NASA SBIR 2014 Phase I Solicitation

H3.02 Atmosphere Revitalization and Fire Recovery for Future Exploration Missions

Lead Center: MSFC

Participating Center(s): ARC, GRC, JSC, KSC

This topic seeks to develop targeted process technologies and equipment to advance the operability and reliability of atmosphere revitalization (AR) subsystems that enable crewed deep space exploration objectives.

Highly reliable AR subsystem equipment and process technologies, supplemented by atmosphere decontamination equipment and methods, are necessary components to crewed deep space exploration mission success. While the International Space Station (ISS) AR subsystem equipment approaches many of the functional goals necessary for deep space exploration mission success, flight operational experience has identified areas for improvement in resource recovery and rapid atmosphere decontamination capabilities. Technologies related to resource recovery include gas compression and management as well as gas separations. Rapid atmosphere decontamination capabilities are needed to remove the functional burden for recovering from a contamination event, such as a fire or chemical spill, from the primary AR subsystem equipment. Details in each functional area of interest are provided by the following:

- *Gas Compression and Management* - NASA is seeking safe, compact, quiet, long-lived, and efficient ways to compress, store, and deliver gaseous oxygen and carbon dioxide within an AR subsystem. Also, methods to store, condition, and deliver reactant gases, primarily carbon dioxide, to carbon dioxide reduction process equipment are sought. Present AR equipment aboard ISS consists of power-intensive, noisy compressors that have service lives less than 2 years. Significant acoustic treatment is necessary to achieve NC-40 criteria. Applications for deep space exploration missions include but are not limited to production of high pressure oxygen for EVA use, and compression and storage of carbon dioxide for use in carbon dioxide reduction systems. Improvements in service life, reliability, and mechanical compression for atmospheric gas recharge to pressures up to 3,600 psia, including long life and reliability, and novel methods to increase tank storage capacity at lower pressures are of particular interest.
- *Hydrogen Purification for Resource Recovery* - Resource recovery and recycling is an enabling functional area for the AR subsystems needed for long-duration missions. For this purpose, NASA is interested in a regenerative separation technology to enable maximum hydrogen recovery from a stream containing water vapor (saturated), carbon monoxide (CO), and hydrocarbons including methane, acetylene, ethane, and ethylene, among others. While a high quantity of methane in the hydrogen product stream is acceptable, and even desirable, the presence of CO, water, and other hydrocarbons is highly undesirable. Final gas composition must be >99% hydrogen with some allowable methane and the dewpoint must be less than -60 °C. System concepts must strive to minimize power, mass, and consumable requirements while maximizing efficiency, operational life, and reliability.
- *Post-Fire Cabin Atmosphere Cleanup* - A portable, self-contained fire and toxic atmosphere cleanup system is desired that can rapidly remove contaminants from a spacecraft volume, to quickly and effectively decontaminate cabin atmosphere after a fire. The capability to reduce starting concentrations by >80% within 15 minutes for a 100-m^3 volume is desired. Methods have involved either deploying a filter assembly

to the commode after a fire and using the commode fan as the source of airflow or attaching a series of filters to a portable fan using an adapter kit. Both methods result in low atmospheric scrubbing flow rates and significant time for deployment as well as limited capacity and non-specific scrubbing. Russian-provided portable equipment aboard the ISS provides 65 m^3 /h flow through a replaceable cartridge. The equipment's mass is 17 kg and the power consumption is 150 W. Filter service life is 7.5 hours. The dimensions are approximately 33 cm diameter and 35 cm tall. Future equipment must provide the rapid contamination reduction within the characteristic size and performance envelope of the Russian-developed portable scrubbing device.

For each technical area, projects are sought to research and demonstrate technical feasibility during Phase I that will develop a clear technical maturation path towards Phase II hardware development and demonstration. Phase II products must include a demonstration unit suitable for testing by NASA.

Phase I Deliverables - Documentation, data, and feasibility assessment proving the proposed approach is suitable to develop the proposed product (at least TRL 3 at completion according to NPR 7123.1 TRL definition). A breadboard developmental unit is desirable.

Phase II Deliverables - Functional engineering development unit at a minimum high fidelity breadboard (brassboard fidelity preferred), defined by NPR 7120.8, and technical maturity level 4 (TRL 4 defined by NPR 7123.1) of the proposed product, along with a full report of developmental and performance results, including drawings, analyses, and models as applicable. Opportunities and plans should also be identified and summarized for potential commercialization.