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

SPACE TECHNOLOGY RESEARCH GRANTS PROGRAM,

EARLY STAGE INNOVATIONS APPENDIX

to

NASA Research Announcement (NRA): Space Technology Research, Development, Demonstration, and Infusion 2024 (SpaceTech REDDI 2024), NNH24ZTR001N

APPENDIX NUMBER: NNH24ZTR001N-24ESI-B2

Appendix Issued: *April 4, 2024*
Notices of Intent Due: *May 9, 2024* (5 PM Eastern)
Proposals Due: *June 6, 2024* (5 PM Eastern, 2 PM Pacific)

NASA Assistance Listing Number 43.012

OMB Approval Number 2700-0092 (Expires 9/30/2026)

Summary of Key Information

Appendix Name: Early Stage Innovations (ESI), hereafter called "Appendix," to the SpaceTech REDDI 2024 NRA, hereafter called "NRA."

Goal/Intent: ESI is focused on the development of innovative, early-stage space technology research of high priority to NASA's Mission Directorates.

Eligibility: Accredited U.S. universities are eligible to submit proposals; teaming and collaboration are permitted as per section 3.

Key Dates:

Release Date:	April 4, 2024
Notices of Intent Due:	May 9, 2024
Proposals Due:	June 6, 2024
Selection Notification:	October 2024
Award Date:	January 2025

Selection Process: Independent subject matter expert peer review.

Typical Technology Readiness Level (TRL): TRL 1 or TRL 2 at the beginning of the effort.

Award Details:

Anticipated Total Number of Awards:	6
Award Duration:	Maximum of three years
Award Amount:	Maximum of $750K

Type of Instrument to Be Used for Awards: Grants. Cost sharing is not required.

Selection Official: NASA Space Technology Mission Directorate Director of Early Stage Innovations and Partnerships.

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Note: The organization and section numbering of this Appendix mirror the SpaceTech REDDI 2024 NRA for convenience when cross-referencing content between the two documents.

Early Stage Innovations

1 SOLICITED RESEARCH/TECHNOLOGY DESCRIPTION

1.1 Program Introduction/Overview

NASA's Space Technology Mission Directorate (STMD) hereby solicits proposals from accredited U.S. universities for innovative, early-stage space technology research of high priority to NASA's Mission Directorates.

This specific Appendix, titled Early Stage Innovations (ESI), is one of five calls for proposals from STMD's Space Technology Research Grants (STRG) Program. Early Career Faculty (ECF), Space Technology Research Institutes (STRI), NASA Space Technology Graduate Research Opportunities (NSTGRO), and Lunar Surface Technology Research (LuSTR) Opportunities appear as Appendix B1, Appendix B3, Appendix B4, and Appendix B5, respectively, under the SpaceTech REDDI NRA.

This Appendix seeks proposals on specific space technologies that are currently at low Technology Readiness Levels (TRL). Investment in innovative low-TRL research increases knowledge and capabilities in response to new questions and requirements, stimulates innovation, and allows more creative solutions to problems constrained by schedule and budget. Moreover, it is investment in fundamental research activities that has historically benefited the Nation on a broader basis, generating new industries and spin-off applications.

Our Nation's universities couple fundamental research with education, encouraging a culture of innovation based on the discovery of knowledge. Universities are, therefore, ideally positioned to conduct fundamental space technology research and to diffuse newly found knowledge into society at large through graduate students and through industry, government, and other partnerships. STMD investments in space technology research at U.S. universities promote the continued leadership of our universities as an international symbol of the country's scientific innovation, engineering creativity, and technological skill. These investments also create, fortify, and nurture the talent base of highly skilled engineers, scientists, and technologists to improve America's technological and economic competitiveness.

The ESI Appendix challenges universities to examine the theoretical feasibility of new ideas and approaches that are critical to making science, space travel, and exploration more effective, affordable, and sustainable. It is the intent of the STRG Program and this Early Stage Innovations opportunity to foster interactions between NASA and the awarded university Principal Investigators (PIs)/teams. Therefore, interaction with NASA researchers should be expected while conducting space technology research under these awards.

1.2 Program Goals and Objectives

The STRG Program within STMD is fostering the development of innovative, low-TRL technologies for advanced space systems and space technology. The goal of this low-TRL endeavor is to accelerate the development of groundbreaking, high-risk/high-payoff space technologies. These technologies, although not necessarily directed at a specific mission, are being developed to support the future space exploration and science needs of NASA, other government agencies, and the commercial space sector. Such efforts complement the other NASA Mission Directorates' focused technology activities, which typically begin at TRL 3 or higher. The starting TRL of the efforts to be funded as a result of this Appendix will typically be TRL 1 or TRL 2; typical end TRLs will be TRL 2 or TRL 3. See Attachment 2 of the NRA for TRL descriptions.

This Appendix seeks proposals to develop unique, disruptive, or transformational space technologies that have the potential to lead to dramatic improvements at the system level — performance, weight, cost, reliability, operational simplicity, or other figures of merit associated with spaceflight hardware or missions. The projected impact at the system level must be substantial and clearly identified. Although system-level demonstrations are likely not possible or expected under an ESI award, meaningful TRL advancement is required. This Appendix does not seek literature searches, survey activities, or incremental enhancements to the current state of the art (SOA).

This Appendix exclusively seeks proposals that are responsive to one of the two topics described in 1.3. Proposals that are not responsive to these topics, as specifically described, will be considered non-compliant and will not be submitted for peer review. NASA anticipates addressing other topics in future Appendix releases.

The topics described in 1.3 are aligned with the STMD Strategic Framework that organizes the agency's space technology investments. They are also consistent with the 2020 NASA Technology Taxonomy and the 2022 NASA Strategic Plan.

1.3 Topics

Topic 1 – Computational Materials Engineering for Lunar Metals Welding

The goal of this topic is to advance the state of the art for in-space assembly and manufacturing (ISAM) metals welding processes through computational physics-based materials engineering. This will help enable manufacturing and assembly processes to be implemented and operated reliably in space environments, a capability that is important for supporting NASA's exploration of the Moon and Mars.

