



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

**GAME CHANGING DEVELOPMENT PROGRAM,
EXTREME ENVIRONMENT SOLAR POWER**

to

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

APPENDIX NUMBER: NNH15ZOA001N-15GCD-C3

Appendix Issued: August 26, 2015

Notices of Intent Due: September 10, 2015 (5:00pm Eastern)

Proposals Due: October 30, 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 or Grants.gov will not be accepted. Additionally, this section states:

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

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

Summary of Key Information

Appendix Name: Extreme Environment Solar Power; hereafter called “Appendix” to the SpaceTech-REDDI-2015 NASA Research Announcement, hereafter called “NRA”.

Appendix Intent:

In the near future NASA will need solar arrays for multiple mission applications associated with both robotic and human space exploration. Traditionally, solar cells and array systems have been developed on the basis of beginning of life (BOL) conversion efficiency for intensity and temperature specifications associated with near Earth operation. As NASA considers missions that require exposure to more intense radiation environments and missions ever farther from the sun, the development of solar cells/solar array design concepts better suited for such missions is warranted. The purpose of this Appendix is to solicit proposals for the development of promising technologies with the potential to increase solar cell conversion efficiencies under low intensity low temperature (LILT) and high radiation environments.

Eligibility: All categories of US and non-US organizations (see NFS 1835.016-72)

Key Dates

Appendix Release Date:	8/26/15
Notices of Intent Due:	9/10/15
Proposals Due:	10/30/15
Selection Announcement:	February 2016 (target)
Award Date:	May 2016 (target)

Proposal Submission & Selection Process: Competitive proposals with an Independent Peer Review

Technology Readiness Level (TRL): NASA is planning to award contracts with a Base set of requirements plus two options that include follow-on requirements for those offerors that are selected for award resulting from this Appendix. During the Base and each Option (if exercised by NASA), the TRL of the selected technologies will be advanced. The culmination of performance starting with the base through all Options, if exercised by NASA, will result in the design and fabrication of developmental hardware (e.g. solar array panels having a TRL as listed below). 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:

Technology Development Phase	TRL at end of Phase	Anticipated Number of Awards*	Max Value of Each Award	Period of Performance (POP)
Base	4	Up to 4	Up to \$400K	Up to 9 Months
Option I	5	Up to 2	Up to \$1.25M	Up to 12 Months
Option II	TBD	1	Up to \$2.0M	Up to 15 Months

* The anticipated number of awards is not expected to exceed the indicated number. However, NASA reserves the right to select for award, or exercise of an option, multiple, one, or none of the proposals in response to this Appendix.

Type of Instrument that may be used for awards: Contracts or Inter- or Intra-Agency Agreements. **Grants or Cooperative Agreements will NOT be awarded from this Appendix.**

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

Point of Contact:

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Referenced Documents: See Section 9.0 of the NRA

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EXTREME ENVIRONMENT SOLAR POWER

1.0 SOLICITED RESEARCH/TECHNOLOGY DESCRIPTION

1.1 Program Introduction/Overview

The Game Changing Development (GCD) program (<https://gcd.larc.nasa.gov/>) is a critical element within the Space Technology Mission Directorate (STMD) (<http://www.nasa.gov/directorates/spacetech/home/index.html>). The GCD Program focuses on the maturation of technologies across the mid-technology readiness levels, namely TRL 3 through 6. The solicited technology development activity will be carried out in accordance with NASA Procedural Requirement (NPR) 7120.8 NASA Research and Technology Program and Project Management Requirements.

1.2 Appendix Goals and Objectives

This Appendix seeks to fund the development of solar cell/solar array design concept technologies for space power applications in high radiation and low solar flux environments. NASA missions focused on outer planets (e.g. Jupiter) are subjected to intense radiation while experiencing less than 10% of the solar flux relative to a mission in the general vicinity of Earth. Under these conditions, present solar array technology is not as efficient in converting the sun's energy and the solar array performance degrades quickly due to the additional radiation exposure. In addition to these deep space missions, there are also multiple classes of NASA missions, Other Government Agencies (OGA), and commercial space interests that perform space missions in Earth orbits exposed to high levels of radiation. The development of new solar cell and array-level component technologies focused on these issues will enable future NASA robotic and human-exploration missions by increasing solar cell performance, and thus increasing mission life and/or decreasing mission mass/cost.

