment is limited due to their capability. In the past, most CubeSats contained no propulsion system at all, and in some cases they did not even perform attitude control. However the propulsion options available to small spacecraft are at a tipping point, driven by the advancement of new technologies and increasing demand for more mission functionality on smaller platforms. Technologies developed under this topic, which is detailed further in Attachment 4, will help to infuse advanced propulsion capabilities into small spacecraft providing, for example: orbit changes for spacecraft utilizing secondary launches; atmospheric drag makeup enabling longer duration missions; orbit maintenance to meet particular observation requirements; orbit changes to provide responsive and agile Earth observation; and high delta-V options to expand applications into cis-lunar space and potentially beyond. In some cases efficient low SWaP propulsive systems for small spacecraft also may provide new capabilities for larger spacecraft. For example, highly efficient micro-electric propulsion systems that would provide station-keeping capabilities for a CubeSat may also serve as an alternative micro-pointing actuator for a large observatory that would typically utilize reaction wheels.

2.0 AWARD INFORMATION

Award Type: Firm Fixed Priced contracts with milestone payments. All awards will require a Corporate and/or Customer Contribution of at least 25% of the total proposed firm-fixed price. Corporate contributions are defined as direct contributions from the lead commercial proposal organization. Customer contributions are defined as direct contributions from a government or commercial organization that intends to utilize the resultant capability in a specifically defined application. Contributions of greater than 25% are strongly encouraged and will improve the Price and Value Proposition evaluation portions of the proposal. Offerors are required to develop their technical approach and price proposal in distinct and severable phases (e.g. pre-flight phase and flight phase). Specific instructions on project phasing are contained in Section 4.0 –

Proposal Submission Information and in the Technology Topic Attachments to this Appendix. Note: In certain unusual circumstances NASA may elect to award cost type contracts (e.g. complex ground demonstration or flight projects that involve significant risk).

Award Duration: Maximum period of performance is dependent on the proposal topic and is defined Section 2.1 below and the availability of funds.

2.1 Funding and Period of Performance Information

Technology Topic	Entry TRL	Anticipated Number of Awards	Value of Each Award	Period of Performance
Topic 1: Robotic In-Space Manufacturing and Assembly of Spacecraft and Space Structures	at least 3	up to 2	*up to $20M per award	up to 24 months
Topic 2: Low Size, Weight, and Power (SWaP) Instruments for Remote Sensing Applications	at least 3	up to 2	*up to $3M per award	up to 24 months
Topic 3: Small Spacecraft Attitude Determination and Control (ADC) Sensors and Actuators	at least 3	up to 2	*up to $3M per award	up to 24 months
Topic 4: Small Spacecraft Propulsion Systems	at least 5	up to 2	*up to $2M per award	up to 18 months

* The value of each award noted in the table above was developed including **only** the STMD portion of the award (i.e. not including Corporate and/or Customer contributions). In compelling cases, NASA may accept a proposal that exceeds the award values noted above.

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 NRA. NASA reserves the right to select for award multiple, one, or none of the proposals in response to this Appendix. NASA reserves the right to negotiate with selected offerors, the scope and magnitude of the proposed effort, cost/price terms, and any other terms, as appropriate

2.3 Award Reporting Requirements/Meetings/Deliverables:

The STMD Program assigned to the project will specify reporting requirements at the time of award. However, proposals should consider, as a minimum:

A. Kick-off meeting in the Washington, D.C. area
B. Project status review approximately every 6 months throughout the contracting period at the offeror's facility
C. Flight readiness review (if applicable to the proposed effort) at the offeror's facility
D. Final project review in the Washington, D.C. area

2.4 Successor Proposals and Resubmission

No change from NRA.

2.5 Use and Disclosure of Research Resulting From Awards

No change from NRA.

2.6 Intellectual Property Resulting From Awards

Data Rights: The objective of a contract awarded under this Appendix is to provide recipients with the incentive to develop commercial applications of technologies developed through the partnership. Data exchanged between NASA and a recipient will generally occur freely without restriction as to its disclosure, use or duplication. However, NASA will protect from disclosure a recipient's proprietary data that is exchanged provided it is clearly marked as such.

If a respondent chooses to submit business sensitive, proprietary, or otherwise confidential information as part of its proposal, it must be clearly and conspicuously marked.

Invention Rights: Recipients that are Small Businesses or nonprofit organizations may elect to retain title to their inventions pursuant to the Bayh-Dole Act (35 U.S.C. § 202). Large business recipients are subject to section 20135 of the National Aeronautics and Space Act (51 U.S.C. § 20135) relating to property rights in inventions. Title to inventions made under an agreement by a large business recipient initially vests with NASA. However, these recipients may request a waiver to obtain title to inventions made under the agreement. Such a request may be made in advance of the agreement or within 30 days thereafter. Even if a waiver request is not made, or denied, a large business recipient may request a waiver on individual inventions made during the course of the agreement.

Accordingly, the resulting contracts will contain the clauses at 14 CFR 1274.905, Rights in Data, and either 14 CFR 1274.912, Patent-Rights – Retention by Large Business or 14 CFR 1274.913, Patent-Rights- Retention by Large Business in lieu of the corresponding FAR clauses.

2.7 Cost-Sharing or Matching

A corporate/customer contribution of 25% is required as defined in Section 3.2 and 4.0 below.

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

No change from NRA.

3.0 ELIGIBILITY INFORMATION

Recent market research activities indicated that U.S private sector industry provides the most compelling "tipping point" technologies combined with promising capabilities that align with the goals and objectives of this Appendix. Furthermore, for-profit businesses are more likely to provide NASA-funded capabilities back to the open market. Accordingly, proposals will only be accepted from for-profit offerors that are incorporated in the United States of America. The offerors are encouraged to propose teaming arrangements (e.g. academia, non-profit, FFRDC, NASA civil servants, JPL) that optimizes the potential for rapid development and infusion of the space technology. Partnerships with NASA civil servants and Jet Propulsion Laboratory employees are highly encouraged.

3.1 Limitation of Number of Proposals per Organization

Only one proposal per topic per offeror is permitted. Proposals may NOT cross topics.

3.2 Other Eligibility Limitations

Corporate/Customer Contribution: For responses to this Appendix, a combined corporate and/or customer contribution of at least 25% of the total proposed firm-fixed price is required. Corporate contributions are defined as direct contributions from the lead commercial proposal organization. Customer contributions are defined as direct contributions from a government or commercial organization that intends to utilize the resultant capability in a specifically defined application. Corporate and customer contributions must: (1) provide for a necessary element advancing the project objectives, (2) be quantifiable and documented, and (3) be incurred after the period of performance start date in the contract (i.e. "Sunk" costs are NOT allowable in calculating corporate/customer contribution). Contributions may be in the form of direct labor, travel, consumables or other in-kind contributions that directly advance the objectives of the proposed effort. Contributions of greater than 25% are strongly encouraged and will improve the Price and Value Proposition evaluation portions of the proposal. Full details on the criteria and procedures associated with the corporate contribution are provided in Section 4.0, Proposal Submission Information.

Note: *While all contributions that reduce the STMD costs to develop the technology are welcome, a higher value is placed on contributing resources coming from a stakeholder/customer as opposed to a technology developer.*

In cases when a proposer has an existing SBIR Phase II contract, the award for a project selected under this solicitation may result in a SBIR Phase III contract to take advantage of funding opportunities offered by the SBIR Program. Note: Follow-on SBIR efforts will be considered under the Value Proposition evaluation criteria defined under Section 5.0 below, but will not be considered part of the 25% Corporate/Customer contribution requirement. Further information is provided in Sections 4.0 and 5.0 below.