Development of integrated computational materials engineering (ICME) methods that capture the physics of the welding process and space environments, as well as the materials behavior at various length scales, will enable critical one-shot welding operations. Integration with experimental measurements will further validate modeling

efforts. The intent of this topic is to provide a modeling toolkit to engineers for the development of in-space welding processes because NASA and other U.S. entities currently do not have the tools required to address this need.

NASA has not conducted welding studies in space since the Skylab Mission, more than 50 years ago. Since then, fundamental metal-solidification and polymer 3D-printing experiments have been performed aboard the International Space Station as part of physical sciences research campaigns. At the same time, ICME workflows have realized great success in U.S. heavy manufacturing on Earth, such as in the automotive sector. Integrating the advances made for Earth-based applications, the ICME approach has the potential to accelerate the development of in-space welding operations.

Welding represents a primary group of manufacturing methods that have long enabled space-exploration hardware to be produced on Earth. There are many welding processes, such as laser-beam and electron-beam welding and allied 3D printing, that have long posed challenges during Earth-based manufacturing due to intensive process development and propensity to defect formation due to normal variations in process control, parent material chemistry, etc. Most importantly, such processes involve complex nonlinear and multiphysics processes that include extreme temperature gradients, short timescales, and multiple phases of matter. The paradigm shift towards building structures in space is at hand, and the introduction of space environments, such as extreme vacuum, temperature, reduced gravity, and the possible presence of contaminants such as regolith, will further complicate reliable implementation of welding. In line with NASA’s exploration goals for the Moon and Mars, near-term priorities for in-space welding applications may include, but are not limited to, large lunar structures such as tall towers and pressurized habitats, as well as other applications in space environments to serve exploration and science needs.

Advanced modeling, including ICME, has the potential to accelerate the development cycle for metal welding processes needed for readiness to sustain human life and reduce the great capital expense needed to achieve NASA’s exploration goals [1][2][3][4]. Limited work has been done to model in-space welding [5][6] and holistic ICME approaches have not been developed for such processes. Computational models and digital twins are needed that will enable virtual process exploration by tuning process parameters, material, and geometry, while capturing the extreme environmental boundary conditions of space itself. An ICME approach that considers physics-based modeling of the structure-property-processing relationships will provide a leap forward in the ability to mature metal welding processes for space readiness.

In order to further readiness for in-space welding to support space exploration and the emerging space economy, this solicitation topic specifically seeks transformative

proposals for developing computational, physics-based models using ICME frameworks for welding on the lunar surface. The proposals must address all of the following points:

- Development of ICME-based in-space metals welding computational models of laser or electron beam welding and workflows that capture the complex structure-property-processing conditions produced in the lunar space environment: lunar gravity, extreme vacuum (< 10^{-6} torr), and temperature variations between 40 and 400 K. In addition, gravity levels considered must span the range from microgravity to Earth gravity.
- Modeling using at least one of the following alloys: AA 2219 or AISI 316L stainless steel.
- Description of extensibility to other alloys, including potential new alloys derived from materials obtained through in-situ resource utilization (ISRU) [7] [8].
- Approach and methods for uncertainty quantification.
- Plans for validation. Data sets to be used in validation can include proposers' own data, comparison of results to NASA historical flight data from Skylab [5][9] and other relevant experiments, such as microgravity metal alloy solidification [10][11][12][13] and thermophysical properties measurements [14], or potential emerging results.

While not required, proposals are encouraged to address:

- Development of systems models that consider energy and mass balances and heat rejection in vacuum to inform digital twins.
- Novel artificial intelligence / machine learning methods that can be used to advance the models.
- Experimental measurement of governing physical processes occurring during materials welding operations in concert with the required model-based approaches. These measurements should be conducted to represent relevant space environments with lead candidate technologies such as laser and electron beam fusion welding for model calibration and validation. Proposals should justify their approach and the selection and level of space environmental conditions to be used.
- Modeling using AA 4XXX alloys, 304L stainless steel or other aerospace materials of interest including alloy systems such as commercially pure Ti, Ti-6Al-4V, or Niobium-based C103.
- Approaches to mitigate effects of possible contamination from lunar regolith [15][16].

References:

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Please refer to 7 – Points of Contact for Further Information of this Appendix if you have technical questions pertaining to this topic. Please note that NASA is unable to comment on whether a proposed area of research is responsive to this topic.

Topic 2 – Passive Lunar Dust Control through Advanced Materials and Surface Engineering

The goal of this topic is to advance the development of technologies to control lunar dust surface adhesion passively through advanced materials and surface engineering technologies.

The lunar environment presents several extreme conditions that must be addressed to enable a sustained lunar presence, including significant thermal variation, high vacuum, exposure to vacuum ultraviolet (VUV) radiation and high-energy ionizing particles, dynamic electrostatic conditions, micrometeoroid bombardment, and the presence of lunar dust [1]. Lunar dust is comprised of fine particles within the lunar regolith; dust particles are jagged, chemically reactive, electrostatically charged, and potentially magnetic. When disturbed (e.g., by a spacecraft landing or launch event), dust particles can travel at velocities greater than 1 km/s. As a result of these properties, the lunar dust can adhere perniciously and abrade nearly any exposed surface, which can result in limited range of motion and/or lifetime of moving parts [2][3][4]. Furthermore, these particles can have deleterious health effects to astronauts, which further complicates a sustained human presence on the lunar surface [5]. Approaches for addressing lunar dust contamination can be broken down into three approaches: isolating sensitive components from direct exposure to the lunar environment, developing architectural solutions or a concept of operations (CONOPS) to minimize activities that would increase localized lunar-dust perturbations, and adhesion mitigation technologies [6][7].

The adhesion-mitigation technologies can be defined as being either active, i.e., requiring external energy (or human intervention, when applicable) to operate, or passive, intrinsic to the material or surface and not requiring power (or human intervention) to operate. Active lunar-dust-adhesion mitigation strategies have included brushes, scrapers, sacrificial cleaning materials, mechanical agitation, piezoelectric systems, electrodynamic approaches, and energetic illumination, among others.

As new materials and technologies are developed to minimize the impact of lunar dust on exposed surfaces, methods to analytically assess and quantitatively evaluate dust mitigation approaches are also being developed. These methods include assessment of dust adhesion properties [12][15].