1.3 Solar Cells and Systems for Extreme Environment Missions

Future NASA missions will require high power solar arrays that operate in radiation environments known to be highly damaging to solar cell semi-conductor materials. A subset of these missions will also encounter low intensity low temperature (LILT) environments as NASA sends spacecraft to explore planets and other bodies farther from the sun. To date, the vast majority of research and development into solar power generation for space systems has focused on increasing cell efficiency with light intensity equivalent to that experienced in or near Earth orbit.

This Appendix aims to increase end of life (EOL) performance for cells exposed to the severe radiation environments found within the Van Allen belts of Earth or in the vicinity of Jupiter, and on reducing the impact of LILT operations on overall efficiency. Improvements to LILT performance may include screening techniques used in present practice, but the focus of the Appendix is on developing new cell designs,

manufacturing methods, and system solutions that control the need for cell inspection during the manufacturing process and therefore minimize the costs of production. Proposed solar cells, concentrator, and array technologies must demonstrate applicability to the space environment found on a deep space NASA mission and demonstrate a reasonable path to space qualification; additional value will be placed on those technologies that are extensible to power production levels of hundreds of kilowatts. Novel solar cell technologies and novel approaches to the systems engineering of power generation (e.g. concentrators) via solar cells are encouraged.

The solar array system goals at the conclusion of Option II are:

- 35% BOL cell efficiency measured at 5 AU and -125 °C¹
- 28% EOL at the blanket (or equivalent) level, given mission conditions characterized in Table 1
- 8-10 W/kg² measured at EOL inclusive of the array structure and deployment mechanism, given mission conditions characterized in Table 1
- Packaging density of at least 60 kW/m³⁽²⁾, calculated at power level predictions for BOL in near earth orbit (1345 W/m²)
- Demonstrate ability to integrate proposed technology into a solar array structure that can be stowed and survive launch conditions.
- Technology capable of operation over the range of 100 – 300 V.
- Technology capable of operation in the presence of plasma exhaust fields equivalent to Xe plasma having an energy level (Te) of 2 eV and a number density of 1e8/cm³.

1. -125° C references the environment and not an intended operational temperature of solar cells on panel or embedded with concentrators.
2. All gimbals, structures, and control systems required for pointing or otherwise achieving end performance levels must be accounted for in both mass, and stowed volume calculations

Temperature	-125° C
Radiation	4E15 1MeV e/cm ²
Solar Intensity	50 W/m ²

Table 1

1.4 Project Descriptions

Pending continued availability of funding and quality of proposed efforts, the Extreme Environment Solar Power project will be awarded with a Base contract and two option periods. The Base requirements will include System Design, Component Test and Analysis with an expected duration of up to nine (9) months. Option I requirements will involve the fabrication of test hardware that can be evaluated by NASA and has a duration of up to 12 months. The Option II requirements will involve the fabrication of a scalable system prototype that can be integrated into a system level application and be demonstrated in a relevant environment. Option II has an expected duration of up to 15 months.

Base – System Design, Component Test and Analysis

The Base Project will initiate with a one (1) day technical coordination meeting. STMD personnel will coordinate and hold this meeting at NASA Glenn Research Center (GRC) approximately four (4) weeks after contract awards. The meeting will address any questions an awardee may have.

During the Base period, competitively selected offerors shall perform design, analysis and component fabrication/testing in order to demonstrate the expected performance of the complete system. The minimum expected entry TRL is nominally TRL 3. However, lower TRL technologies will receive consideration provided that the offeror's proposal realistically demonstrates that the technology will achieve a TRL 4 during the Base period of performance (up to 9 months). At the conclusion of the Base period, each awardee shall provide test data and analysis to demonstrate the expected system performance and the feasibility of further advancing the TRL during each of the Option periods.

