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

NASA SBIR 2014 Phase I Solicitation

H1 In-Situ Resource Utilization

The purpose of In-Situ Resource Utilization (ISRU) is to harness and utilize resources (both natural and discarded material) at the site of exploration to create products and services which can enable new approaches for exploration 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 provide significant benefits for sustained human activities beyond Earth very early in exploration architectures. Since ISRU can be performed wherever resources may exist, ISRU systems will need to operate in a variety of environments and gravities and need to consider a wide variety of potential resource physical and mineral characteristics. 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, atmosphere, 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 gas, water, and Mars atmosphere processing.

Subtopics

H1.01 In-Situ Resource Utilization - Mars Atmosphere/Gas Chemical Processing

Lead Center: JSC

Participating Center(s): ARC, GRC, JPL, KSC, MSFC

In-Situ Resource Utilization (ISRU) involves collecting and converting local resources into products that can reduce mission mass, cost, and/or risk of human exploration. ISRU products that provide significant mission benefits with minimal infrastructure required are propellants, fuel cell reactants, and life support consumable. Innovative technologies and approaches are sought related to ISRU processes associated with collecting, separating, pressurizing, and processing gases collected from in-situ resources including the Mars atmosphere, trash processing, and volatiles released from in-situ soil/regolith resources, into oxygen, methane, and water. State of the art (SOA) technologies for these ISRU processes either do not exist or are too complex, heavy, inefficient, or consume too much power. The innovative technologies and process sought must operate in low and micro-gravity environments, must be scalable from low demonstration processing and production flow rates of 0.045 kg/hr of carbon dioxide (CO_2) and 0.015 kg/hr of oxygen (O_2) to utilization flow rates of 2.25 kg/hr for CO_2 and 0.75 kg/hr for O_2. Chemical processing technologies must operate between 15 to 75 psia.

Technologies of specific interest include:

- Regenerative dust filtration, especially Mars dust, that is: scalable, has minimum pressure drop, can operate at low inlet pressures, and provides 99% @ 0.3 um collection efficiency, with >95% regeneration capability for multiple cleaning cycles. SOA filters are replaced by the crew or sized for the complete mission. Since Mars ISRU operations will occur without a crew present and between 100 and 480 days in duration, cleaning and regeneration of filtration approaches is required.

- Dust/particle measurement device that allows for size and particle density measurements before and after filtration. Optional additional capabilities including electrostatic and or mineral characterization are also of interest. Dust measurement devices must integrate into limited volume areas and interface with atmosphere-inlets/trash processing outlet tubing.
- Lightweight, low-power device to deliver fresh Mars 'air' (0.1 psia) to the plant with small head pressure capability (10's torr). SOA blowers currently do not exist which can effectively move the low pressure Mars atmosphere efficiently (power and mass) for long-periods of time. Thermal management and/or use must be clearly defined for proposed devices.
- Lightweight, lower power device to collect and pressurize CO_2 from 0.1 psia to >15 psia; maximum 75 psia. SOA mechanical compressors are heavy, power intensive, and have limited life. Mars atmosphere CO_2 collection devices will need to operate for a minimum of 100 days and up to 480 days. Thermal management and/or use must be clearly defined for proposed devices.
- High throughput water separation from gas streams. SOA devices utilize water tanks and chillers which are potentially large, heavy, and power intensive. Highly efficient, low power, and compact membrane and adsorption based separation devices allowing for very low dew point exhaust are sought.
- High throughput carbon monoxide/carbon dioxide separation and recycling concepts for processes with only partial conversion of CO_2 into usable products. Highly efficient, low power, and compact membrane and adsorption based separation devices are sought with minimum pressure drop.
- Highly efficient chemical reactors and heat exchangers based on modular/stackable microchannel plate architectures. SOA catalyst bed type reactors are inefficient in mass and volume and are not easily scalable to higher processing rates without reactor bed redesigns and thermal management changes. Thermal management and/or use must be clearly defined for proposed devices.

Proposals must identify and provide clear benefits compared to state of the art technologies and processes in the areas of mass, volume, and/or power reduction as well as define the expected impact of changing gravity orientation and strength. SOA for most processing technologies are terrestrial applications or space life support systems. Phase I proposals for innovative technologies and processes must include the design and test of critical attributes or high risk areas associated with the proposed technology or process. Phase II proposals must further Phase I efforts leading to the design, build, test, and delivery of hardware (at rates specified above) that can be integrated into breadboard ISRU systems for testing with other technologies and processes (Technology Readiness Level 4 to 6).