3.3 Foreign Participation

Foreign participation is strictly prohibited on this Appendix.

3.4 China Funding Restriction

No change from NRA.

4.0 PROPOSAL SUBMISSION INFORMATION

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

- Offerors shall submit proposals via *NSPIRES* See 4.3.1 of the NRA.

- **Notice of Intent (NOI) to Propose**: is requested, but not required. The information contained in an NOI is used to expedite the proposal review activities and is, therefore, of value to both NASA and the offeror. 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/. 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. A brief description of the primary Technology Topics and objective(s) of the anticipated technology development.
  3. The name of the proposal lead. Proposal lead, must have previously accessed and registered in NSPIRES.

- **Quad Chart**: Provide a single 8.5 x 11 page summary chart which will be used to represent your proposal during the review process. This required summary chart does not count against the 20-page limit. Please closely follow the template provided at: http://www.nasa.gov/feature/opportunities-to-foster-commercial-space-technologies, and include the following components:
    - Upper Left Quadrant: **Company Overview** - Title, company name and address, total number of company employees, brief company description, and teaming partners
    - Lower Left Quadrant: **Technology Overview** - Technology overview to include: brief technology description, key required development, starting TRL, ending TRL, and short description of TRL basis
    - Upper Right Quadrant: **Project Overview** - Project approach description to include: price, schedule, and major milestones
    - Lower Right Quadrant: **Commercialization Overview** - Brief summary of commercialization strategy to include an estimate of the market value of the matured product/technology, intended commercial application, and NASA application
    - Centered Across Four Quadrants: Technology image (size may be varied to best illustrate/explain)

  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.**

- Proposal Cover Page, Program Specific Data (PSD): This Appendix contains program specific data (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

- 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, if the offeror proposes to use ISS, the following guidance is provided. The ISS program provides transportation to the ISS and standard experiment integration activities free of charge to approved, sponsored technology development investigations. 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. For STMD, Advanced Exploration Systems (AES), or general engineering research, development, or demonstration proposals, the point of contact is:

  Dr. George Nelson: Manager, ISS Technology Demonstration Office, 281.244.8514, george.nelson-1@nasa.gov

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

	Proposal Section	***Maximum Page Length***
1.	**Table of Contents**	**1**
2.	**Technical and Management Section**	**up to 20**
3.	**Price Proposal and Milestone Payment Schedule**	**as needed**
4.	**Letters of Corporate / Customer Commitment**	**see below**
5.	**FAR Provision 52.227-15**	**as needed**
6.	**Small Business Subcontracting Plan or Small Business Participation Description (if applicable)**	**as needed**
7.	**Statement of Work – does not count toward Technical/Management page count—See Attachment 5 for SOW Draft Template format**	**as needed**

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

1. Table of Contents:

Offerors should include a one-page Table of Contents that provides a guide to the organization and contents of the proposal. This item may also incorporate customized formats of the offeror's own choosing, e.g., identification of the submitting organization through use of letterhead stationery, project logos, etc.

2. Technical and Management Section:

Relevance to Solicitation Objectives:

A. Alignment: Define the technology underpinning the endeavor and its overall benefits. Provide evidence that the technology is actually at a tipping point (per the definition provided in this Appendix). Describe how the proposed effort is aligned with the goals and objectives in the solicited topic. Describe how the proposed technology development timeline aligns with the need date for future missions and applications.

B. Comparison to State-of-the-Art (SOA): Define the current state-of-the-art and provide quantitative rationale how the proposed effort offers a revolutionary, disruptive, or transformational space technology that significantly improves performance over the current SOA.

C. Commercialization Plan: Provide a Commercialization Plan that includes a discussion of the commercial market for the capability or technology. Provide a viable business case for the development and commercialization of the technology.

D. Infusion Potential: Provide documentation that potential end users of the technology (infusion customers, not technology developers) acknowledge the potential benefits of the technology and advocate for the investment in the technology. Demonstrate that there is a clear "receiving organization" that will benefit from the technology development. Provide clear evidence of NASA mission infusion potential and commercial sector application.

E. Value Proposition: Value proposition here is defined as the potential benefits of maturing the technology vs. the price (in this case the cost to STMD not including SBIR funding) to mature the technology. Provide an assessment of the value proposition offered by examining the relative proposed price versus the projected benefits or improvements in performance over the SOA. Demonstrate that a NASA investment in this technology effort will make a substantial difference compared to the existing investments in this technical area by other external organizations. Offerors that are currently performing or have completed Small Business Innovated Research (SBIR) Phase II contracts that are related to one or more of the technology topics contained in this Appendix should discuss potential follow-on efforts and additional funding from the SBIR Program.

Technical Approach:

A. Technology Development Plan: Provide a technology development work plan that includes a discussion of: the overall technical approach to accomplish the objectives of the effort within the proposed time period; the capability of proposed facilities, laboratory space, fabrication methods, equipment, and test techniques to accomplish the work; and the major technical challenges and risks and feasible mitigation strategies. Ensure the work plan includes distinct and severable phases, such that the work reaches a logical break point before executing the next phase. These phases are project specific.

B. Qualifications and Capabilities: Describe the qualifications and capabilities of the project lead and team members including the skill, expertise, and experience needed to successfully execute the proposed technical approach.

C. TRL Assessment: Identify and substantiate that the entry TRL is appropriate for this solicitation and provide compelling rationale demonstrating that the proposed technical approach will achieve the TRL advancement specified in this Appendix.

D. Schedule: Provide a detailed schedule that includes major phases of the work and adequate margin. The schedule shall incorporate major milestones including measurable metrics consistent with the Milestone Payment Schedule identified below under paragraph 3 for each major milestone.

3. Price Proposal, Corporate/Customer Contribution, and Milestone Payment Schedule:

Price Proposal: The price proposal shall include the total firm fixed price for the development project through completion. The total firm fixed price shall be broken down into distinct and severable phases that align with the major break points of the project defined in the Technology Development Plan and Schedule (e.g. pre-flight phase price + flight phase price = total firm fixed price). A price breakout by Government Fiscal Year (October 1 through September 30) shall also be included. The offeror shall provide total direct labor hours and dollars by labor category, indirect rates (e.g. overhead and G&A), travel, other direct costs (e.g. materials, equipment, and supplies), subcontracts, and profit in accordance with the format set forth in Attachment 6. The offeror may revise the format set forth in Attachment 6 to accommodate their accounting system.

If partnering with a NASA Center, the price proposal shall list all NASA costs (e.g. procurements, equipment, personnel, or facilities) **separately by Government Fiscal Year** in accordance with the format set forth in Attachment 6.

Corporate/Customer Contribution: For responses to this Appendix, a combined corporate and/or customer contribution of at least 25% of the total project price is required. The total value of the contribution shall be included as a separate line in the price proposal as shown in Attachment 6. Offerors shall support the proposed total amount in Attachment 6 by providing a list of proposed corporate and customer contributions, including amount, purpose, source, and status. Corporate contributions are defined as direct contributions from the lead commercial proposal organization. Customer contributions are defined as direct contributions from a government or commercial organization that intends to utilize the resultant capability in a specifically defined application. Corporate or customer contributions may include any aspect of the total project life cycle costs such as contributions of equipment, property, facilities or services. Note: While all contributions that reduce the STMD costs to develop the technology are welcome, a higher value is placed on contributing resources coming from a stakeholder/customer as opposed to a technology developer.