At a minimum, the offerors shall perform the following during the Base period:

- Provide a detailed technical description of all major system components:
 - Solar cell materials, fabrication techniques, and design components specific to the objectives of the project
 - Blanket, array, and deployment design
 - Expected mass and performance characteristics
- Conduct performance tests and provide data and test methodology for all tests. Testing can be conducted at the contractor's facility, NASA GRC or by a 3rd party (See Section 4.0 Proposal Submission Information for Point of Contact for utilizing NASA GRC facilities). (8 months after award)
- Quantify system performance based on the aforementioned test data and engineering analysis
- Provide proposed system concept, empirical data demonstrating the current TRL and evidence documenting the feasibility of further developing the technology to TRL 5 during Option 1. (8 months after award)
- Present Base effort performance results as an oral presentation and provide a complete written Base period final report (to include the oral presentation charts)
 - The Contractor shall submit a final report that summarizes the results of the entire Base effort, including recommendations and conclusions based on the experience and results obtained. The final report should include tables, graphs, diagrams, curves, sketches, photographs, and drawings in sufficient detail to explain comprehensively the results achieved under the contract.

NASA's decision to exercise the Option will be based on programmatic decisions, including the strength of the empirical and analytical evidence acquired during the Base period of performance. The empirical and analytical evidence provided must show a clear and achievable plan for producing the prototype hardware with a TRL of at least 5 during Option I. Note that NASA's decision to exercise an option is entirely within its discretion and it is anticipated that no more than two Base contract awardees will

proceed to Option I. If no Base efforts demonstrate adequate strength of the empirical and analytical evidence of a clear achievable plan, NASA may not exercise any of the options.

Option I – Test Hardware

NASA anticipates exercising the Option for prototype hardware development for up to two (2) offerors based on the success in meeting the Base contract performance requirements and milestones, the strength of the empirical and analytical evidence to reach TRL 5 at the end of the Option I period, and the continued availability of funding. The offeror shall fabricate test articles during Option I predicated upon the designs developed during the Base period.

Option I will initiate with a one (1) day technical coordination meeting. STMD personnel will coordinate and hold this meeting at NASA GRC approximately four (4) weeks after contract awards. The meeting will address any questions the awardee may have, and ensure that all participants understand the requirements and objectives of the Option I period of performance.

Awardees shall further develop the proposed technology and develop a system-level design capable of achieving the goals outlined in Section 1.3 of this Appendix. Component hardware developed under Option I shall be made available to NASA for independent testing and evaluation. At the conclusion of the Option I period, the component technology shall achieve a TRL 5 and offerors shall provide evidence supporting the ability to develop and manufacture a complete solar array based on the design developed during the Option I period. The proposal shall demonstrate that the array meets the performance goals of Section 1.3 and is capable of being qualified for space applications.

At a minimum, offerors shall perform the following during Option I:

- Design component hardware capable of meeting the goals and objectives of this Appendix as stated in Section 1.3.
- Complete design reviews for the prototype hardware and fabricate components based on the final design.
 - A detailed design review shall occur within the first six (6) months of Option I.
- Complete component testing that demonstrates the cell-array system design performance (~12 months after Option begins). Offerors should complete testing in sufficient time to complete all activities within the 12 month POP. This testing may be conducted at NASA facilities or contractor facilities, but the location and manner of testing shall be specified in the proposal and in the statement of work. (See Section 4.0 Proposal Submission Information for Point of Contact for utilizing NASA GRC facilities).
- If necessary, update analytical models using the experimental results from the components test(s).

- Provide proposed system concept, empirical data demonstrating the current TRL, and evidence documenting the feasibility of further developing the technology through Option II. (~11 months after award)
- Deliver test articles to NASA GRC that are representative of the cell-array system components for NASA testing, nominally 6"x6" but dependent on offeror's manufacturing constraints (12 months after Option begins).
- Assess the technology performance against figures of merit and key performance parameters.
- Complete a TRL assessment.
- Participate, in person, in a final review of the development activity to be held at the Contractor's facility (12 months after Option begins).
- At the conclusion of the Option I period, offerors shall present their proposed system concept, empirical data demonstrating the TRL, and evidence documenting the feasibility of further developing the technology for a specific flight mission application.

