SBIR/STTR
Small Business Innovation Research / Small Business Technology Transfer

NASA SBIR 2011 Phase I Solicitation

X1 In Situ Resource Utilization

The purpose of In-Situ Resource Utilization (ISRU) is to harness and utilize resources at the site of exploration to create products and services which can enable and significantly reduce the mass, cost, and risk of near-term and long-term space exploration. The ability to make propellants, life support consumables, fuel cell reagents, and radiation shielding can significantly reduce the cost, mass, and risk of sustained human activities beyond Earth. The ability to modify the landscape for safer landing and transfer of payloads, creation of habitat and power infrastructure, and extraction of resources for construction, power, and in-situ manufacturing can also enable long-term, sustainable exploration of the solar system. Since ISRU can be performed wherever resources may exist, both natural and discarded, ISRU systems will need to operate in a variety of environments and gravitations. Also, because ISRU systems and operations have never been demonstrated before in missions, it is important that ISRU concepts and technologies be evaluated under relevant conditions (gravity, environment, and vacuum) as well as anchored through modeling to regolith/soil and environmental conditions. While the discipline of ISRU can encompass a large variety of different concept areas, resources, and products, the ISRU Topic will focus on technologies and capabilities associated with solid in-situ material handling and processing along with atmospheric and trash/waste processing.

Subtopics

X1.01 In-Situ Resource Characterization, Extraction, Transfer, and Processing

Lead Center: JSC

Participating Center(s): GRC, KSC, MSFC

The ability to characterize, collect, transfer, and process resources at the site of exploration on the Moon, Mars, and Near Earth Objects (NEOs)/Phobos can completely change robotic and human mission architectures. The subtopic seeks proposals for the design and subsequent build of hardware and technologies that perform critical functions and operations for characterization, collection, transfer, and processing operations that can be inserted for integration into on-going and future system-level development and demonstration efforts. The technologies and hardware must utilize local materials with the minimum Earth-supplied feedstock possible. There are three main areas of interest:

Extraterrestrial Material-Based ISRU

- Methods for collection and transfer of NEO/Phobos material under micro-gravity conditions under vacuum/space environmental conditions. Proposals must state and explain material properties and water content considered in the design.

- Methods for the transfer of Mars surface material containing water at 1 to 5 kg/hr under Mars surface environmental conditions. Proposals must state and explain material properties and water content considered in the design, and locations on Mars where the method proposed is applicable

- Use of ionic liquids for processing and extracting oxygen and metals from extraterrestrial material at temperatures below 200 C at 0.2 kg/hr. Proposals must include methods for product separation and ionic liquid reagent regeneration for subsequent processing.

- Development of reactors with dust tolerant gas-tight seals and valving to extract and collect of water and other potential volatiles from extraterrestrial materials at 0.5 to 5 kg/hr of material processing rate. Proposals must state and explain material properties, water content, mixing technique, and gravity conditions considered in the design. Proposals may combine material transfer with water/volatile processing to minimize mass and power. Proposals for processing reactor systems should focus on highly effective approaches to energy utilization, including internal heat and mass transport enhancements and/or other physical or operational characteristics. Proposals that cover more than one material for consideration are of particular interest.

- Development of a compact, lightweight gas chromatograph - mass spectrometer (GC-MS) instrument that can quantify volatile gases released by sample heating below atomic number 70 (of particular interest H_2, He (and isotopes), CO, CO_2, CH_4, H_2O, N_2, O_2, Ar, NH_3, HCN, H_2S, SO_2). The instrument should be designed to be able to withstand exposure to the release of HF, HCl, or Hg that may result from heating regolith samples to high temperatures. The instrument should be capable of detecting 1000 ppm to 100% concentration of the volatiles in the gas phase. The instrument should have a clear path to flight with a flight instrument design with a mass of less than 5 kg not including any vacuum components required to operate in the laboratory environment.

Extraterrestrial Atmosphere Based ISRU

- Devices that collect and separate Mars atmospheric argon and nitrogen using a standalone device or as part of carbon dioxide collection concepts at carbon dioxide collection rates (0.5 to 2 kg CO_2/hr rate and supply pressure at >15 psi for subsequent processing).

- Micro-channel reactor and heat exchanger concepts for efficient processing of carbon monoxide and carbon dioxide into water and/or methane with hydrogen at 0.5 to 2 kg/hr rate.

Discarded Material-Based ISRU

- Trash processing reactor concepts for production of carbon monoxide, carbon dioxide, water, and methane from plastic trash and dried crew solid waste. Proposals must define use of solar or electrical energy during processing, and any reagents/consumables. Recycling schemes for reactants/reagents used in the processing should be included. Highly efficient, compact water vapor removal/separation devices from product gas streams is also of interest.

Proposals must consider the physical/abrasive, mineral, and volatile/water properties and characteristics of the material/resource of interest, and the gravity environment in which collection, transfer, and processing will occur. Concepts that can operate in micro & low-gravity (1/6-g & 3/8-g), as well as multiple resources are of greater interest. Designs that are compatible for subsequent analog, micro/low-g flight experiments, and ground vacuum experiments are also of greater interest. Proposals that utilize rotating gears and actuators must be designed for abrasive/dusty environmental conditions. Proposals will be evaluated against state-of-the-art capabilities with respect to mass, power, and process efficiency. Figures of merit include consumable production rate (kg/hr), production energy efficiency (kg produced/ hr per KWe), and extraction/reactant recovery efficiency.