Materials developed for passive mitigation of lunar dust adhesion have focused predominantly on changes to the surface topography and surface chemistry [5][6][8]. Topographical modification efforts have focused on reducing the available contact area for particle-surface interactions using isotropic, periodic surface structures. Nanometer-to-micrometer-sized features have been generated on surfaces either through additive or subtractive techniques. Surface chemical modification has been demonstrated through integration of surface-modifying agents in the material matrix, low-surface-energy coating deposition, ion-beam exposure, and other techniques. Modification of surface-material composition has also been evaluated to address triboelectric charging. Changes in surface composition to match the work function of silica have been evaluated as a method to mitigate electrostatic interactions.

Advancements in materials and surface-engineering technologies are needed to alter incident lunar-dust-particle adhesion and influence the motion of the dust particle on a surface of interest [9][10]. These advancements include, but are not limited to:

- Anisotropic surface topographies;
- Anisotropic surface mechanical properties (durotaxis-enabling surfaces);
- Metamaterials;
- Stimuli-responsive surfaces;
- Mechanoreactive/mechanoresponsive surfaces;
- Synergistic active mitigation technologies; and
- Simulated lunar-environmental performance characterization.

This solicitation topic specifically seeks proposals to develop passive dust-mitigation materials and surface-engineering technologies that will be applicable to the lunar environment [10] and that address the control of fundamental particle/surface interactions, such as:

- Van der Waals forces;
- Electrostatic and magnetic interactions;
- Mechanical interlocking;
- Particle embedding due to high-velocity impact events; and
- Potential multiple particle interaction/cohesion forces.

Proposals must address the anticipated approach to dust-adhesion testing, including existing capabilities and plans for those to be developed, as well as plans for the demonstration of the efficacy of the passive-dust-mitigation technology via dust-adhesion testing. Plans for the characterization of the developed passive dust-mitigation materials and surface-engineering technologies must be presented in the proposal. Examples of typical characterization methods used to date are provided in [8] and [12].

Potential approaches include but are not limited to physical, spectroscopic, mechanical, and thermal characterization.

Proposals must identify intended use case scenario(s) and present testing plans to address as many pertinent environmental conditions as possible for each use case including:

- Vacuum (<10^{-6} Torr);
- Lunar thermal environment (40 K to 400 K);
- Relevant lunar regolith simulant and particle size distribution;
- Controlled electrostatic environments (-150 V to 5 V); and
- VUV and other high-energy radiation exposure.

Proposals must justify the selection and level of environmental factors to be used in testing for each scenario (e.g., in a pressurized module/airlock or natural lunar surface environment). Additionally, durability of the passive dust-mitigation technology should be evaluated as it pertains to the potential use case(s) to include abrasion and wear characterization.

Target goals include:

- Passive dust mitigation materials and surface-engineering technologies scalable to 1 m^2 ;
- Demonstration of dust-adhesion by testing under vacuum (<10^{-3} Torr) exhibiting up to 90% clearance (i.e., dust being removed from or not adhering to 90% of the "new" or treated material surface);
- Comparison of dust adhesion relative to reference space-heritage material performance (e.g., traditional aerospace aluminum, titanium, and stainless steel alloys, polymeric materials such as polytetrafluoroethylene and polyimides, and ceramic materials such as alumina and titania) for the utilized adhesion test after multiple cycles of dust exposure.

Proposers are encouraged to address reduced-gravity considerations but are not expected to conduct testing in reduced gravity as part of the proposed effort.

Proposals that feature active dust-mitigation approaches as identified above would be considered non-responsive.

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Please refer to 7 – Points of Contact for Further Information of this Appendix if you have technical questions pertaining to this topic. Please note that NASA is unable to comment on whether a proposed area of research is responsive to this topic.

2 AWARD INFORMATION

As noted in 2 of the NRA, awards are authorized by The National Aeronautics and Space Act of 1958, 51 U.S.C. § 20113(e).

2.1 Funding and Period of Performance Information

NASA plans to make approximately 6 awards – across all topics – as a result of this Appendix, subject to the receipt of meritorious proposals. The actual number of awards resulting from this Appendix and for each topic will depend on the quality of the proposals received; NASA reserves the right to make no awards, or exceed 6, under this Appendix. It is possible that the Selection Official may decide to defer selection decisions on some proposals while making selection decisions on others. If the Selection Official exercises this option, proposals will be categorized as "selected," "declined," or "deferred." Proposals receiving deferred decisions may be considered for supplemental selection at a later date. Offerors who receive a deferred selection decision will be notified of the timeline for supplemental selection decisions.

The ESI Appendix covers only proposals for new awards; continuations of existing awards are handled separately.

The total award value may not exceed $750K, and the amount in any one year may not exceed $250K. All amounts must be justified.

The maximum award duration will be three years; proposals for less than three years are allowed. Initial funding will be for one year, and subsequent funding will be contingent on the availability of funds, technical progress, and continued relevance to NASA goals. Annual continuation reviews – to assess technical progress and continued relevance – are required.

The anticipated type of award instrument is grants, subject to the provisions of the 2 CFR (Code of Federal Regulations) 200, 2 CFR 1800, and the NASA Grant and Cooperative Agreement Manual (GCAM). Contracts will not be awarded as a result of this Appendix.

3 ELIGIBILITY INFORMATION

3.1 Limitation on Number of Proposals Per Organization

Only accredited U.S. universities are eligible to submit proposals to this solicitation, and teaming is permitted, subject to the eligibility of offerors (see 3.2 of this Appendix). There is no limit on the number of proposals that may be submitted by an accredited U.S. university.

3.2 Eligibility of Offerors, Limitation on Number of Proposals Per PI/Co-I, and NASA's Commitment to Diversity and Inclusion

The PI on a proposal must be either a tenured faculty member or an untenured faculty member on the tenure track from the proposing university. Teaming is permitted, subject to the following restrictions:

- In order to facilitate broad, nationwide participation in this opportunity, a PI or Co-Investigator (Co-I) may participate in no more than two proposals in response to this Appendix. When more than one proposal is submitted on behalf of a PI or Co-I, each proposal must be a separate, stand-alone, complete document for evaluation purposes. More than two submissions may result in all being deemed non-compliant;
- At least 50% of the proposed budget must go to the proposing university;
- At least 70% of the proposed budget must go to accredited U.S. universities;
- Industry and non-profit entities are permitted to partner, subject to the above restrictions;
- Other government agencies and non-NASA Federally Funded Research and Development Centers (FFRDCs) are permitted to collaborate (see definition of collaboration below) only; therefore, they are not permitted to receive any funds through an award resulting from this Appendix;
- NASA Centers and the Jet Propulsion Laboratory (JPL) are not permitted to collaborate on proposals submitted to this Appendix.