Option II – Scalable System Hardware

Based on the success in meeting the technical goals and milestones of the Extreme Environment Solar Power Base and Option I periods of the contract, NASA STMD may exercise Option II. Option II will be focused on delivering scalable system hardware. The hardware will be the equivalent of the designed solar array system at the flexible blanket/panel level and be capable of meeting the requirements as specified in Section 1.3. Further the system design represented by the delivered hardware shall be scalable to 5kW EOL power delivered in Jupiter's orbit without modification.

At a minimum, offerors shall perform the following during the Option II period:

- Complete design of solar array system hardware capable of meeting the goals and objectives of this Appendix as stated in Section 1.3.
- Complete design reviews for the prototype hardware and fabricate a prototype system based upon the final design.
 - A detailed design review shall occur within the first six (6) months of Option II.
- Complete a detailed experiment to demonstrate flexible blanket/panel system performance (~15 months after Option begins). Offerors should complete testing in sufficient time to complete all activities within the 15 month POP. This experiment may be conducted at NASA facilities or contractor facilities, but the location and manner of testing shall be specified in the proposal and the statement of work.
- Deliver a prototype system to NASA GRC.
- Assess the technology performance against figures of merit and key performance parameters.
- Complete a TRL assessment.
- Participate, in person, in a final review of the development activity to be held at the Contractor's facility (15 months after Option begins).

- At the conclusion of the Option II period, offerors shall present their proposed system concept, empirical data demonstrating the TRL, and evidence documenting the feasibility of further developing the technology for a specific flight mission application.

2.0 AWARD INFORMATION

No change from NRA except as noted below:

2.1 Funding and Period of Performance Information

Award Details:

Technology Development Phase	TRL at end of Phase	Anticipated Number of Awards*	Max Value of Each Award	Period of Performance (POP)
Base	4	Up to 4	Up to \$400K	Up to 9 Months
Option I	5	Up to 2	Up to \$1.25M	Up to 12 Months
Option II	TBD	1	Up to \$2.0M	Up to 15 Months

* The anticipated number of awards is not expected to exceed the indicated number. However, NASA reserves the right to select for award, or exercise of an option, multiple, one, or none of the proposals in response to this Appendix.

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 payment can be made 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, or exercise an option for, multiple, one, or none of the proposals in response to this Appendix.

2.3 Award Reporting Requirements/Meetings/Deliverables:

The following reporting requirements, meetings, and deliverables will be required for Base:

- Project Initiation/Technical Coordination Meeting at NASA GRC (~4 weeks after award)
- Status reports including fund balance, milestone achievement, and test data (~ every 3 months)
- Virtual (no travel required) Technical Interchange Meeting (~4 months after award)
- Deliver Draft Final Report to include all requirements in Section 1.4 (8 months after award)
- Final Oral Presentation, at the Contractor's Facility (9 months after award)

- Final Report (to include oral presentation charts and all requirements in Section 1.4)
 - The Contractor shall submit a final report that summarizes the results of the base period effort, including recommendations and conclusions based on the experience and results obtained (all test results and complete analysis data). For example, the final report may include tables, graphs, diagrams, curves, sketches, photographs, and drawings in sufficient detail to explain comprehensively the results achieved under the contract.