Criteria and procedures for the allowability and allocability of cash and non-cash contributions shall be governed by FAR Parts 30 and 31, and NFS Parts 1830 and 1831. Corporate and customer contributions must: (1) provide for a necessary element advancing the project objectives, (2) be quantifiable and documented, and (3) be incurred after the period of performance start date in the contract (i.e. “Sunk” costs are NOT allowable in calculating corporate/customer contribution). Note: Something that is proposed as a non-cash contribution for the project may be counted as a contribution at the time-use equivalent current fair market value, even though it may have been acquired at some point in the past. Furthermore, development costs for an item or a service that were incurred prior to the period of performance start date of the contract **cannot** be counted as a contribution. Contributions include, but are not limited to: (1) donated equipment/property/facilities by an external source, (2) third party funded non-cash contributions, (3) funding from a third party other than STMD. For this Appendix, cash and non-cash contributions from other federal agencies, are acceptable as customer contributions and can count towards the 25% contribution requirement as well as improving the Value Proposition provided that such federal agencies are end-users of the technology. Other funding such as from the SBIR program or funding from other federal programs is still welcome and will be evaluated under the Value Proposition. Cash contributions from federal appropriated funds must be authorized for the proposed purpose and available for obligation. When the contribution is in the form of personal services, the contributor must certify that the amount contributed is comparable to the individual's regular rate of compensation. When contributions are for other than personal services, the provider must state the fair market value of the item. The portion of the technology demonstration mission that is dependent upon cost contributions from a source other than STMD shall be detailed in the proposal accompanied by written indications that such funding or in-kind contribution is consistent with the current planning of the funding source.

Milestone Payment Schedule: The offeror shall provide a list of proposed capability/technology development and demonstration milestones per project phase. Each milestone shall include a descriptive title, objective success criteria, planned achievement dates (month and year), and corresponding payment amount. Milestones should represent significant technical and business progress in the program. At least one milestone per calendar quarter is recommended.

4. Letters of Corporate/Customer Commitment:

Include letters of commitment from corporate/customer contributors demonstrating the 25% corporate/customer contribution detailing the funding or in-kind contribution to be provided from sources outside of STMD. Note: Potential SBIR funding - cannot count towards the 25% corporate/customer requirements of this Appendix. Proposed SBIR funding will be evaluated under the Value Proposition. See proposal paragraph 3 above, under Section 4.0 – Proposal Submission Information for more details on the corporate/customer contributions.

4. FAR Provision 52.227-15 “Representation of Limited Rights Data and Restricted Computer Software”:

For offerors seeking contracts, FAR 52.227-15 should be completed and included in the proposal.

5. Small Business Subcontracting Plan:

Offerors are advised that, by law, FAR clause 52.219-9 titled “Small Business Subcontracting Plan” applies to NASA prime **contracts** with organizations other than small business concerns (including non-profit organizations and universities) that offer subcontracting possibilities and exceed $5,000,000.

NASA is subject to statutory goals to allocate a fair portion of its contract dollars to small businesses and subcategories of small businesses as defined in FAR clauses 52.219-8 and 52.226-2, including Small Disadvantaged Business concerns (SDBs), Women owned Small Businesses (WOSBs), Service Disabled Veteran owned small businesses (SDVOSB), Historically Black Colleges and Universities (HBCUs), and Other Minority Institutions (OMIs). Offerors are encouraged to assist NASA in achieving these goals by using best efforts to involve these entities as subcontractors to the fullest extent consistent with efficient performance of their missions.

Accordingly, offerors proposing to receive contracts that exceed $5,000,000 are required to submit a small business subcontracting plan with all of the elements listed in FAR 19.704. This plan shall be submitted with the proposal, and is subject to negotiation after selection. It is not included in the proposal page count. Failure to submit an acceptable plan will make the offeror ineligible for award. (Subcontract plans for contract awards below $5,000,000 will be negotiated after selection).

Acceptable plans will address the participation goals and quality and level of work performed by small business concerns overall, as well as that performed by the various categories of small business concerns listed in FAR 52.219-9.

6. Statement of Work:

A draft Statement of Work (SOW) shall be included in the proposal. The SOW shall follow the format included in Attachment 5. The offeror shall not include proprietary information in the SOW. The SOW does NOT count toward the Technical/Management page count.

5.0 PROPOSAL REVIEW INFORMATION

The following information supplements, where applicable, the information provided in Section 5.1 through 5.6 of the NRA:

Evaluation Criteria

The evaluation criteria considered in evaluating proposals under this Appendix are listed below. The criteria are essentially equally weighted.

Relevance to Solicitation Objectives:
Evaluation includes consideration of the following:

A. Alignment: The extent to which the proposed effort sufficiently defines the technology underpinning the endeavor and its overall benefits. The degree to which the proposal provides sufficient evidence that the technology is actually at a tipping point (per the definition provided in this Appendix). The extent to which the proposed effort is aligned with the goals and objectives in the solicited topic. The degree to which the proposed technology development timeline aligns with the need date for future missions and applications.

B. Comparison to State-of-the-Art (SOA): The extent to which the proposal adequately and accurately defines the SOA for comparison. The extent to which the proposed effort offers a revolutionary, disruptive, or transformational space technology that significantly improves performance over the current SOA.

C. Commercialization Plan: The overall merit, rationale, and feasibility of the proposed Commercialization Plan including the reliability of the commercial market for the capability or technology. The extent to which the proposal presents a viable business case to develop and commercialize the technology.

D. Infusion Potential: The degree to which potential end users of the technology (infusion customers, not technology developers) acknowledge the potential benefits of the technology and advocate for the investment in the technology. The extent to which there is a clear "receiving organization" that will benefit from the technology development. The extent to which the proposed effort provides clear evidence of NASA mission infusion potential and commercial sector application.

E. Value Proposition: Value proposition here is defined as the potential benefits of maturing the technology vs. the price (in this case the cost to STMD not including SBIR funding) to mature the technology. The extent of the value proposition offered in the proposed effort as determined by examining the relative proposed price versus the projected benefits or improvements in performance over the SOA. The extent to which a NASA investment in this technology effort will make a substantial difference compared to the existing investments in the area by other external organizations. The extent to which Offerors that are currently performing or have completed SBIR Phase II contracts that are related to one of the topics in this solicitation offset the costs of the proposed project with SBIR Program funds.

Technical Approach:

Evaluation includes consideration of the following:

A. Technology Development Plan: The extent to which the offeror proposes a convincing technology development work plan; the feasibility and soundness of the technical approach to accomplish the objectives of the effort within the proposed time period; the capability of proposed facilities, laboratory space, fabrication methods, equipment, and test techniques to accomplish the work; the extent to which major technical challenges and risks are identified and feasible mitigation strategies are proposed.

B. Qualifications and Capabilities: The extent to which the proposal demonstrates that the project lead and team members have the skill, expertise, and experience needed to successfully execute the proposed technical approach.

C. TRL Assessment: The extent to which the entry TRL is appropriate for this solicitation and the degree to which the proposed technical approach will achieve the TRL advancement specified in this Appendix.

D. Schedule: The realism of the schedule relative to the major phasing of the work and adequate margin. The extent the schedule incorporates major milestones including measurable metrics.