Diversity and inclusion are integral to mission success at NASA (see the NASA Equity Action Plan). The agency recognizes the benefits of having diverse and inclusive scientific, engineering, and technology communities and expects the reflection of such values in the execution of its funded efforts. Research effort leadership or participation from U.S. universities and organizations that support and serve under-represented groups, including Historically Black Colleges and Universities, Hispanic-Serving Institutions, Tribal Colleges, and other Minority Serving Institutions (MSIs), is strongly encouraged. NASA encourages submission of ESI proposals on behalf of tenure-track or tenured faculty members at all U.S. universities and especially encourages proposals that are submitted on behalf of and/or that include as team members women, members of underrepresented minority groups, and persons with disabilities. (See 3.2 of the NRA) Proposers are asked to describe any activities related to developing a diverse and powerful U.S. aerospace technology community that they are planning to employ or leverage specifically as part of the proposed effort through a question in the Program Specific Data questionnaire on the Proposal Cover page (see 4.4.2.1 of the Appendix and the NRA). Providing this information is optional and does not impact the evaluation of the proposal.

Other Proposal Personnel

Co-Investigators, postdoctoral associates, consultants, and collaborators are permitted, subject to the restrictions listed above and explained below. As specified in Appendix B of the 2023 NASA Proposer's Guide, a collaborator is not critical to the proposal but is committed to providing a focused but *unfunded* contribution for a specific task. The Scientific/Technical/Management Plan must document the nature and need for all collaborations; see 4.4.2.3 of the Appendix for specific requirements. If research collaboration is a component of the proposal, it is presumed that the collaborator(s) have their own means of research support; that is, an ESI proposed budget may not include any expenses for the collaboration effort.

This ESI Appendix is seeking to fund the best research proposed to the solicited topics from *outside* of NASA. NASA civil servants and JPL employees may not appear as collaborators on submitted proposals**,** and there may be no solicitation-related communications with NASA (including JPL) personnel from the time this Appendix is released until proposal selections are final. Although interaction with NASA researchers under these awards is expected, the proposer is *not* permitted to include potential specific interactions with agency experts (including JPL) in any part of the proposal. In addition, possible future interactions may not be discussed with NASA (including JPL) personnel while the solicitation is open, and letters of commitment from NASA (including JPL) are not permitted. NASA interactions will be addressed after proposal selection.

Failure to meet an eligibility requirement will result in NASA returning the proposal without review.

3.3 Cost Sharing

Cost sharing is not required and is not considered a part of the evaluation.

3.5 Proposals Involving Non-U.S. Organizations

Collaboration by non-U.S. organizations in proposed efforts is permitted as specified in 3.5 of the NRA.

4 PROPOSAL SUBMISSION INFORMATION

4.1 Introduction

The following information supplements the information provided in 4 of the NRA. Note that in instances where this Appendix and the NRA or the 2023 NASA Proposer's Guide differ, the Appendix takes precedence.

Proposals submitted to in response to this Appendix will be evaluated and selected through a one-step process.

4.3 NSPIRES Registration

In order to submit a proposal, all team members and their institutions must be registered in the NASA Solicitation and Proposal Integrated Review and Evaluation System (NSPIRES). Therefore, every organization (including Co-I and collaborator organizations) that intends to participate in a proposal submitted to NASA in response to this solicitation must be registered in NSPIRES. See 4.3 of the NRA for NSPIRES registration requirements.

NASA strongly encourages proposal team members, particularly PIs and Co-Is, to include their digital persistent identifier (e.g., ORCID), if available, as part of their profile in NSPIRES. It can be provided during NSPIRES registration or, after registration, under Account Management > Personal Profile. The digital persistent identifier is a unique, open digital identifier that distinguishes the individual from every other researcher with the same or a similar name.

4.4 Proposal Content and Submission

Dual-Anonymous Peer Review

The STRG Program is strongly committed to ensuring that proposal review is performed in an equitable and fair manner that reduces the impacts of any unconscious biases. To this end, this Appendix will employ a Dual-Anonymous Peer Review (DAPR) process (see 5.2.2.1 of the NRA).

As described in detail below, proposers will provide two anonymized proposal documents and a non-anonymized proposal document that contains identifying expertise and resource information.

Proposers must adhere to the instructions in this Appendix on how to prepare proposals that enable DAPR. Further instructions for the preparation of proposals are provided in the Guidelines for Proposers Responding to SpaceTech REDDI Dual Anonymous Peer Review Appendices document available under "Other Documents" on the NSPIRES page for this Appendix.

DAPR is still a fairly new aspect in the preparation of ESI proposals and, as such, STMD recognizes that there may be minor errors in writing anonymized proposals. However, STMD reserves the right to return without review proposals that are egregious in terms of violating the DAPR requirements described in this Appendix and the accompanying Guidelines for Proposers Responding to SpaceTech REDDI Dual Anonymous Peer Review Appendices document.

4.4.1 Notice of Intent to Propose

Notices of Intent (NOIs) are strongly encouraged by May 9, 2024. The NOI is submitted via NSPIRES. The information contained in an NOI is used to expedite the proposal review process and is, therefore, of value to both NASA and the proposer.

The NOI summary must include the following:

- A full title of the anticipated proposal (which must not exceed 254 characters and is of a nature that is understandable by a scientifically trained person); and
- A brief description of the primary research area(s) and objective(s) of the anticipated work (in the Summary field) (Note: the information in this item does not constrain in any way the Proposal Summary that must be submitted with the final proposal).

Due to DAPR, the names and institutions of the PI and any Co-Is and/or collaborators as known at the time of NOI submission may not be included in the NOI summary. Rather, Co-I, collaborator, and other known participant names and institutions should be provided in response to one of the Program Specific Data questions.