Option I Deliverables:

- Project Initiation/Technical Coordination Meeting at GRC (~4 weeks after Option begins)
- Status reports including fund balance, milestone achievement, and test data (approximately every three months)
- Detailed Design Review (~6 months after Option begins)
- Complete component testing as stated in Section 1.4 (11 months after Option begins)
- Update analytical models, if necessary as stated in Section 1.4 (11 months after Option begins)
- Provide system concept, empirical data demonstrating the current TRL and evidence documenting the feasibility of further advancing the technology through Option II (11 months after Option begins)
- Delivery Draft Final Report (to include all requirements of Section 1.4) (11 months after Option begins)
- Deliver test article (12 months after Option begins)
- Final Oral Presentation, at the Contractor's Facility (12 months after Option begins)
- Final Reports (to include oral presentation charts and all requirements in Section 1.4) (12 months after Option begins)
 - The Contractor shall submit a final report that summarizes the results of the Option 1 effort, including recommendations and conclusions based on the experience and results obtained (all test results and complete data analysis). For example, the final report may include tables, graphs, diagrams, curves, sketches, photographs, and drawings in sufficient detail to explain comprehensively the results achieved under the contract.

Option II Deliverables:

- Project Initiation/Technical Coordination Meeting at GRC (~4 weeks after Option II begins)
- Status reports including fund balance, milestone achievement, and test data (approximately every three months)
- Detailed Design Review (~6 months after Option II begins)
- Deliver test article (15 months after Option II begins)

- Final Oral Presentation to include all requirements in Section 1.4, at the Contractor's Facility (15 months after Option II begins)
- Final Reports (to include oral presentation charts and all requirements of Section 1.4) (15 months after Option II begins)
 - The Contractor shall submit a final report that summarizes the results of the Option 2 effort, including recommendations and conclusions based on the experience and results obtained (all test results and complete data analysis). For example, the final report may include tables, graphs, diagrams, curves, sketches, photographs, and drawings in sufficient detail to explain comprehensively the results achieved under the contract.

3.0 ELIGIBILITY INFORMATION

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:

Proposal submissions shall be in accordance with Section 2 entitled "Proposal Preparation and Organization" of the *NASA Guidebook for Proposers* (<http://www.hq.nasa.gov/office/procurement/nraguidebook/proposer2015.pdf>)

- Offerors may submit proposals via *NSPIRES* or *Grants.gov*. 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. The proposal lead must have previously accessed and registered in NSPIRES.

- Proposal Cover Page, Program Specific Data (PSD): This Appendix contains program specific data (PSD) questions. See section 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. The point of contact is:

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

- Proposal Attachments: See 4.3.4.2 of the NRA
- While testing of materials at NASA during this project is not required, NASA will allow the use of its facilities for component/system testing. If the offeror proposes to use these facilities, the following guidance is provided. The NASA Photovoltaics and Electrochemical Systems Branch (LEX) provides solar cell and component testing with regard to overall performance and durability for a variety of space environments including LILT and high radiation mission environments. All costs associated with this testing must be included within the proposal.

For offerors proposing to utilize NASA LEX facilities, please contact NASA GRC to **obtain a letter of feasibility and associated costs. This letter of feasibility and associated costs must be included within the proposal and will NOT count against the page limitation.** The point of contact is:

Todd Peterson
216-433-5350
todd.t.peterson@nasa.gov

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

	<i>Proposal Section</i>	<i>Maximum Page Length</i>
1.	Table of Contents	1
2.	Technical and Management Section	20
3.	Cost	as needed
4.	References and Citations	as needed
5.	Biographical Sketches	see below
6.	Current and Pending Support	as needed
7.	Statements of Commitment and Letters of Support	as needed
8.	Special Notifications and/or Certifications	as needed
9.	FAR Provision 52.227-15 (<i>if contracts are awarded</i>)	as needed
10.	Small Business Subcontracting Plan or Small Business Participation Description (if applicable)	as needed
11.	Statement of Work – does not count toward Technical/Management page count. The SOW cannot be used to supplement the Technical and Management Section and shall be broken out by Base, Option I and Option II requirements	as needed

Reviewers will not consider any content in excess of the page limits specified in the Table above.