Price:

Evaluation includes consideration of the following:

A. Pricing Strategy: Overall strategy for maturing the technology from a financial perspective. The extent to which the proposal makes a compelling case that the most affordable approach possible is pursued. The extent to which government facilities and personnel are utilized to achieve the technology advancement.

B. Price Reasonableness: The reasonableness of the proposed price of the technology development effort and proposed funding profile. The reasonableness of the payment distribution in the Milestone Payment Schedule.

C. Corporate/Customer Contribution: The Corporate/Customer Letters of Commitment including the extent of any proposed corporate and/or customer contributions, including amount, purpose, source, and status. The extent to which corporate/customer contribution commitments meet or exceed the 25% contribution requirements. Note: While all contributions that reduce the STMD costs to develop the technology are welcome, a greater importance is placed on contributing resources coming from a stakeholder/customer as opposed to a technology developer.

NOTE: If any criteria in this Appendix conflict with any other part of the NRA, the criteria identified in this Appendix take precedence.

By submitting a proposal, the offeror acknowledges that the proposal is valid for no less than six (6) months from submission.

6.0 AWARD ADMINISTRATION INFORMATION

No change from NRA.

7.0 POINTS OF CONTACT FOR FURTHER INFORMATION

No change from NRA except as noted below:
Questions and comments about this Appendix may be submitted via email to:
HQ-STMD-TippingPointAppendix@nasaprs.com

NOTE: Questions of a general nature will be added to the FAQs for this Appendix. The FAQs will be located under "Other Documents" on the NSPIRES page associated with this Appendix.

8.0 ANCILLARY INFORMATION

No change from NRA.

9.0 REFERENCES

No change from NRA.

10.0 ATTACHMENTS

ATTACHMENT 1:

Robotic In-Space Manufacturing and Assembly of Spacecraft and Space Structures

1 Description of Topic

As NASA evolves its plans to send humans deeper into space and advance its science capabilities, a significant demand exists for larger but more affordable and more flexible contiguous spacecraft and space-based structures. To date the strategy for large in-space systems followed two primary approaches: 1) Design, develop, assemble, qualify, launch, and deploy a monolithic spacecraft using a single launch, deploying the large elements once in space. This approach is constrained by the size of the launch vehicle fairing and the need to design spacecraft as well as the deployable elements for the launch environment. 2) The spacecraft is designed, developed, assembled, and qualified on the ground as major system components, and then launched (sometimes independently) and assembled on orbit. Regardless, costs and complexity are high because these approaches can require astronaut extra-vehicular activity (EVA), remotely operated appendages, critical (one-time) deployments, or risky rendezvous activities. While all highly successful, NASA experiences with assembling the International Space Station (ISS), the rendezvous and docking of elements of the Apollo program, and the periodic servicing and upgrading of the Hubble Space Telescope, suggest the need for more economic and extensible approaches.

Serious limitations with monolithic spacecraft strategies include meeting system design requirements to tolerate launch environments, size, and integration restrictions imposed by the launch vehicle, and the need to build in adequate reliability for critical deployments, redundancy where required (particularly for human applications), and long service life. If the requirements to accommodate launch loads and environments were reduced, alternative designs providing significant efficiencies in mass and cost would result. Further, with in-space automated spacecraft assembly it may be possible to perform robotic maintenance, upgrades, and reconfiguration, and possibly relax reliability and fault tolerance requirements, promising further mass and cost reductions. It is anticipated that in-space automation and robotics technologies will serve crosscutting functions greatly improving the affordability and capability of both NASA missions and commercial space applications.

This Appendix attachment solicits proposals in tipping point technologies for in-space manufacturing and/or supervised-autonomy robotics to enable versatile and adaptive in-space assembly processes that can change the paradigm of launching pre-assembled spacecraft and structures. This in-space assembly approach would work with multiple or batch deliveries of materials or discrete components in combination with persistent in-space presence of robotic assembly, manufacturing, or aggregation equipment, freeing mission architecture designs from the constraints of using a single launch. The technology areas of interest include but are not limited to (1) automated/robotic in-space assembly and construction technologies, (2) automated/robotic joining methods that offer reversibility and reconfiguration for the aggregation/disaggregation of large space-based systems and (3) automated/robotic in-space manufacture of the required components for these systems. Examples of systems that the proposed technologies of interest will enable include more affordable, more reconfigurable commercial communications satellites, large RF or optical reflectors, large solar arrays (> 100 kW), fuel depots or space docks, in-space habitats, and backbone structures for Mars cruise vehicles.

While a necessary element of a successful proposal may involve the identification and development of the discrete components or material involved in assembly, aggregation, or manufacture, the focus of the proposed effort must emphasize the design, development, and demonstration of the actual in-space space system creation process. That is, the proposal must focus on how a spacecraft is built in space rather than what is used to build it.

Successful proposals must clearly demonstrate utilization in at least one commercial application but also make the case for how the new capability has crosscutting potential for NASA/OGA missions. The proposal must describe in detail how the proposed approach enables benefits for reducing cost, mass, and/or the need for redundancy over systems developed using the conventional monolithic spacecraft paradigm. The proposal should provide clear evidence of the potential benefits in terms of affordability, mass, and flexibility.

Successful proposals must include sufficient detail to describe the key technology advancement(s), including the primary joining concept(s), the required robotic equipment and processes to perform the in-space assembly, and the concept of operations (e.g., assembly order, metrology, integrated sensing, calibration, post-assembly verification, etc.). Proposals should describe in detail any software, sensing, and control approaches unique to the proposed solution. Approaches that allow for ease of repair and re-configuration are of particular interest. In-space manufacturing of the required components is also welcome but not required. Concepts that allow for the efficient and reliable prediction of the integrated performance of the assembled system (including joint performance) are desired. As with most space systems, results of the current work should provide for extended in-space operations, thus the durability and reliability of the assembled structures or systems in the space environment (includes stiffness, fatigue, fracture, and aging characteristics of the joining components) must be addressed.

Key example characteristics of interest for this capability include:

- Versatility – ability to adapt the assembly process to allow for more than one end product
- Precision – ability to attain the desired precision and to adjust the post-assembly shape and precision to enable multiple end products
- Reversibility of the connections to allow for repair, re-configuration, and/or re-use of the assembly components
- Efficiency (in terms of cost, mass, stowed volume at launch and reduced redundancy requirements)

2 Programmatic Considerations

Proposals to this Technology Topic should follow the direction (award type, funding, period of performance, organization, reporting requirements, etc.) outlined in Sections 2.0, 4.0, and 5.0 of this Appendix.

Proposals under this Technology Topic may consider ground demonstration **or** flight demonstration. Phased approaches that make use of ground demonstrations to mature key technologies prior to demonstration in space are encouraged.

For proposals to this Technology Topic that only include a ground demonstration, it is left to the offeror to organize the phasing and milestones in the work plan, schedule, and price sections.

For proposals to this Technology Topic that include a flight demonstration, proposals should be separated into at least two distinct phases:

Phase 1: **Critical Technology and Flight Payload Maturation** - Phase 1 should focus on advancing critical technology elements to mature the payload hardware and performing the engineering for flight readiness. Offerors must identify the critical technologies requiring maturation for the proposed concept and their current technology readiness. Offerors must also identify the major technical challenges for developing the flight hardware and the plan to overcome them. STMD will conduct a Critical Technology Readiness Review at the end of Phase 1 to determine if the project is ready to enter into Phase 2. NASA will determine whether to proceed with Phase 2 only if: a) the technology maturation reaches high confidence for a successful flight demonstration mission, and b) flight demonstration is warranted to infuse a high priority technology.