The proposal number restriction described in 3 of this Appendix – a maximum of two per PI or Co-I – does not apply to NOIs. However, prospective offerors are encouraged to consider this restriction as early in the proposal window as possible, ideally prior to the NOI submission due date.

NASA is unable to provide feedback on NOIs.

4.4.2 Proposal Format and Contents

4.4.2.1 Proposal Cover Page

The Proposal Cover Page for each proposal shall include the proposal team, the proposal summary (abstract), responses to Program Specific Data questions, and the budget. See 4.4.2.1 of the NRA for instructions on how to complete the Cover Page. Additional information on how to prepare the Cover Page elements within DAPR requirements are provided in the Guidelines for Proposers Responding to SpaceTech REDDI Dual Anonymous Peer Review Appendices document.

4.4.2.3 Proposal

The proposal must include the following documents and sections, as needed, and in the order listed. Please note frequent references to 2. Proposal Preparation and Organization of the 2023 NASA Proposer's Guide. Proposals that fail to meet the requirements specified herein may be rejected without review.

The proposal documents that must be uploaded into NSPIRES for proposal submission include the ***Anonymized Proposal Summary Chart, Anonymized Proposal Document, and Expertise and Resources – Not Anonymized Proposal Document.***

All proposal documents – whether anonymized or non-anonymized – must be formatted as searchable, unlocked PDF files containing the elements enumerated in the tables below. The Anonymized Proposal Summary Chart and the Anonymized Proposal Document must not contain any information pertaining to the identity of the proposal team members or their organization(s). Failure to submit searchable, unlocked PDF files may result in the proposal being deemed non-compliant.

Reviewers *will not* consider any content in excess of the page limits specified in the tables below.

Anonymized Proposal Summary Chart

The proposal summary 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). The proposal summary chart shall be uploaded to NSPIRES as a separate document.

The chart must include the following information:

- The proposal title and a representative graphic with a caption;
- The objectives of the research, a comparison to the SOA, discussion of the innovation, and start TRL and projected end TRL;
- A high-level summary of the research approach, including methods to be employed;
- The potential impact of the research (i.e., benefits, outcomes).

The chart must be prepared in an anonymized manner and must not include any identifying information. The chart should not include any proprietary or sensitive data (see 4.4.2.2 of the NRA).

The proposal summary chart should be organized as illustrated in Figure 1 – Template for Required Proposal Summary Chart and must be oriented as shown (i.e., landscape mode). Font size 10 or above must be used.

Title • Graphic Depicting Proposed Technology (with caption)	**Research Objectives** • What will be accomplished? • What is the innovation? • How does your effort compare to the SOA? • What are the start and end TRLs (with justification)?
Approach • Methods to accomplish goals	**Potential Impact** • Benefits of the proposed space technology research to future space science and exploration needs if the technology is eventually successful • Other benefits and outcomes of proposed work

Figure 1 – Template for Required Proposal Summary Chart

Anonymized Proposal Document

Anonymized Proposal Document Section	*Maximum Page Length*	*NASA Proposer's Guide Section*
1. Table of Contents	1	2.12
2. Scientific/Technical/Management Plan	10	2.13
3. Data Management Plan	1	2.11
4. References and Citations	As needed	2.14
5. Table of Personnel and Work Effort	As needed	2.20
6. Proposal Budget with Budget Narrative and Budget Details	As needed	2.18

The proposer must make sure that Sections 1-6 do not contain any information pertaining to the identity of the proposal team members or their organizations. Team members, including collaborators, and their organizations must be referred to by role

(e.g., modeler, experimentalist, etc.) or must be given a set designation (e.g., Co-I 1, Co-I 2, Collaborator 1, Collaborator 2, Org 1, Org 2, etc.).

Section 1: Table of Contents

See 2.12 of the 2023 NASA Proposer's Guide.

Section 2: Scientific/Technical/Management Plan

The Scientific/Technical/Management Plan, the main body of the proposal, is limited to 10 pages with standard (12-point) font, and the text must have 1-inch margins. This page limit includes illustrations, tables, figures, and all sub-sections.

The Scientific/Technical/Management Plan must cover the following sub-sections in the order given.

a) The **relevance** of the proposed research to the specific ESI Appendix goals and objectives and topics, as described in 1.2 and 1.3.
   i. Please note that the NRA and this Appendix describe how ESI is relevant to the NASA Strategic Plan; therefore, it is not necessary for individual proposals to show relevance to NASA's broader goals and objectives. The proposal should instead focus on demonstrating **responsiveness** and relevance by discussing how the proposed investigation is directly responsive to one of the topics and how the proposed space technology could lead to dramatic improvements at the system level—performance, weight, cost, reliability, operational simplicity, or other figures of merit associated with spaceflight hardware or missions;
   ii. A comparison between the proposed effort and the existing **SOA**, including a discussion of the perceived impact of the proposed research to the state of knowledge in the field;
   iii. A clear statement of the proposed **innovation,** as well as how the proposed technology might make space science, space travel, and space exploration more effective, affordable, and sustainable;
   iv. A discussion of **next-step technology development;** specifically, a clear description of a path for further development and exploitation of the technology beyond the proposed effort for space science and exploration needs and any crosscutting potential of the technology.
b) The **technical approach** and methodology (types of analyses, testing, experimentation, and other research activities) to be employed in conducting the proposed research. This section should describe, in an anonymized manner, the need for and utilization and salient capabilities of the facilities and equipment required to execute the proposed research. See the Guidelines for Proposers Responding to SpaceTech REDDI Dual Anonymous Peer Review Appendices document for examples on how to discuss facilities and equipment in an

anonymized manner. Access to NASA facilities should not be assumed during the course of the ESI effort, nor should NASA facilities be included in the proposal.

c) A general **work plan**, including a schedule and anticipated key milestones for accomplishments. The proposal must identify the planned work for all years for which support is sought and include a discussion of the potential risks and mitigation strategies.
d) A discussion of the current **TRL** of the proposed technology (see Attachment 2 of the NRA) as well as the projected TRL at the end of the research.
e) The **management approach** for the proposal team members, referred to by roles or generic designations (see examples above), any substantial collaboration(s) and/or use of consultant(s) that is (are) proposed to complete the investigation, and a description of the expected contribution to the proposed effort by each proposal team member, regardless of whether or not they derive support from the proposed budget.
   It is not permissible to include biographical information; discussion of years of experience or prior efforts of team members and/or their organizations may not be included as part of the management approach or any other section of the Anonymized Proposal Document. The qualifications, capabilities and experience of the proposal personnel must be submitted as part of the Expertise and Resources – Not Anonymized proposal document (see below).

