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

NASA STTR 2018 Phase I Solicitation

T6.01 Innovative Solutions to Carbon Dioxide Removal for Spacecraft, Surface Systems, and EVA Systems

Lead Center: JSC

Participating Center(s): ARC, MSFC

Technology Area: TA6 Human Health, Life Support and Habitation Systems

Technology advancements in Extra-Vehicular Activity (EVA) and spacecraft cabin life support systems are required to enable forecasted microgravity and planetary human exploration mission scenarios and to support potential extension of the International Space Station (ISS) mission beyond 2020.

Providing cost effective, efficient and reliable carbon dioxide removal for human space applications has been a challenge. The state-of-the-art zeolite-based system currently in use in for closed-loop atmosphere revitalization on the ISS has suffered from the production of fines, resulting in the need for frequent maintenance. Vacuum-based swing bed systems for potential use in the Portable Life Support Systems (PLSS) used in EVA space suits will not be effective in the Mars surface environment due to the partial pressure of carbon dioxide in the Mars atmosphere. Both solutions become less efficient if the inlet partial pressure of CO_2 from the crew environment is reduced.Â Novel solutions are sought for applications including Spacecraft, Surface Systems, and EVA Systems.

Advanced Extravehicular Mobility Unit (EMU)

Technologies are sought for continuous CO_2 and relative humidity removal capability that can operate within space vacuum and Martian atmospheres (0.6 kPa, or 4.5 torr). Examples of advancements sought include:

- Improvements in sorbent CO_2 and H_2O uptake leading to smaller, more efficient beds.
- Providing for independent control and selectivity for CO_2 and water vapor.
- Consideration for alternative process technologies, including but not limited to metal organic frameworks, ionic liquids, other liquid sorbents and supported structures, or selective permeable membranes.
- Novel systems integration and enhancements, such as using efficient boost compressors that may enable pressure swing operation in the Martian atmosphere, or temperature swing cycles that do not place a large power burden on the EMU.

Systems for Spacecraft Cabin and Surface Systems

Currently state-of-the-art CO_2 removal systems are large and power intensive. Alternative systems have been proposed, including but not limited to, metal organic frameworks, ionic liquids and liquid sorbents, structured or other alternative solid sorbents, selective membranes, electrochemical separation, etc. Many of these novel alternative technologies are at a low TRL and require additional research and development to prove the concepts, especially at the low partial pressures required for use in the cabin environment. Improvements are sought in the following areas:

- Improvements in sorbent CO_2 capacity and selectivity leading to smaller, more efficient components, lower energy consumption and operation at lower CO_2 partial pressures.
- Increases in the robustness of sorbent materials to mechanical stresses, temperature and humidity changes, or poisoning.
- Advanced and novel methods to increase the efficiency of temperature and pressure swing adsorption processes.
- Innovations and improvements in capillary structures and gravity insensitive frameworks for containment and management of ionic liquids and liquid sorbents.

NASA is especially interested in systems that can be incorporated into closed loop life support systems that recycle CO_2 and humidity, and could achieve the following performance targets.Â These parameters address the full system, including fans, valves, heat exchangers, etc.):

- Removal rate of 4.16 kg/day (a four-person load).
- Operate in an environment with 2.0 mmHg ppCO_2 for cabin applications (based on the daily average ppCO_2).
- System size **â‰¤**0.3 cubic meters for the 4-person load.
- System power use **â‰¤**500 watts of power for the 4-person load.
- System mass of **â‰¤**100 kilograms for the 4-person load.
- Effectively separate out water vapor (less than 100 ppm water vapor in the CO_2 product is desired).
- Effectively separate out oxygen and nitrogen (less than 1% O_2 and 2% N_2 by volume in the CO_2 product is desired).

Phase I Deliverables - Detailed analysis, proof of concept test data, and predicted performance (mass, volume, thermal performance) addressing inlet partial pressures of CO_2 below and above 2 mmHg, with description of regeneration requirements, especially relationship to Mars atmosphere vacuum. Deliverables should clearly describe and predict performance over the state of the art.

Phase II Deliverables - Delivery of technologically mature components/subsystems that demonstrate functional performance with appropriate interfaces are required. Prototypes should be at least at a 1-crewmember scale.