Phase 2: **Flight Demonstration Mission** - Phase 2 of the proposed effort should focus on fabrication, assembly, integrated test, launch, and operation of the actual technology flight demonstration. Offerors must scope the entire flight demonstration including any necessary launch and operations. Offerors are strongly encouraged to minimize the cost/price of Phase 2 with innovative launch and operations concepts (e.g. small spacecraft platforms, partnering with an existing flight program to fly as a secondary payload, etc.).

NOTE:

Flight demonstrations proposed under this Technology Topic will be awarded for **Phase 1 ONLY**. Although NASA will only make awards for Phase 1, offerors shall include Phase 2 details (work plan, schedule, and price/cost) in their proposal in accordance with Section 4.0 – Proposal Submission Information. Phase 2 proposal details will be Rough Order of Magnitude (ROM) estimates and used only for evaluation purposes. Launch costs should also be broken out separately, as NASA may propose a more affordable or leveraged launch opportunity. Detailed Phase 2 proposals may be requested and awarded after implementation of Phase 1 in accordance with the decision criteria noted under the description of Phase 1 above.

Award information found in the table under Section 2.1 of this Appendix is for ground demonstration or Phase 1 flight demonstration projects only. Phase 2 estimates should be guided by the offeror's best estimates of the most economical approach to demonstrating the technology in flight.

ATTACHMENT 2:

Low Size, Weight, and Power (SWaP) Instruments for Remote Sensing Applications

1 Description of Solicitation Topic

Space-based remote sensing is a major commercial space growth area with numerous constellations of low earth orbit spacecraft coming online or in development. Reducing the size, weight, and/or power (SWaP) of sensor instruments will allow for the utilization of smaller spacecraft platforms, affording more agile, lower cost observation systems with higher revisit frequencies. Recent announcements confirm significant market growth of constellations of small low earth orbiting satellites, both in terms of new entrants and capability expansion. These ventures are employing a range of electromagnetic sensors and geodetic detectors including panchromatic and multispectral imaging, GPS radio occultation, and other instruments to generate marketable datasets. As the foundations of commercial Earth observation are laid, more advanced and lower SWaP sensors/instruments including hyperspectral imagers, RADARs, LiDARs, radiometers, infrared devices, and gravimeters/gradiometers will offer additional marketable opportunities. If these sensors and detection systems are delivered at sufficiently low power, low mass, and low size then they can utilize small spacecraft platforms, enabling entirely new business plans due to the greatly improved affordability.

NASA and OGAs are also continually looking to develop sensors and detection systems for new, innovative measurements as well as more efficient instruments to perform existing measurements. For NASA Earth science missions existing geodetic, atmospheric, and other detailed observation instruments often rely on larger platforms with abundant power, volume, and mass accommodations. These missions, as with NASA astronomy, astrophysics, heliophysics, and planetary science missions, place an absolute premium on measurement data quality and fidelity. As a result, some of these instruments require significant additional support capabilities such as maintaining precise environmental conditioning (e.g. temperature) and wide bandwidth communications to download the large volumes of science data. NASA planetary science pays close attention to low SWaP instruments since the power, mass, and volume “gear ratios” to place assets in planetary orbits, or on surfaces, is high. As a result most of these instruments are SWaP starved and already at the cutting edge in terms of science data precision given the resource limitations. NASA heliophysics missions generally face the same challenges as planetary; placing assets at distant locations from Earth severely restricts available instrument SWaP. In some future cases, science measurements may shift toward utilizing constellations of smaller spacecraft to obtain data more affordably, even leveraging commercial systems. In all cases NASA science interests point toward obtaining at least the same quality of data of present instruments while reducing the SWaP. Human exploration missions also demand new sensors and instrumentation, particularly radiation sensors to support environmental monitoring and astronaut health and safety. Technologies that can expand and enable new commercial space business models while also enhancing

NASA mission remote sensing capabilities for earth science, planetary science, heliophysics, astronomy and astrophysics, or human exploration are especially encouraged.

NASA science instrument requirements are guided by decadal surveys produced by the National Research Council for each of the science disciplines: *Earth Science and Applications from Space: National Imperatives for the Next Decade and Beyond* and *Earth Science and Applications from Space: A Midterm Assessment of NASA's Implementation of the Decadal Survey (2012)* (Earth Science); *Visions and Voyages for Planetary Science in the Decade 2013 – 2022* (Planetary Science); *Solar and Space Physics: A Science for a Technological Society* (Heliophysics); and *New Worlds, New Horizons in Astronomy and Astrophysics* (Astronomy and Astrophysics). Decadal surveys are available through the National Academies Press http://www.nap.edu.

For additional information on current and future NASA instrument applications and sensor needs consult the *Research Opportunities in Space and Earth Sciences (ROSES) – 2015 NASA Research Announcement* available through http://science.nasa.gov/researchers/sara/letters-from-sara/2015/2/19/research-opportunities-space-and-earth-sciences-roses-2015/.

For more information on current and future NASA instrument applications and sensor needs consult the Research Opportunities in Space and Earth Sciences (ROSES) – 2015 NASA Research Announcement (http://science.nasa.gov/researchers/sara/letters-from-sara/2015/2/19/research-opportunities-space-and-earth-sciences-roses-2015/).

NASA is seeking to foster the commercial remote sensing market with investments in instruments utilizing radical technological approaches to lowering size, weight, and power (SWaP) while maintaining or improving gain and sensitivity that also have significant NASA crosscutting application. Example investments include products that provide substantial performance increases while reducing power consumption and size, such as advanced focal planes based on new material systems and fabrication techniques, high sensitivity gravimeters/gradiometers instruments for geodesy and asteroid tomography, improved solar blind detectors, compact hyperspectral imagers, miniature gamma ray/neutron detectors, smaller instrument components utilizing advanced manufacturing approaches, and compact/low power support subsystems and components including high speed control electronics and cryocoolers.

Suggested design goals for low SWaP remote sensing instrument now at the tipping point:

- Lower mass, power, and/or size relative to the current best state of the art
- >10x improvement in key performance parameter(s)

It is important to note that technologies of interest to NASA under this topic must not simply provide an incremental improvement but must offer the potential to significantly improve upon existing device size, mass, and/or power. Proposals submitted in response to this topic must state the initial component state of the art and justify the final performance metrics.

2 Programmatic Considerations

Proposals to this Technology Topic should follow the direction (award type, funding, period of performance, organization, reporting requirements, etc.) outlined in Sections 2.0, 4.0, and 5.0 of this Appendix.

Proposals under this topic should focus on ground demonstrations, however the inclusion of the development of flight hardware as part of the proposal is also acceptable. In the case that the development of flight hardware is proposed, offerors must specify the accommodation interface goals for the flight instrument – power, mass, volume, conditioning, communications, expected space environment and location, etc. NASA will consider such proposals and may offer to accommodate the instrument in an actual spaceflight at a later date (i.e. post award). NASA reserves the right to make decisions regarding the appropriateness of a spaceflight, as well as the manner (e.g. spacecraft design, development, and operations) that the spaceflight will occur. Thus, while offerors can propose the development of flight appropriate hardware, they should not include complete in-flight demonstrations of such hardware, nor should they include the development or operations of any potential spacecraft.

