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 insight into proposed deliverables and technical progress. Offerors are expected to apply independent scientific and engineering judgment in selecting technical approaches and proposed solutions.

For additional details on the solicitation, refer to Appendix A.

2. BACKGROUND/MISSION NEED

NASA's space exploration and science mission objectives rely on advancements in advanced material innovations to meet their objectives. Innovative nanomaterials can support these objectives in several key areas, such as novel habitats optimized for crew safety, large-area radiators and heat exchangers for nuclear-powered spacecraft and surface assets, high-strength ropes and cabling for manipulation of payloads, regolith, logistics, and/or equipment in the extreme lunar environments, deployable components for power generation and distribution infrastructure, and advanced sensors for environmental and structural health monitoring.

Advancing these innovative nanomaterials will expand the palette of structural and sensory materials available for multiple systems, enabling performance levels that cannot be achieved with existing materials. Improving the commercial availability of these high-performance nanomaterials is critical for testing high-payoff concepts essential to NASA's exploration goals. Furthermore, producing and demonstrating these materials at practical, application-relevant scales enable mission designers to confidently incorporate them into component solutions thereby addressing existing Civil Space Technology Shortfalls and Moon to Mars Architecture-Driven Gaps.

This topic seeks to advance commercial availability, performance, quality, and consistency of nanomaterials to support Moon to Mars Architecture applications.

3. OBJECTIVES

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 – Large-Scale Nanomaterial Manufacturing**: Develop scalable manufacturing approaches of innovative macroscale (one-dimensional and two-dimensional) nanomaterial assemblages suitable for structural space applications, demonstrating advancement in Manufacturing Readiness Level (MRL) of an initial MRL of 3-4 to a target MRL of 5.

3.2 **Objective 2 – Structural Component Applications**: Demonstrate the application of innovative nanomaterials in structural components relevant to space systems, including primary and secondary structural applications. Proposed efforts shall demonstrate measurable performance improvements relative to current industry-standard materials and approaches.

3.3 **Objective 3 – Non-Structural Component Applications:** Demonstrate the application of innovative nanomaterials in non-structural space-relevant components or subsystems where nanomaterial-enabled performance improvements can provide operational or mission benefit.

4. PERFORMANCE OUTCOMES

Successful efforts shall achieve the following outcomes:

4.1 Large-Scale Nanomaterial Manufacturing

4.1.1 Demonstration of increased manufacturing readiness levels for scalable nanomaterial production processes.

4.1.2 Validation of improved material performance, quality, consistency, or manufacturability for space-relevant applications.

4.1.3 Manufacturing of high strength one-dimensional (fiber-like) nanomaterial assemblage with linear density uniformity index less than 14 % at a failure force ≥ 25 N at a length ≥ 5 km and tenacity ≥ 2.5 N/tex.

4.1.4 Manufacturing of two-dimensional (sheet-like) nanomaterial assemblage with axial strength greater than 0.4 GPa and transverse strength ≥ 50 % of the axial strength at a sheet size ≥ 1 m x 2 m.

4.2 Structural Component Applications

4.2.1 Demonstration of component-level prototypes incorporating innovative nanomaterials with measurable performance improvements over current industry-standard materials.

4.2.2 Documentation of envisioned space applications, operational benefits, performance targets, and viable technology infusion pathways.

4.2.3 Market research supported analysis of the supply chain for the target innovative nanomaterials at quantities and performance levels consistent with the envisaged application.

4.2.4 Analysis-supported transition strategies describing the potential integration of the demonstrated technology into future commercial or NASA-relevant space systems.

4.3 Non-Structural Component Applications

4.3.1 Demonstration of component-level prototypes incorporating innovative nanomaterials with measurable performance improvements over current industry-standard materials.

4.3.2 Documentation of envisioned space applications, operational benefits, performance targets, and viable technology infusion pathways

4.3.3 Market research supported analysis of the supply chain for the target innovative nanomaterials at quantities and performance levels consistent with the envisaged application.

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4.3.4 Analysis-supported transition strategies describing the potential integration of the demonstrated technology into future commercial or NASA-relevant space systems.

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.

5.1 In-Scope: The following materials and applications shall be considered in scope and included in this effort:

5.1.1 All Objectives: Nanomaterials including, but not limited to, carbon nanotubes, boron nitride nanotubes, graphene, or hybrids thereof.
5.1.2 Large-Scale Nanomaterial Manufacturing: Macroscale assemblage relevant to space structural applications including but not limited to yarns and sheets.
5.1.3 Structural Component Applications: Nanomaterial based structural components relevant to space systems, including primary and secondary structural applications.
5.1.4 Nonstructural Component Applications: Nanomaterial enabled nonstructural components relevant to space applications. Includes, but is not limited to, sensors, actuators, wiring, or improvements of non-structural material properties of a structural component, e.g. thermal or electrical conductivity of trusses, etc.

5.2 Out-of-Scope: The following materials and applications shall be considered out of scope and are excluded from this effort:

5.2.1 Matrix-Heavy Composites for Structural Component Applications: Composite materials consisting predominantly of a matrix material such as nanomaterial-doped polymers with low nanomaterial loading that cannot meet the performance needs of a structural space application.
5.2.2 Excluded Applications: Catalysis or biomedical related uses of nanomaterials.
5.2.3 Non-Space Applications: Materials or components that lack relevance to space applications.
5.2.4 Lack of Advancement: Any materials or components that fail to advance the current state of the art for structural or non-structural space applications.

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:

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6.1 Demonstrations and supporting documentation validating advancements in manufacturing capability, operational readiness, or application integration for one-dimensional and two-dimensional nanomaterial assemblages and nanomaterial-enabled components.

6.2 Material samples, component artifacts, prototypes, or demonstration articles representative of the proposed technology and suitable for evaluating manufacturing progression, material performance, and operational applicability.

6.3 Technical reports and briefings documenting manufacturing development, process maturation, material characterization, testing activities, performance improvements, and technical progress throughout the period of performance.

6.4 Materials characterization, manufacturing, and performance data supporting assessment of scalability, quality, repeatability, and suitability for space-relevant applications.

6.5 Test reports documenting structural, operational, functional, or environmental performance of nanomaterial-enabled components or systems relevant to proposed space applications.

6.6 Documentation describing the proposed pathway for advancing the Technology Readiness Level (TRL), Manufacturing Readiness Level (MRL), or operational applicability of the demonstrated technology for future NASA or commercial space applications.

6.7 Government insight activities including technical interchange meetings, monthly status reports and meetings, milestone reviews, 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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