1. Table of Contents:

Offerors shall 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.). The electronic system chosen may provide some assistance in preparing the Table of Contents, but offerors are responsible for the accuracy of proposals submitted. (Section 2.3.4 of the *NASA Guidebook*)

2. Technical and Management Section:

Relevance to Solicitation Objectives:

- A. Alignment: Describe how the proposed solar array technology, including rationale as to how the technology is applicable to space flight systems, is aligned with the goals and objectives stated in this Appendix (e.g. specific power, radiation tolerance, system integration, and stowed volume as described in Section 1.3 of this document).
- B. Comparison to State of Art (SOA): Define the current SOA and provide quantitative rationale on how the proposed effort offers a revolutionary, disruptive, or transformational space technology that significantly improves performance over the current SOA.
- C. Infusion Potential: Provide an assessment of the infusion potential of the technology, including the ability of the proposed design to be manufactured and qualified for use in space and how the proposed technology will be infused into future NASA missions, other government agencies, and/or commercial sector applications. Provide an assessment of the degree to which the proposal demonstrates extensibility to very high power regimes, i.e. 300 kW.
- D. Value Proposition: Value proposition here is defined as the potential benefits of maturing the technology compared to the cost to mature the technology. Provide an assessment of the value proposition offered by examining the relative proposed cost versus the projected benefits or improvements in performance over the SOA.

Technical Approach:

- A. Technology Development Plan: Provide a technology development work plan that includes a discussion of:
 - a. the overall technical approach to accomplish the objectives of the effort within the proposed time period;
 - b. the capability of proposed facilities, laboratory space, fabrication methods, equipment, and test techniques to accomplish the work;
 - c. identify and quantify key figures of merit and key performance parameters that are unique to the technology proposed and describe how these key performance parameters will advance and how validation will occur over the course of the development activity;
 - d. and the major technical challenges and risks and feasible mitigation strategies for each.
- B. Qualification and Capabilities: Describe the qualifications and capabilities of the project lead and team members including the skill, expertise, and experience required to successfully execute the proposed technical approach.

- C. TRL Assessment: Identify, and substantiate, that the entry TRL is appropriate for this Appendix and provide compelling rationale demonstrating that the proposed technical approach will achieve TRL Advancement specified in the Appendix.
- D. Schedule: Provide a detailed schedule that includes major milestones, deliverables and reports including measurable metrics, and adequate schedule margin that align with the Appendix objectives.

3. **Cost:**

Provide detailed costs required for the successful development of the technology for the Base, Option I, and Option II. **The costs associated with the Base, Option I, and Option II shall be broken out separately.** Offerors must follow the budget format requirements provided in Section 2.3.10 of the *NASA Guidebook for Proposers* and Section 4.3.5 and 4.3.6 of the NRA. The Budget Section will not count towards the Technical/Management Section page count but it will count toward the 10 Mb limit of the single Attachment. The budget discussion must be adequate to justify the budget as provided.

4. **References and Citations:**

See Section 2.3.6 of the *NASA Guidebook for Proposers*.

5. **Biographical Sketches:**

See Section 2.3.7 of the *NASA Guidebook for Proposers*.

6. **Current and Pending Support:**

See Section 2.3.8 of the *NASA Guidebook for Proposers*.

7. **Statements of Commitment and Letters of Support:**

See Section 2.3.9 of the *NASA Guidebook for Proposers*.

8. **Special Notifications and/or Certifications:**

See Section 2.3.11 of the *NASA Guidebook for Proposers*.

9. **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.

10. 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 the subcontracting opportunities are expected to exceed \$650,000.

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.

11. Statement of Work:

A draft Statement of Work (SOW), which will be incorporated in any resultant contract, shall be included in the proposal. **(See Attachment for guidance on SOW development)**. Do not include proprietary information in the SOW. The SOW does NOT count toward the Technical/Management page count and the SOW cannot be used to supplement information in the Technical/Management section. **The Base, Option I, and Option II requirements shall be clearly separated within the SOW.**

5.0 PROPOSAL REVIEW INFORMATION

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

Evaluation Criteria

The evaluation will be **INCLUSIVE** of Option I and Option II.