ATTACHMENT 3:

Small Spacecraft Attitude Determination and Control (ADC) Sensors and Actuators

1 Description of Solicitation Topic

New business models that look to expand space-based communications, navigation, and remote sensing markets increasingly center on operational small spacecraft. Small spacecraft, for the purpose of this solicitation, 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. Emerging commercial space companies use small spacecraft as a platform for technology demonstration/proof of concept as well as a platform for core business. CubeSats in particular have moved beyond academic applications and have become serious design options in both government and commercial mission concepts. They are projected to substantially increase in numbers as new applications and constellations are proposed and realized. The base CubeSat dimension is 10x10x10 cm, one “unit” or “1U”, with a mass of up to 1.5 kg. Larger 3U, 6U, and 12U form factors, with appropriately scaled masses, are commonplace. Established satellite manufacturers presently contemplate even more capable systems to extend multiple mission applications to these smaller platforms and thus leverage the promise of dramatic improvements in the affordability of space based applications.

Small spacecraft are also increasingly the focus of mission architectures to meet NASA and OGA objectives. Designing certain future NASA science missions to take advantage of small spacecraft platforms not only promises dramatic reductions in mission cost but, through the use of constellations and distributed sensing, may also enable science missions not possible via large monolithic spacecraft. The Cyclone Global Navigation Satellite System (CYGNSS) mission presents a striking example by utilizing a constellation of 8 small spacecraft each with a mass less than 30 kg and consuming less than 40 W of power. The example illustrates how larger microsatellites (>12 U form factor) will serve an important role in future science investigations. In many cases science demands for improved accuracy of ADC systems in small spacecraft supersede the needs of commercial applications. The field has progressed to the extent that even those interested in deep space science missions now consider small spacecraft in some cases. Furthermore, in some cases NASA mission objectives will place additional requirements on future ADC systems for small spacecraft, including operation in extreme environments such as interplanetary space, and extreme resource constraints (power/mass/volume).

The attitude determination and control (ADC) subsystems of small spacecraft often limit small spacecraft applicability to various missions. Spacecraft positioning and pointing is required to meet scientific or commercial data gathering requirements as well as antenna/optics pointing and gimbaling to maintain communications links. High performance sensors for small spacecraft guidance, navigation, and control will become more important as advanced applications emerge, such as for dead reckoning autonomous navigation applications or pointing optical communication systems to enable the high-data-volume downlink required by remote sensing instruments. Actuator reliability will also become more important as mission lifetime requirements and the desire to articulate instruments and solar arrays increase. Products now emerging in the area of ADC for small spacecraft, driven by innovative low power, low size component and assembly technologies could provide radical performance improvements while achieving extremely low cost. NASA STMD is interested in both fostering the commercial small spacecraft sector and developing an expansion of pathways for utilizing small spacecraft for NASA missions by investing in these low cost, high performance ADC sensors and non-propulsive actuators for small satellites.

ADC sensors include assemblies such as inertial measurement units (IMU); accelerometers; magnetometers; gyroscopes; stellar reference units (star trackers); sun sensors; earth sensors; horizon sensors; low-fractional-instability, ultra-compact atomic clocks; and GPS-based attitude determination systems. An example of a small spacecraft ADC sensor at the tipping point might be a high performance (bias <0.001 degree/hour, random noise <0.005 degree/√hour) small form factor IMU enabled by low-cost fiber-optic components, fast/slow light technology, or pulse light cold atom interferometer technology.

Non-propulsive ADC actuators include assemblies such as momentum wheels, control moment gyros, spin stabilization systems, and torque rods for small spacecraft. ADC actuators also have applications within pointing and gimbaling mechanisms for instruments and solar arrays. An example of a small spacecraft ADC actuator at the tipping point might be a spin motor or momentum wheel requiring no thermal control providing much lower power consumption, or one with no wear surfaces that can reduce lifetime and reliability concerns.

Suggested design goals for a single ADC sensor or actuator for small spacecraft:

- Lower mass, power, or volume than current capability
- >10x improvement in key performance parameter(s)
- Radiation tolerant for the intended application environment (LEO vs. beyond GEO)
- High reliability (minimizing life-limiting design features)
- >2x cost reduction over current products

It is important to note that technologies of interest to NASA under this topic must not simply provide an incremental improvement but must have the potential to significantly improve upon an existing device's operating performance and form characteristics. Proposals submitted in response to this topic must state the initial component state of the art and justify the final performance metrics.

2 Programmatic Considerations

Proposals to this Technology Topic should follow the direction (award type, funding, period of performance, organization, reporting requirements, etc.) outlined in Sections 2.0, 4.0, and 5.0 of this Appendix.

Proposals under this topic can consider ground development and demonstration and/or the development of flight hardware for a flight demonstration. In the case that the development of flight hardware is proposed, offerors must specify the accommodation interface goals for the flight ADC hardware – power, mass, volume, conditioning, communications, expected space environment and location, etc. The offeror must also make the case within the proposal that an in-space demonstration is warranted to push the technology over the tipping point. NASA will consider such proposals and will likely offer to integrate and accommodate the ADC hardware in an actual spaceflight at a later date (i.e. post award). NASA reserves the right to make decisions regarding the appropriateness of a spaceflight, as well as the manner (e.g. spacecraft design, development, and operations) that the spaceflight will occur. Thus, while offerors can propose the development of flight appropriate hardware, they should not include complete in-flight demonstrations of such hardware, nor should they include the development or operations of any potential spacecraft.

ATTACHMENT 4:

Small Spacecraft Propulsion Systems

1 Description of Solicitation Topic

Small spacecraft, largely due to their cost, have become ubiquitous in the expanding commercial space market. Small spacecraft, for the purpose of this solicitation, 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. Previously used largely as platforms for technology development and education, they now find increased utility in NASA science and exploration mission architectures. Small spacecraft enjoy increasing launch rates and more manageable launch costs but they are typically forced to fly as secondary payloads, restricting their orbital elements such as inclination, altitude, and local time of the ascending node. These orbital placement limitations can impact the spacecraft design and mission applicability including, mission duration due to atmospheric drag, lighting conditions for imaging systems, instrument coverage due to orbital inclination, and power generation due to beta angle. Other applications for small spacecraft with high delta-V capability include transfer from geo-transfer orbit (GTO) to geostationary earth orbit (GEO) and the ability to perform cis-lunar and deep space small spacecraft missions of interest to NASA.

Few, if any, commercially available high delta-V and high-thrust propulsion systems sized for small spacecraft are available to address these needs. Additionally, current small spacecraft also have limited operational choices in terms of low size, weight, and power (SWaP) propulsion applicable for orbital maintenance and drag makeup. While cold/warm gas systems have shown some utility to perform these functions in experimental cases, such systems do not offer the long term, highly efficient low SWaP capabilities needed to allow for a rapid expansion in small spacecraft mission applicability. In some cases efficient low SWaP propulsive systems for small spacecraft may also provide new capabilities for larger spacecraft. For example, highly efficient micro-electric propulsion systems that would provide station keeping capabilities for a CubeSat may also serve as an alternative micro-pointing actuator for large observatory systems that typically utilize reaction wheels that may be more prone to failure.

