1. PURPOSE

This Statement of Objectives (SOO) defines the mission need, objectives, desired outcomes, and constraints to enable industry to propose commercially viable and credible solutions for a system-level In-Situ Resource Utilization (ISRU) Lunar Oxygen Production demonstration.

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

ISRU capabilities are required to enable a sustainable human and robotic presence on the lunar surface and are directly aligned with NASA Moon-to-Mars (M2M) objectives for producing propellant, consumables, and usable materials from lunar resources. Current technology gaps exist in demonstrating integrated oxygen extraction systems from lunar regolith at scales relevant to future exploration missions.

While individual oxygen extraction and regolith processing technologies have matured independently to approximately Technology Readiness Level (TRL) 5–6, NASA seeks to mature integrated system-level capability through demonstration of subsystem interoperability, interface maturity, and system performance in relevant operational environments. Existing efforts have largely focused on component-level validation; however, significant technical risk remains associated with integration, interface compatibility, system controls, operational sequencing, and end-to-end performance validation.

This effort is fundamentally a research and development initiative intended to mature integrated ISRU oxygen production system concepts and reduce risk for future lunar surface architectures. The demonstration is intended to validate both hardware and system-level models while informing future mission trades, system scaling, and architecture decisions. NASA anticipates using results from this effort to support future sustained lunar exploration initiatives and potential oxygen production architectures supporting surface operations and propellant generation.

NASA has previously funded component technologies across multiple industries and government performers, particularly in oxygen extraction reactor technologies. This solicitation seeks to integrate these higher-TRL technologies into a credible system-level demonstration while maintaining flexibility for Offerors to propose innovative system engineering, integration, and operational approaches.

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3. OBJECTIVES

The overall objective of this effort is to demonstrate an integrated Oxygen-from-Regolith ISRU system capable of advancing system-level technology maturity through integrated testing The effort shall focus on reducing system integration risk, validating interfaces between subsystems, characterizing oxygen production performance, and developing models and data products to support future flight system trades and scaling assessments. 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 – Demonstrate advancement of Oxygen-from-Regolith ISRU technologies from component-level TRL 5–6 to an integrated system-level demonstration approaching TRL 5. The demonstration shall validate system integration, subsystem interoperability, and operational functionality

3.2 Objective 2 - Identify, integrate, and demonstrate all major components required for an Oxygen-from-Regolith ISRU system at a defined and scalable system level (see Attachment B4. Proposals shall define hardware selection, integration approaches, testing strategies, and schedules necessary to achieve system demonstration objectives.

3.3 Objective 3 – Demonstrate integrated system operation under relevant environmental and operational conditions representative of lunar oxygen production processes. Testing shall characterize oxygen production performance, cleanliness, interface functionality, and operational stability across integrated subsystems

3.4 Objective 4 – Develop estimates and assessments for scaling demonstrated technologies toward future pilot-scale and full-scale lunar oxygen production systems. Assessments shall address system mass, power, scalability, operational considerations, and key flight-forward design implications

3.5 Objective 5 – Identify major system and subsystem technical risks and define potential pathways for reducing those risks through future demonstrations and flight-relevant development activities. Proposals shall identify critical interfaces, environmental considerations, and technology gaps requiring additional maturation.

3.6 Objective 6 - Develop and validate system-level models capable of supporting architecture studies, performance assessments, scaling evaluations, and future lunar ISRU trade studies. Models and supporting data products shall be deliverable to NASA for future analysis and integration into broader ISRU frameworks.

4. PERFORMANCE OUTCOMES

The requirements contained in Attachment B2 establish the minimum technical capabilities and performance objectives expected to be achieved during execution of the proposed effort. Successful efforts shall achieve the following outcomes and associated performance objectives:

4.1 Demonstration of an integrated Oxygen-from-Regolith ISRU system architecture capable of producing clean oxygen from lunar regolith simulant through integrated subsystem operation in a relevant environment.

4.2 Validation of integrated subsystem functionality and system performance sufficient to demonstrate advancement toward system-level TRL 5, including successful operation of integrated oxygen extraction, material handling, and supporting process interfaces.

4.3 Characterization and validation of oxygen production output and cleanliness suitable for assessing compatibility with downstream oxygen liquefaction and propellant production applications.

4.4 Demonstration of system integration approaches and interface definitions sufficient to identify critical integration risks, operational constraints, and subsystem interoperability challenges.

4.5 Development of flight-forward assessments for pilot-scale and full-scale oxygen production architectures, including estimated system SWAP (Size, Weight, and Power), scalability considerations, and operational implications.

4.6 Delivery of validated system-level models, test data, and analytical products capable of supporting NASA architecture studies, system trades, and future ISRU mission planning activities

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 additional information regarding evaluation considerations associated with compliance to scope boundaries.

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

5.1.1 Integrated Ground Demonstration: Ground-based integrated demonstrations of Oxygen-from-Regolith ISRU systems where processes are at relevant lunar operating conditions, including operation of integrated subsystems under representative thermal, pressure, and operational conditions.

5.1.2 System Integration and Testing: Integration and testing of subsystem hardware necessary to demonstrate end-to-end oxygen production functionality and characterize interface performance. An end-to-end system must include a regolith feed system and end with production and verification of purified Oxygen that is sufficiently clean & dry to be compatible with a liquification system for propellent use.

5.1.3 Modeling and Data Validation: Development and validation of component and system-level models informed by demonstration data and suitable for future NASA architecture studies and scaling assessments.

5.1.4 Scalable System Architecture: System concepts demonstrating scalability toward full-scale oxygen production systems (10MT of O2 per year) and future lunar operational architectures.

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

5.2.1 Flight Demonstrations: Flight demonstrations, flight mission implementation, or commitments to future flight opportunities.

5.2.2 Flight Qualification Hardware: Procurement or fabrication of fully flight-qualified hardware systems intended for operational deployment.

5.2.3 Upstream excavation and size sorting systems, large-scale regolith transportation systems, downstream oxygen liquefaction systems, or long-duration storage systems beyond what is necessary to support integrated demonstration objectives. An integrated end-to-end control system, avionics, and autonomy are not required so long as individual component interfaces and operation allow for relevant end to end function.

5.2.4 Non-Relevant Environmental Testing: Integrated thermal vacuum testing of the full integrated system.

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:

6.1 Deliverables

6.1.1 Integrated system demonstrations of continuous operation (time specified in Attachment B4) with uninterrupted product flow stream between components and subsystems and supporting technical documentation validating subsystem interoperability, oxygen production functionality, interface maturity, and operational performance.

6.1.2 Technical reports and briefings documenting system design, integration activities, testing methodologies, operational performance, oxygen production characterization, and technical progress throughout the period of performance.

6.1.3 System modeling products, simulation tools, and analytical data suitable for use by NASA to support scaling assessments, architecture trades, performance evaluations, and future flight-forward ISRU studies. Deliverables shall include physics-based numerical models capable of predicting system performance and estimating Size, Weight, and Power (SWAP) characteristics across relevant operational scales. The modeling products should include individual component-level models integrated into a system-level model that captures interactions and input/output relationships between major subsystems. Supporting test data and analytical products used for model validation shall also be provided to enable future NASA analysis and application. Test reports documenting operational, thermal, functional, and performance characteristics of integrated systems and subsystems under relevant operational document.

6.1.4 Documentation describing pathways for advancing demonstrated technologies toward future flight-relevant applications, including identification of major technical risks,

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interface challenges, predicted system SWAP for full scale, and required future maturation activities.

6.1.5 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.

6.1.6 A publicly-available publication of the results include performance metric results.

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