1. PURPOSE

This Statement of Objectives (SOO) defines mission need, objectives, desired outcomes, and constraints to enable industry to propose commercially viable and credible solutions to Topic 5 of NextSTEP-3 Appendix A.

NASA will actively engage with selected Offerors through ongoing technical engagement, milestone reviews, and Government insight and oversight activities to support assessment of technical progress, and achievement of program objectives. Offerors are expected to apply independent scientific and engineering judgment in selecting technical approaches and proposed solutions that best satisfy the objectives and outcomes defined herein.

See Appendix A for additional solicitation details.

2. BACKGROUND/MISSION NEED

NASA seeks higher conversion efficiency Radioisotope Power System (RPS) technologies that are reliable, robust, and capable of long operational lifetimes to support future exploration missions to the Moon, Mars, and the outer planets. Higher-efficiency power conversion systems, such as Stirling Radioisotope Generators (SRGs), can reduce the amount of required fuel by a factor of three to four compared to current RPS technologies while also enabling the potential use of alternative fuels. Advancing SRG technology to higher technology readiness levels is critical for reducing engineering risk and developing scalable power system architectures that can operate in dark, dusty, and extreme environments across the solar system.

The effort is fundamentally a research and development initiative aimed at refining system designs and demonstrating innovative approaches where full system definitions are still evolving. NASA will lead this effort's development of system designs for potential future adoption into a nuclear-fueled mission. Future nuclear missions could potentially be regulated by the Nuclear Regulatory Commission (NRC) and Federal Aviation Administration (FAA) for non-plutonium fueled systems. The NRC and FAA are collaborating on safety, security, and licensing for space-based nuclear systems and security overflights. The FAA licenses space nuclear launches, while the NRC sets radiological safety standards, with recent guidance focused on licensing, hazard analysis, and radiological safety for space vehicles.

3. OBJECTIVES

The overall objective of this effort is to design a high-efficiency Radioisotope Stirling Generator (RSG) and fabricate and test an electrically heated prototype for lunar applications. An RSG includes a Stirling power convertor(s), electronic controller, thermal management, heat source, and potentially dynamic balancer. However, proposals should consider designs with extensibility for survival in the Mars environment, higher levels of power output, longer life to support Moon to Mars objectives, and the use of isotope fuel. Extensibility to higher power levels can be achieved through a single system design or by integrating multiple redundant systems. Proposals should include evidence such as description of functionality, analysis, and test results to support TRL claims for proposed subsystems. The scope of work described herein applies to all Contract Line Item Numbers (CLINs) under this Topic (see Section 6, Contract Structure, of the Appendix A).

Successful efforts shall address the following key objectives:

3.1 Objective 1 – System Design: Produce a system design of a high-efficiency RSG capable of supporting future missions to the Moon and Mars, providing necessary survival heat and power for landers and rovers to endure harsh environments (e.g., permanently shadowed regions and extended lunar nights). Designs should provide 40-50% of full power upon a single failure.

3.2 Objective 2 – Prototype Fabrication & Testing: Demonstrate advancement of SRG technologies from a starting Technology Readiness Level (TRL) of 3–4 to a target TRL of 5–6 through subsystem and system-level demonstrations in relevant ground environments. This includes demonstrating an electrically heated prototype operating with a simulated spacecraft bus in relevant environments to validate integrated system performance (efficiency, fault tolerance, monitoring, and control).

3.3 Objective 3 – Interface Maturation & Extensibility: Mature interfaces for delivering rejected heat to key spacecraft locations and document extensibility to higher power levels and longer life.

3.4 Objective 4 – Regulatory Pathways: Develop draft regulatory processes and schedules, including identifying major milestones and risks for the selected fuel type.

4. PERFORMANCE OUTCOMES

Successful efforts shall achieve the following outcomes and defined Key Performance Parameters (KPPs):

4.1 Demonstration of an RSG design capable of providing 50-150 We DC power output (KPP), extensible to approximately 300 We (KPP), and designed exclusively for a vacuum environment (KPP).

4.2 Validation of integrated system performance achieving at least 20% system efficiency (KPP), a specific power of at least 1 W/kg (KPP), and a minimum design life of 5 years, with extensibility to 10 years (KPP).

4.3 Demonstration of 40-50% of the heat rejected from the Stirling converter is made available for host spacecraft survival (KPP).

4.4 Functional demonstration of technologies using subsystems to reduce risk, alongside validation of a Technology Development Plan that reduces risk for key interfaces.

4.5 Successful operation of an electrically heated RSG on a simulated spacecraft bus in relevant environments, characterizing performance during simulated environments based on lunar mission concept of operations and fault scenarios.

4.6 Delivery of a Draft Report of Regulatory Processes and schedule that defines met safety criteria, fuel production, regulation, and integration informed by regulatory bodies for a selected fuel type. Any fuel type that meets the design life is acceptable (KPP).

5. CONSTRAINTS AND SCOPE

The following in-scope and out-of-scope constraints apply to all proposed technical approaches. Offerors shall ensure their proposed technical approach strictly adheres to these boundaries. See

Section 8.2, Evaluation Criteria, of Appendix A for further information on how compliance with these boundaries affects proposal scoring.

a. In-Scope: The following elements shall be considered in scope and included in this effort:
    i. Fuel Options: Heat source designs that utilize Americium 241 fuel and support the required KPPs.
b. Out-of-Scope: The following elements shall be considered out of scope and are excluded from this effort:
    i. Extraneous Fabrication: Fabrication of costly subsystems and/or systems not directly supporting the required prototype demonstration.
    ii. Flight Hardware: Flight hardware procurement suitable for the qualification of flight designs.
    iii. Destructive Testing: Destructive inspection of the system hardware.
    iv. Excluded Fuels: Selection and use of fuel types other than Americium, such as Plutonium, Strontium, Cobalt, and Tritium.

6. DELIVERABLES AND REVIEWS

Offerors shall propose deliverables and reviews appropriate to the maturity, scope, and technical approach of their proposed efforts. Deliverables are expected to provide sufficient technical evidence to demonstrate progress toward the stated objectives and outcomes. The desired deliverables and reviews of a successfully awarded contract include:

a. Design reviews including systems requirements, conceptual design, preliminary design, final design, and test readiness. Associated review artifacts, data packages, and supporting documentation shall be provided in formats and with content mutually agreed upon during review planning with NASA.
b. Delivery of hardware including prototype components, sub-systems, or integrated system demonstration articles representative of the proposed system design.
c. Technical reports consisting of system design description, as-built drawings, assembly and integration, verification and validation plan, test procedures, risk reduction for critical technology elements and key interfaces, lunar mission concept of operations and fault scenarios, technology and manufacturing maturity, and technical progress throughout the period of performance.
d. Design and performance data supporting the assessment of extensibility to higher power levels including impact on key performance parameters.
e. Test reports documenting validation of key performance parameters and characterization of electrical, thermal, operational, functional, and environmental performance (e.g., efficiency, power output, heat rejection, flight design mass) of the RSG subsystems and systems.
f. Documentation describing the proposed pathway for advancing the Technology Readiness Level (TRL) of the demonstrated technology, alongside draft regulatory

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processes, schedules, safety criteria, and integration hurdles for future NASA space applications.

g. Government insight activities, including technical interchange meetings, monthly status reports and meetings, demonstrations, and site visits, as appropriate and coordinated with the Government, to support technical assessment, collaboration and programmatic visibility throughout the period of performance.

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