Section 3: Data Management Plan

One of NASA's missions is to provide for the widest practicable and appropriate dissemination of information concerning its activities and the results thereof. It is NASA's intent that all data/metadata and as many of the research products as possible developed under this Appendix be shared broadly through dissemination of the results.

Therefore, all proposals submitted under this Appendix are required to submit a Data Management Plan (DMP), in accordance with the NASA Plan for Increasing Access to the Results of Scientific Research. Award recipients are subject to reporting requirements under this plan, including submitting peer-reviewed manuscripts and metadata to a designated repository and reporting publications with progress reports. More information can be found on the NASA Scientific and Technical Information website.

The DMP is limited to 1 page and applies to any data needed to validate the conclusions of peer-reviewed publications, including data that underlie figures, maps, and tables. Other data, models, software, and hardware designs that would enable future research must be addressed in the DMP. The DMP must discuss how research products will be made available to NASA and the public and include evidence (if any) of

past research-product sharing practices. Sound rationale must be provided for any open-access limitations.

The DMP must be written in an anonymized manner that does not explicitly identify the names of the team members or their institutions. It must include information on how the proposal team plans to archive research products, including details on types of products, where products will be archived, schedule for archiving products, how the DMP will enable long-term preservation, and roles/responsibilities of team members to accomplish the DMP. For information about data rights, and other aspects of intellectual property such as invention rights resulting from awards, see 6.6 of the NRA and Appendix I of the 2023 NASA Proposer's Guide.

Also see 2.11 of the 2023 NASA Proposer's Guide.

Section 4: References and Citations

References must be in the [1], [2] format when cited in other sections of the Anonymized Proposal Document, and author names may be revealed only in this section. References will necessarily require names, but proposers must take care not to explicitly reveal information that would compromise DAPR (e.g., identifying an author in the list of references as a PI of the proposal).

Also see the Guidelines for Proposers Responding to SpaceTech REDDI Dual Anonymous Peer Review Appendices document and 2.14 of the 2023 NASA Proposer's Guide.

Section 5: Table of Personnel and Work Effort

The Table of Personnel and Work Effort must include the planned work effort of all personnel necessary to perform the proposed effort, regardless of whether the personnel is at the proposing organization, and whether or not NASA would be paying for their effort as part of this proposal. The table must list all the planned work commitment in an anonymized manner by role without any identifying information. The table is not part of the Scientific/Technical/Management Plan and therefore shall not describe the work each member will be performing or include any other technical details that belong in the Plan. Note that any planned work not funded by NASA that is listed in the table is not considered cost-sharing as defined in 2 CFR 200.29, Cost sharing or matching.

Also see the Guidelines for Proposers Responding to SpaceTech REDDI Dual Anonymous Peer Review Appendices document and 2.20 of the 2023 NASA Proposer's Guide. The Guidelines document includes an example of an acceptable table for this Appendix.

Section 6: Proposal Budget with Budget Narrative and Budget Details

An anonymized budget justification must include details adequate to substantiate the requested funding. The proposal must provide planned budgets for all years for which support is sought. Additional restrictions for this ESI Appendix include:

- The maximum annual and total award values are detailed in 2 of this Appendix. All amounts must be justified.
- Funds may be used for student (undergraduate or graduate) and postdoctoral fellow support, provided these individuals are directly involved in the proposed research and any costs related to such individuals are allowable and allocable according to governing cost principles.
- Funds may be used for research expenses, such as costs incurred in experiments, purchase of equipment and/or supplies, computing, travel, etc.
- If research collaboration is a component of the proposal, it is presumed that the collaborators have their own means of research support; that is, an ESI award may not include any expenses for the collaboration effort. See 3.2 for further discussion of research collaboration.

Also see the Guidelines for Proposers Responding to SpaceTech REDDI Dual Anonymous Peer Review Appendices document and 2.18 of the 2023 NASA Proposer's Guide.

Expertise and Resources – Not Anonymized Proposal Document

In addition to the anonymized documents described above, proposers must submit a separate Expertise and Resources – Not Anonymized Proposal Document; this document contains identifying expertise and resource information.

Expertise and Resources – Not Anonymized Proposal Document Section	***Maximum Page Length***	***NASA Proposer's Guide Section***
1. Table of Contents	1	2.12
2. Team Member Qualifications and Capabilities	1	N/A
3. Biographical Sketches	As needed. Maximum of 2 pages per PI/Co-I	2.15
4. Current and Pending Support	As needed	2.16

5. Statements of Commitment and Letters of Resource Support	1 page each, if needed	2.17
6. Facilities and Equipment	2 pages	2.19

Section 1: Table of Contents

See 2.12 of the 2023 NASA Proposer's Guide.

Section 2: Team Member Qualifications and Capabilities

Provides a summary of the team's qualifications and capabilities, with details provided in the rest of the document. Identifies all involved team members and organizations, revealing the roles and/or designations used in the Anonymized Proposal Document (e.g., Dr. J. Doe (Co-I 1), ABC University (Org 1)). A non-anonymized version of the Table of Personnel and Work Effort may be used for this purpose. Any prior or current work that demonstrates that the proposal team has the skill, expertise, and experience needed to successfully execute the proposed technical approach should be described. The relationship between strongly related and/or leveraged resources involving any PI or Co-I and the proposed research must be described in this section.

Section 3: Biographical Sketches

The PI and all Co-Is must provide biographical sketches, regardless of whether or not they intend to derive support from the proposed budget. A biographical sketch (not to exceed 2 pages in length) should include professional experiences, positions, involvement in any foreign programs, and a bibliography of recent publications, highlighting the publications relevant to the proposed investigation. Also see 2.15 of the 2023 NASA Proposer's Guide.

Section 4: Current and Pending Support

Information must be provided for all ongoing and pending projects and proposals that involve the proposing PI or Co-I, even if the PI or Co-I would receive no salary support from the project(s).