The evaluation criteria considered in evaluating proposals under this Appendix are listed below:

Relevance to Solicitation Objectives (weight 40%):

Evaluation includes consideration of the following:

- A. **Alignment**: The extent to which the proposed solar array technology is applicable to space flight systems and is aligned with the goals and objectives stated in the Appendix (e.g. specific power, radiation tolerance, system integration, and stowed volume as described in Section 1.3 of this document).
- B. **Comparison to State of 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. **Infusion Potential**: The extent to which the proposed effort provides clear evidence that the proposed design can be manufactured and qualified for use in space and the degree to which the proposed technology will be infused into NASA missions, other government agencies, and/or commercial sector applications. The degree to which the proposal demonstrates extensibility to very high power regimes, i.e. 300 kW.
- D. **Value Proposition**: Value proposition here is defined as the potential benefits of maturing the technology as compared to the cost to mature the technology. The extent of the value proposition offered in the proposed effort as determined by examining the relative proposed cost versus the projected benefits or improvement in performance over the SOA.

Technical Approach (weight 40%):

Evaluation includes consideration of the following:

- A. **Technology Development Plan**: The extent to which the offeror proposes a convincing technology development work plan that demonstrates:
 - a. the feasibility and soundness of the technical approach to accomplish the objectives of the effort within the proposed time period;
 - b. the capability of proposed facilities, laboratory space, fabrication methods, equipment, and test techniques to accomplish the work;

- c. the extent to which the offeror identified and quantified key figures of merit and key performance parameters that are unique to the technology proposed and described how these key performance parameters will advance and how validation will occur over the course of the development activity;
- d. and 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 required to successfully execute the proposed technical approach.
- C. TRL Assessment: The extent to which the entry TRL is appropriate for this Appendix and the degree to which the proposed technical approach will achieve the TRL advancement specified in the Appendix.
- D. Schedule: The realism of schedule relative to the major milestones, deliverables and reports, including measurable metrics, and adequate schedule margin that aligns with the Appendix objectives.

Cost (weight 20%):

Evaluation includes consideration of the following:

The realism and reasonableness of the proposed cost of the effort and the proposed funding profile. **The Base, Option I, and Option II costs shall be priced separately.**

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

Review and Selection Processes

The Selection Official has been delegated to the STMD Deputy Associate Administrator, for Programs

Selection Announcement and Award Dates

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

Debriefings

If requested, it is NASA's intent to provide written feedback letters to offerors after selections are announced.

6.0 AWARD ADMINISTRATION INFORMATION

No change from NRA

7.0 POINTS OF CONTACT FOR FURTHER INFORMATION

Technical questions and comments about this Appendix may be directed to:

Ryan Stephan
Program Executive, STMD Game Changing Development Program
NASA HQ, Mail Suite 6Y53
300 E Street SW
Washington, DC 20546-0001
HQ-STMD-GCDC3@mail.nasa.gov

Procurement questions and comments about this Appendix may be directed to:

LaShonda Jacobs-Terry
Contracting Officer
Research & Development Contracting Branch
HQ-STMD-GCDC3@mail.nasa.gov

All questions shall be submitted in writing to the email address provided above. 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

NASA Procedural Requirement (NPR) 7120.8 is available online at:
<http://nodis3.gsfc.nasa.gov/displayDir.cfm?t=NPR&c=7120&s=8>

10.0 ATTACHMENT SOW 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-15GCD-C3.

2.0 Scope of Work: This section should include an overarching statement of scope for the technology area to be investigated, specific quantifiable goals, major milestones, etc. 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. For example, the phrase "the contractor shall perform," is preferred in lieu of "it shall be performed" because the latter does not definitively state which party shall perform. Avoid "should" or "may" because they leave the decision for action up to the contractor. 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 LaRC). Specifically identify tasking which the contractor shall perform verses government involvement.

5.0 Program Schedule/Milestones: Identify all planned presentations and meetings including but not limited to preliminary and critical design reviews, program reviews, regular status meetings, etc.

6.0 Deliverables: This section should contain information on what is to be provided to NASA and when it is required.