STMD is interested in both fostering the commercial small spacecraft sector and developing an expansion of pathways for utilizing small spacecraft for NASA missions by investing in these new propulsion systems for small spacecraft that are nearing the tipping point. Technologies developed under this topic will help infuse advanced propulsion capabilities into small spacecraft providing for example: orbit changes for spacecraft utilizing secondary launches; atmospheric drag makeup for longer duration missions; orbit maintenance to meet particular observation requirements; orbit changes to provide responsive and agile Earth observation; and high delta-V options to expand small satellite capabilities out of low Earth orbit (LEO) and into medium Earth orbit (MEO), geosynchronous/geostationary Earth orbit (GSO/GEO), as well as cis-lunar space and beyond. Offerors are encouraged to consider the extent to which their proposed small spacecraft propulsion system can also provide added capabilities for larger spacecraft.

In addition to complying with the scope described above, proposals are sought for technologies that offer one or more of the following desirable features:

- Low cost or short time to develop
- Low cost to procure flight units when technology is mature
- Small system volume or low mass
- Low power consumption in operation
- Suitable for rideshare launch opportunities (minimum hazards)
- Relatively mature or especially novel technology
- Able to be refueled in space
- Potential to use in-situ space resources or recycled waste materials as propellant
- Able to store the system in space for several years prior to use

Example investments include low cost propulsion subsystems or components utilizing green propellant or advanced manufacturing approaches, high delta-V systems enabled by innovative chemical or electric propulsion technologies, and high specific impulse micro-thrust propulsion technologies.

2 Programmatic Considerations

Proposals to this Technology Topic should follow the direction (award type, funding, period of performance, organization, reporting requirements, etc.) outlined in Sections 2.0, 4.0, and 5.0 of this Appendix.

Proposals under this topic must include the development of flight hardware for a flight demonstration. The proposal must describe and provide evidence for the expected performance of the propulsion system including thrust, specific impulse, delta-V, and lifetime when used with an appropriately sized spacecraft. The propellant storage and feed system, and in the case of electric propulsion systems, the power processing components must be described. NASA is seeking propulsion systems that are ready or nearly ready for demonstration in space, meaning that the offeror could deliver flight-ready hardware within 6 to 18 months of award. NASA intends to then integrate those systems into CubeSat-scale satellites. NASA will develop the satellite bus and carryout the system integration and operations either through a separate open solicitation or through a directed NASA project. Offerors must specify the accommodation interface goals for the flight propulsion hardware – power, mass, volume, conditioning, communications, expected space environment and location, etc. The offeror must also make the case within the proposal that the propulsion technology has reached a maturity level that warrants an in-space demonstration of the technology. NASA will likely offer to integrate and accommodate the propulsion hardware in an actual spaceflight at a later date (i.e. post award). NASA reserves the right to make decisions regarding the appropriateness of a spaceflight, as well as the manner (e.g. spacecraft design, development, and operations) in which the spaceflight will occur.

Thus, while offerors must propose the development of flight appropriate hardware, they should not include complete in-flight demonstrations of their hardware, nor should they include the development or operations of any potential spacecraft in their proposal.

ATTACHMENT 5:

Statement of Work Template

PERFORMANCE BASED STATEMENT OF WORK TEMPLATE

FOR AWARDS UNDER NASA RESEARCH ANNOUNCEMENTS (NRAs)

Performance-based Statements of Work (SOW) are the preferred method of stating needs. A performance based SOW structures all aspects of an acquisition around the purpose of the work to be performed and does not dictate how the work is to be accomplished. It is written to ensure that contractors are given the freedom to determine how to meet the Government's performance objectives and provides for payment only when the results meet or exceed these objectives. It maximizes contractor control of work processes and allows for innovation in approaching various work requirements. Performance based SOWs emphasize performance that can be contractually defined so that the results of the contractor's effort can be measured in terms of technical and quality achievement, schedule progress, or cost performance.

EXHIBIT A

STATEMENT OF WORK

FOR

(Insert Title)

1.0 Introduction/Background: This section is intended to give a brief overview of the project. It should describe why the effort is being pursued and what is to be accomplished**.** Include the following in this section: “This statement of work is the result of a proposal submitted by Company XYZ for award under the NASA Headquarters Space Technology Mission Directorate (STMD) NASA Research Announcement (NRA) entitled “Space Technology Research, Development, Demonstration, and Infusion” – 2015, Appendix NNH15ZOA001N-15STMD-001.

2.0 Scope of Work: This section should include an overarching statement of scope for the technology area to be investigated, specific quantifiable goals, and major milestones for the effort.

3.0 Applicable Documents/Background: This section should identify appropriate specifications, standards and other documents that are applicable to the effort to be performed.

4.0 Description of Tasks/Technical Requirements: The detailed description of tasks, which represents the work to be performed under the contract, is binding. Thus, this section should be developed in an orderly progression and in enough detail to establish the feasibility of accomplishing the overall project goals. The work effort should be segregated into major tasks and identified in separately numbered paragraphs according to a numeric decimal system (4.1, 4.2, 4.3 etc.). Each numbered major task should delineate by subtask the work to be performed (4.1.1, 4.1.2, 4.1.3 etc.). The SOW must contain every major task to be accomplished. **The tasks must be definite, realistic, and clearly stated.**

4.1 Use **Active verbs**. Examples include: analyze, audit, calculate, create, design, develop, erect, evaluate, explore, interpret, investigate, observe, organize, perform, and produce (work words). For instance, the SOW could require the contractor to "conduct the experiment and produce a report describing and analyzing (or interpreting) the results."

4.2 Avoid **Passive verbs** that can lead to vague statements. Use "shall" when describing a provision binding on the contractor. Use "will" to indicate actions by the Government (i.e. Wind tunnel services will be provided by NASA). Specifically identify tasking which the contractor shall perform verses government involvement.

Attachment 6

Price Proposal Instructions and Forms

	Year X: Dates - XX/XX/20XX thru XX/XX/20XX		
	hrs, indirect cost base, or fee/profit base, as applicable	Rates	Costs
Personnel / Labor Categories: [1]			
XXXX	XXX	$ XX.XX	$ XXXX
XXXX	XXX	$ XX.XX	$ XXXX
XXXX	XXX	$ XX.XX	$ XXXX
XXXX	XXX	$ XX.XX	$ XXXX
XXXX	XXX	$ XX.XX	$ XXXX
XXXX	XXX	$ XX.XX	$ XXXX
XXXX	XXX	$ XX.XX	$ XXXX
XXXX	XXX	$ XX.XX	$ XXXX
Total Direct Labor Cost [1]	XXX		$ XXXX
Fringe Benefits [2]	$ XXXX	XX.XX %	$ XXXX
Labor Overhead [2]	$ XXXX	XX.XX %	$ XXXX
Travel [3]			$ XXXX
Material, Equip., and ODCs [4]			$ XXXX
Subcontract(s) [5]			$ XXXX
Consultant [6]	XXX	$ XXX.XX	$ XXXX
Subtotal			$ XXXX
G&A [2]	$ XXXX	XX.XX %	$ XXXX
Total Cost			$ XXXX
Fee or Profit	$ XXXX	XX.XX %	$ XXXX
Total Price less NASA Civil Servant Costs			$ XXXX
NASA Civil Servant Costs [7]			$ XXXX
Grand Total Price			**$ XXXX**
Less: Corporate/Customer Contribution			**$ XXXX**
Net Price NASA Pays			**$ XXXX**