All current project support from any source (e.g., federal, state, local or foreign government agencies, public or private foundations, industrial or other commercial firms) must be listed, regardless of whether the source is U.S. or foreign. This information must also be provided for all pending proposals already submitted or submitted concurrently to other possible sponsors. Do not include the current proposal (i.e., the proposal in response to this Appendix) on the list of pending proposals unless it has also been submitted to another possible sponsor.

For pending research proposals involving substantially the same kind of research as that being proposed to NASA under this Appendix, the proposing PI must immediately notify the NASA Program Officer identified for this Appendix of any successful proposals that are selected any time after the ESI proposal due date and until the time that NASA's selections are announced.

Also see 2.16 of the 2023 NASA Proposer's Guide.

Section 5: Statements of Commitment and Letters of Resource Support (if needed)

Each team member identified as a participant on the Proposal Cover Page and/or in the proposal's Scientific/Technical/Management Section must acknowledge their intended participation in the proposed effort. This acknowledgement of commitment is expected to occur through NSPIRES (see 4.4.2.1 of the NRA). NSPIRES allows for participants named on the Proposal Cover Page to acknowledge a statement of commitment electronically; acknowledgement via NSPIRES is considered sufficient for this Appendix. In the event that a Co-I or collaborator is unable to confirm participation through NSPIRES, the proposer should include a statement of commitment (one page maximum each) in the body of the proposal.

In addition, a letter of support (one page maximum each) is required from the owner of any facility or resource that is not under a team member's direct control, acknowledging that the facility or resource is available for the proposed use during the period of performance.

The letter(s) may not include statements of affirmation (that endorse the value or merit of a proposal). NASA does not solicit, permit, or evaluate such endorsements for proposals. The value of a proposal is determined by peer review using the evaluation criteria defined in 5 of this Appendix.

Statements of commitment and/or letters of support from NASA civil servants and JPL employees are not permitted.

Also see 2.17 of the 2023 NASA Proposer's Guide.

Section 6: Facilities and Equipment

The Facilities and Equipment section is limited to 2 pages. Access to NASA facilities should not be assumed during the course of the ESI effort, nor should NASA facilities be included in the proposal.

Also see 2.19 of the 2023 NASA Proposer's Guide.

4.6 Electronic Proposal Submission

Offerors must submit proposals via NSPIRES. The electronic proposal must be submitted in its entirety by an Authorized Organizational Representative (AOR) of the submitting organization no later than 5 PM Eastern (2 PM Pacific) on June 6, 2024. Proposals submitted after the proposal deadline will be considered late and may be rejected without review.

See 4.6 of the NRA for details.

4.9 Proposal Funding Restrictions

The funding restrictions and requirements given in 2 CFR 200, 2 CFR 1800, 14 CFR 1274, and the GCAM are applicable to this Appendix and are detailed in 4.9 of the NRA.

4.10 Pre-Award Costs

Pre-award costs, expenses incurred within the 90-day period preceding the effective date of the award, may be authorized but such expenses are made at the proposer's risk. NASA will not pay any pre-award costs incurred for unfunded proposals.

5 PROPOSAL REVIEW INFORMATION

5.1 Evaluation Criteria

The technical review criteria considered in evaluating proposals under this Appendix are given below. The questions associated with each criterion are provided to elaborate on the meaning of each criterion; the order of the questions does not indicate order of importance. The three primary evaluation criteria are 1) Relevance (40%); 2) Technical Approach (50%); and 3) Management Approach and Proposal Cost (10%).

Relevance (40%)

Evaluation includes consideration of the following:

- **Responsiveness to Topic**: Does the proposed effort specifically address a technology topic identified in this Appendix? Could the proposed space technology lead to dramatic improvements at the system level — performance, weight, cost, reliability, operational simplicity, or other figures of merit associated with spaceflight hardware or missions?
- **State of the Art (SOA):** How does the proposed effort compare to the existing SOA? Does the proposal state how the research might impact the direction, progress, and thinking in relevant fields of research?
- **Innovation**: Is the proposed research innovative? Does it have the potential to lead to revolutionary or breakthrough improvements in performance, new approaches, or entirely new missions?

- **Next-Step Technology Development**: Does the proposal clearly describe a path for further development and exploitation beyond the proposed effort for space science and exploration needs? Does the technology have the potential to be crosscutting?

Technical Approach (50%)

Evaluation includes consideration of the following:

- **Technical Approach**: Are the research approaches technically sound, logical, and feasible? Are the conceptual framework, methods, and analyses well justified, adequately developed, and likely to lead to scientifically valid conclusions?
- **Facilities/Capabilities:** Are described facilities/capabilities appropriate for the proposed effort?
- **Work Plan:** Is the work plan complete and appropriate to successfully accomplish the proposed technology development? Is the schedule, including key milestones, appropriate and realistic? Does the proposal recognize significant potential problems and consider reasonable mitigation strategies?
- **Data Management Plan:** Does the data management plan ensure widespread dissemination of results? Does the proposal provide evidence of past data-sharing practices?
- **TRL**: Is the proposed work at the appropriate entry TRL as stated in 1.2 of this Appendix? Does the proposal achieve meaningful TRL advancement?

Management Approach and Proposal Cost (10%)

Evaluation includes consideration of the following:

- **Management Approach:** Are roles, including those of any collaborators, clearly defined? Are the staffing levels adequate? Is the management approach sound with practices that are appropriate for the proposed work?
- **Budget**: Is the proposed budget reasonable for the scope of the effort? Is the budget of sufficient fidelity? Are the assumptions and components of the proposed budget defined?

5.2 Review Process

5.2.1 Administrative Review

In addition to steps described in 5.2.1 of the NRA, proposals will be pre-screened for compliance with DAPR requirements (see 4.4 of this Appendix). NASA reserves the right to return, without review, proposals that are egregious in terms of violating the DAPR requirements described in this Appendix and the accompanying documents on the NSPIRES page for this Appendix.

5.2.2 Dual Anonymous Peer Review Process

A technical review panel will evaluate the proposals against the evaluation criteria noted in 5.1. This evaluation of the anonymized proposals will not take into account the qualifications and capabilities of proposers.

