NASA SBIR 2019 Phase I Solicitation

H4.01 Exploration Portable Life Support System (xPLSS) for deep space and surface missions

Lead Center: JSC

Participating Center(s): JSC

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

The current Extra-Vehicular Mobility Unit (EMU) on International Space Station (ISS) has a limited life span. NASA plans to continue using the current EMU/spacesuit for the life of ISS. Future missions being contemplated will also need a new spacesuit to meet the technology objectives. With the anticipation of a replacement suit for ISS or other future mission, the plan for an Exploration EMU (xEMU) is underway. As part of the xEMU, an Exploration Portable Life Support Subsystem (xPLSS) is currently being developed, integrated, and tested in house at JSC. Technology gaps remain for the xPLSS especially for deep space and surface missions. The first focus area is for small, radiation hardening (Rad-Hard), isolated direct current (DC) to DC (DC/DC) converters with an efficiency of greater than 80 percent (%) which would be helpful in low-earth orbit as well as deep space. The second focus area is for a boost compressor to enable the xPLSS pressure swing adsorption (PSA) carbon dioxide (CO_2) and water (H_2O) removal system to function in a partial atmosphere which exists on Mars. The boost compressor would be helpful in a surface mission to Mars. Based on these xPLSS technology gaps, the two focus areas are specifically detailed below for the SBIR 2019 solicitation cycle:

Small, Rad-Hard, Isolated DC/DC Converters with an Efficiency of >80%

For spacesuit life support systems, there are a number of small point of load applications such as smart instruments, controllers, etc. that require small, low power output, isolated DC/DC converters. With derating and the limited offering available from existing catalog parts, the available efficiency is often much lower than the rated efficiencies advertised for the part of 70-80% as the converter losses become a larger part of the overall output dropping the realized efficiencies below 65%. Develop a converter family with the following attributes:

- Power output families: 500mW, 1W, 2W, 5W:
  - The Electrical, Electronic, and Electromechanical (EEE) and Mechanical Parts Management and Implementation Plan for Space Station requires derating depending on the implementation that can range from 0.5-0.75 permissible of rated power output
- Input voltage: 34VDC max, 28VDC nominal
- Output voltages: Variable set by resistor with 1.5-15 VDC range minimum
- Regulation accuracy < 1%
- Converter efficiencies: >80% after EEE derating
- Total dose: >30 krad (Si)
- Single Event Latch (SEL) immune to 60 MeV-cm^2/mg
- Single Event Upset (SEU) errors less than 10^{-2} events/2000 hrs operating time
- Overcurrent protection, set by a resistor
- Over-temperature protection – shutdown

- Under-voltage lockout
- Soft-start, set by capacitor
- Packages: hermetically sealed flatpacks
- Options: programmable switching frequency, set by a resistor

Boost Compressor to Enable xPLSS Pressure Swing Adsorption (PSA) CO_2/H_2O Removal Function in Partial Atmosphere

The state of the art with respect to continuously regenerable carbon dioxide (CO_2)/water (H_2O) removal functions small enough to deploy in a spacesuit life support system is the amine swingbed using pressure swing adsorption. The current xPLSS system design planned for xEMU Demonstration on ISS will function in 1-2 torr condition. However, the current xPLSS amine swingbed system cannot function in the martian environment. Therefore, develop a boost compressor that can meet the following basic performance goals in a partial environment:

- Outlet Pressure: 0.2-9 torr
- Robust outlet pressure tolerance: System integration via pressure switches and valving can preclude outlet pressures higher than the 9 torr listed above. However, a concept with tolerance of pressures up to 15.2 psia would greatly simplify the integration and potentially produce a more reliable system.
- Inlet Pressure: 5 psia down to 0.1 torr
- Robust inlet pressure: System integration via pressure switches and valving can preclude inlet pressures higher than the 5 psia listed above. However, a concept with tolerance of pressures up to 19.5 psia would greatly simplify the integration and potentially produce a more reliable system.
- Effective pumping Speed > 600 lpm
- Constituents in the flow: oxygen (nearly 100% at initial opening of the bed), CO_2, H_2O, ammonia (NH_3) Motivation from 28VDC (nominal) input BLDC Stepper motor
- Structure born vibration needs to be minimized
- Conduction cooling for waste heat
- Operational life > 5000 hours

Phase I products: By the end of Phase I, it would be beneficial to have a concept design for infusion into the xPLSS. Testing of the concept is desired at this Phase.

Phase II products: By the end of Phase II, a prototype ready for system-level testing in the xPLSS or in a representative loop of the xPLSS is desired.

The xPLSS Subtopic is relevant to the xEMU Project, Human Exploration and Operations Mission Directorate (HEOMD), International Space Station, and Gateway for space suit development. More focused development beyond SBIR could come through Space Technology Mission Directorate (STMD).

The transition from the current Extravehicular Mobility Unit (EMU) to a new Exploration EMU (xEMU) for deep-space missions will necessitate a relevant demonstration of critical life support capabilities including scarring for upgrades to a full xEMU functionality. As the strategy for human space exploration beyond low-Earth Orbit (LEO) progresses, the plan for an Exploration xEMU flight demonstration suit on ISS in the mid-2020s will offer flexibility and adaptability to accommodate several potential outcomes. The progressive development, integration, and testing to prepare for a flight demonstration unit will enable a technical path to the current EMU replacement or a deep-space exploration Extravehicular Activity space suit or both.

The expected TRL for this project is 2 to 4.