(1) DIRECT LABOR: Explain how the total quantity and mix of labor was estimated. Provide basis of estimates (BOEs) to support proposed hours. Provide the job title, qualifications, and experience for each proposed labor category. Identify the proposed direct labor rates by labor category and the source of the rates (e.g., FPRA, FPRP, average category rates, actual rate for a specific individual employee). Include the basis for any proposed escalation factors. Identify the yearly labor rate escalation percentages. If the proposed rates equal DCAA or DCMA approved rates, provide a copy of the approval letter.			
(2) INDIRECT COSTS: Show the proposed rates by year for all applicable indirect burdens. Identify the application base for each indirect burden, and provide documentation regarding the basis for the proposed rates/factors (e.g., FPRA, FPRP, internal estimate, provisional billing rate). If the proposed rates equal DCAA or DCMA approved rates, provide a copy of the approval letter.			
(3) TRAVEL: See worksheet titled "Table 2 – Travel (below)"			
(4) OTHER DIRECT COSTS (ODCs): See worksheet titled "Table 3 – ODCs (below)"			
(5) SUBCONTRACT(s): Provide a summary listing of anticipated subcontractors/amounts; include the anticipated subcontract type (e.g., FFP, CPFF, etc.). In accordance with FAR 15.404-3(b)(1), provide the appropriate cost or price analysis establishing the reasonableness of each proposed subcontract price. Provide a complete cost proposal from the subcontractor. Subcontract cost proposals shall provide a breakout of all elements to the same extent required of the prime offeror, as detailed in these instructions. This requirement includes all lower tier subcontractors. Subcontract proposals containing proprietary data can be sent directly to the Government. All required data should be received by the same date and time as that required of the prime offeror.			
(6) CONSULTANT(s): Provide the job title, qualifications, and experience for each proposed consultant. Explain how the total quantity and mix of labor was estimated for each consultant.			
(7) NASA CIVIL SERVANT COSTS: See worksheet titled "Table 4 - NASA Civil Serv. Cost (below)".			

Table 2 - Travel:						
Origin - Dest.	**Purpose**	**Month / Year**	**Duration (days)**	**# of Travelers**	**Total Cost**	**Basis of Estimate (BOE)**
XXXX - XXXX	XXXXXXXX	XX / 20XX	X	X	$ XXXXX	XXXXX
XXXX - XXXX	XXXXXXXX	XX / 20XX	X	X	$ XXXXX	XXXXX
XXXX - XXXX	XXXXXXXX	XX / 20XX	X	X	$ XXXXX	XXXXX
XXXX - XXXX	XXXXXXXX	XX / 20XX	X	X	$ XXXXX	XXXXX
XXXX - XXXX	XXXXXXXX	XX / 20XX	X	X	$ XXXXX	XXXXX
XXXX - XXXX	XXXXXXXX	XX / 20XX	X	X	$ XXXXX	XXXXX
XXXX - XXXX	XXXXXXXX	XX / 20XX	X	X	$ XXXXX	XXXXX
XXXX - XXXX	XXXXXXXX	XX / 20XX	X	X	$ XXXXX	XXXXX
XXXX - XXXX	XXXXXXXX	XX / 20XX	X	X	$ XXXXX	XXXXX
		Total Travel Cost:			**$ XXXXX**	

Table 3 - Material, Equipment, Supplies, and Other Direct Costs (ODCs):							
Item Description	**Purpose**	**Month / Year**	**Qty**	**Unit of Measure**	**Unit Cost**	**Total Cost**	**Basis of Estimate (BOE)**
XXXXXXXX	XXXXXXXX	XX / 20XX	XXX	XXX	$ XX.XX	$ XXXXX	XXXXX
XXXXXXXX	XXXXXXXX	XX / 20XX	XXX	XXX	$ XX.XX	$ XXXXX	XXXXX
XXXXXXXX	XXXXXXXX	XX / 20XX	XXX	XXX	$ XX.XX	$ XXXXX	XXXXX
XXXXXXXX	XXXXXXXX	XX / 20XX	XXX	XXX	$ XX.XX	$ XXXXX	XXXXX
XXXXXXXX	XXXXXXXX	XX / 20XX	XXX	XXX	$ XX.XX	$ XXXXX	XXXXX
XXXXXXXX	XXXXXXXX	XX / 20XX	XXX	XXX	$ XX.XX	$ XXXXX	XXXXX
XXXXXXXX	XXXXXXXX	XX / 20XX	XXX	XXX	$ XX.XX	$ XXXXX	XXXXX
XXXXXXXX	XXXXXXXX	XX / 20XX	XXX	XXX	$ XX.XX	$ XXXXX	XXXXX
XXXXXXXX	XXXXXXXX	XX / 20XX	XXX	XXX	$ XX.XX	$ XXXXX	XXXXX
XXXXXXXX	XXXXXXXX	XX / 20XX	XXX	XXX	$ XX.XX	$ XXXXX	XXXXX
Total Material, Equipment, & ODCs						**$XXXXX**	

Table 4 - NASA Civil Servant Costs:						
			Government Fiscal Year			
	Name, Job Title, & Technical Area of Expertise	NASA Center	Fraction of Full-Time Equivalent (FTE)	Fully-Burdened Labor Costs	Material, Travel, & ODCs	Total Fully-Burdened Costs
NASA Civil Servants:						
XXXX			XXX	$ XXXX	$ XXXX	$0
XXXX			XXX	$ XXXX	$ XXXX	$0
XXXX			XXX	$ XXXX	$ XXXX	$0
XXXX			XXX	$ XXXX	$ XXXX	$0
XXXX			XXX	$ XXXX	$ XXXX	$0
XXXX			XXX	$ XXXX	$ XXXX	$0
XXXX			XXX	$ XXXX	$ XXXX	$0
XXXX			XXX	$ XXXX	$ XXXX	$0
Total Requested Funds for the NASA Civil Servant Team Members:				$0	$0	$0

Table 5 - Milestone Payment Schedule:

Milestone No.	SOW Section	Objective Success Criteria	Achievement Date [1]	Payment Amount [2]
1	XXX	XXX	XXX	$ XXXX
2	XXX	XXX	XXX	$ XXXX
3	XXX	XXX	XXX	$ XXXX
4	XXX	XXX	XXX	$ XXXX
5	XXX	XXX	XXX	$ XXXX
6	XXX	XXX	XXX	$ XXXX
7	XXX	XXX	XXX	$ XXXX
8	XXX	XXX	XXX	$ XXXX
9	XXX	XXX	XXX	$ XXXX
10	XXX	XXX	XXX	$ XXXX
11	XXX	XXX	XXX	$ XXXX
12	XXX	XXX	XXX	$ XXXX
13	XXX	XXX	XXX	$ XXXX
14	XXX	XXX	XXX	$ XXXX
15	XXX	XXX	XXX	$ XXXX
16	XXX	XXX	XXX	$ XXXX
17	XXX	XXX	XXX	$ XXXX
18	XXX	XXX	XXX	$ XXXX
19	XXX	XXX	XXX	$ XXXX
20	XXX	XXX	XXX	$ XXXX
21	XXX	XXX	XXX	$ XXXX
22	XXX	XXX	XXX	$ XXXX
23	XXX	XXX	XXX	$ XXXX
24	XXX	XXX	XXX	$ XXXX
25	XXX	XXX	XXX	$ XXXX
26	XXX	XXX	XXX	$ XXXX
27	XXX	XXX	XXX	$ XXXX
28	XXX	XXX	XXX	$ XXXX
29	XXX	XXX	XXX	$ XXXX
30	XXX	XXX	XXX	$ XXXX

(1) Unless specified otherwise, months after contract award.

(2) Each payment shall only be made after: (i) The Government's receipt of each respective deliverable and (ii) The Contracting Officer's determination that each respective deliverable is adequate / complete.