After the technical evaluation of *all* anonymized proposals has been finalized, the panelists will be provided with the Expertise and Resources – Not Anonymized Proposal Document for a subset of proposals that scored highly (the cutoff being dependent on the distribution of evaluations and projected selection rate). For each proposal considered, the panel will verify that this document clearly confirms the team has the capabilities and resources required to execute the proposed technology development effort. If there are clear, compelling deficiencies in the expertise or resources required to execute the goals of the proposal, the panel may note this in its comments to the NASA Selection Official. This review may not be used to "upgrade" proposals for having particularly strong team qualifications, nor may it be used to reevaluate the proposals.

5.2.3 Additional Review and Selection Information

Both government (NASA and non-NASA) and non-government reviewers may be used, and submission of a proposal constitutes agreement that this is acceptable to the investigator(s) and the submitting institution. Peer reviewers are selected with regard to their scientific expertise, and the review is conducted in accordance with the STMD's Organizational Conflict of Interest (OCI) Mitigation Plan and Appendix D of the 2023 NASA Proposer's Guide. Also see 4.8 of the NRA.

The Selection Official for this Appendix will be the NASA Space Technology Mission Directorate Director of Early Stage Innovations and Partnerships or designee. The Selection Official may take portfolio balance and other programmatic considerations into account when making final selections.

5.3 Selection Announcement and Award Dates

Selection notifications are anticipated in October 2024. PIs and university AORs will receive notification via NSPIRES.

Research grants are expected to be awarded as a result of this announcement. Assuming the availability of appropriated funds, a January 2025 award date is expected. If selected, NASA expects the grantee to commence with the proposed research on the award start date; deferrals will not be permitted.

6 FEDERAL AWARD ADMINISTRATION INFORMATION

All awards are subject to the terms and conditions, cost principles, and other considerations described in 2 CFR 200, 2 CFR 1800, and the GCAM. This Appendix does not invoke any special administrative or national policy requirements.

6.1 Federal Award Notices

For those proposals being recommended for an award, the notification should not be regarded as an authorization to commit or expend funds. Notification will be consistent with the policy given in Section 5 of the 2023 NASA Proposer's Guide. For selected proposals, a NASA Award Officer, who is the only official authorized to obligate the Government, will contact the proposer's business office.

6.2 Administrative and National Policy Requirements

6.2.1. Research Terms and Conditions

Awards from this funding announcement are subject to the Federal Research Terms and Conditions (RTC) located at http://www.nsf.gov/awards/managing/rtc.jsp. In addition to the RTC and NASA-specific guidance, three companion resources can also be found on the website: RTC Appendix A Prior Approval Matrix, RTC Appendix B Subaward Requirements, and RTC Appendix C National Policy Requirements.

6.2.2. Environmental Impact

All awards made in response to proposals to this Appendix must comply with the National Environmental Policy Act (NEPA). The majority of grant-related activities are categorically excluded from specific NEPA review as research and development projects that do not pose any adverse environmental impact. A blanket NASA Grants Record of Environmental Consideration (REC) provides NEPA coverage for these anticipated activities, and it is expected that all awards resulting from this Appendix will be covered by this REC. See 6.2. 2 of the NRA and 2.21 of the 2023 NASA Proposer's Guide for more information.

6.3 Award Reporting Requirements

The reporting requirements will be consistent with 2 CFR 1800.902 "Technical Publications and Reports" and Appendix F - Required Publications and Reports of the GCAM. Grants and cooperative agreements typically require annual and final technical reports, financial reports, and final patent/new technology reports. Electronic copies of publications and presentations should be submitted along with progress reports.

The following requirements will also be incorporated into the ESI awards:

Quarterly Research Performance Progress Reports (RPPRs). The PI shall submit progress reports quarterly, with the first one due approximately 90 days from the grant

start date. The precise reporting schedule is provided by the Program at the start of each award year. The reports will provide a summary of progress against the work plan, discussion of upcoming activities, accomplishments, student information, and any issues or concerns that should be brought to the attention of the program. In addition, information related to publications, presentations, conferences, inventions, follow-on funding, and press received – referred to as grant visibility and impact data – must be provided. For detailed information on reporting project performance, please refer to the Post-award Phase Section of the GCAM.

Continuation Review Package/Presentation. If more than one year is proposed, annual continuation reviews are required. The continuation review package will be submitted in place of one of the quarterly RPPRs in applicable grant years. The package will consist of a comprehensive report (i.e., a description of the research progress and findings to date or since the last continuation review, discussion of relevance, and any updates to the overall work plan and associated schedule), in addition to the grant visibility and impact data, and a research summary. An associated continuation review presentation, virtually or at a NASA Center, of progress and plans will also be required.

Technical Seminars. The PI shall present a minimum of two technical seminars at NASA Centers over the course of the grant award; seminar travel must be included in the grant budget. Upon permission from the program, the seminars may also be conducted in a suitable conference setting. The purpose of these presentations is to promote excitement about the space technology research efforts being conducted under the award and to create opportunities for technical interaction and collaboration.

Final Performance Reports. The PI shall submit closeout report documentation (final technical report, final grant visibility and impact data, and final research summary) at the end of the final grant year.

Awards issued under this Appendix must comply with the provisions set forth in the NASA Plan for Increasing Access to the Results of Scientific Research; see 4.4.2.3 of this Appendix for more detailed information.

7 POINTS OF CONTACT FOR FURTHER INFORMATION

Questions (technical, programmatic, grants management, etc.) or comments about this Appendix may be directed to:

Matthew Deans
Space Technology Research Grants Program Executive
Space Technology Mission Directorate, NASA Headquarters
hq-esi-call@mail.nasa.gov

Questions to the manager of the NRA associated with this Appendix may be directed to:

SpaceTech REDDI NRA Manager
hq-esi-call@mail.nasa.gov

Questions of a general nature may be added to the Frequently Asked Questions (FAQ) for this Appendix. The FAQ document will be located under “Other Documents” on the NSPIRES page for this Appendix.

All technical questions will be incorporated into one of the topic-specific Questions and Answers (Q&A) documents, also located under “Other Documents” on the NSPIRES page for this Appendix. When submitting a technical question, proposers are agreeing to have the question, and associated response, published in one of the Topic Q&A documents. Questions will be accepted through May 30, 2024; no technical questions will be accepted after this date. Please note that NASA is unable to comment on whether a proposed area of research is responsive to a topic described in 1.3.