NASA SBIR 2018 Phase I Solicitation

H4.01 Advanced Space Suit Portable Life Support System (PLSS)

Lead Center: JSC

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

NASA plans to continue using the current EMU/spacesuit for the life of ISS. However, with the anticipation of a replacement suit for ISS or other future mission, the plan for an Advanced EMU is underway. Technology gaps remain for the PLSS. The following is a list of technology focus areas specifically for the Advanced PLSS:

- *Continuous trace contaminant removal capability* - Activated charcoal is the state of the art and provides a logistics impact to future missions. The primary trace contaminants to remove include ammonia (NH_3), carbon monoxide (CO), formaldehyde (CH_2O), and methanethiol (also known as methyl mercaptan) (CH_3SH). The minimum objective would be to remove all of the significant compounds that threaten to exceed the 7-day SMAC[2] during an EVA. For continuous removal, the most advantageous integration with the current state of the art CO_2/H_2O removal system would be integrated such that regeneration or desorption occurs with a pressure swing from 4.3 psia to <1 torr over a ~2min period half-cycle at temperatures in the 60-80° F range. A small amount of heat flux is available from the cross-coupled adsorbing bed; additional heat input requirements from resistance heaters, etc. would negatively impact the system trade the more significant the value becomes.
- *Small, oxygen compatible gas flow meter for suit operations* - Small, oxygen compatible gas flow meter for suit operations: The current state of the art for flow measurement on the ISS EMU space suit is a flapper valve attached to a microswitch which is limited to a single set-point. The accurate measurement ranges required for the sensor are 2-8 acfm +/- 1% with a pressure drop of less than 0.68 in-$H_2$0 in a 100% oxygen (O_2) environment (traces of NH_3, H_2O, CO_2); suit pressure from 3.5-25 psia, temperature from 50-90° F, relative humidity (RH) 0-50%, and CO_2 from 0-15mmHg. This flow meter needs to fit within a volume/shape factor of approximately 2.5 in x 1.5in x 3in or less including fluid ports and electrical connectors; if added as an in-line flow, 1 in inlet/outlet porting will be necessary. Operating life objective is 8 years without calibration and 5000 hours of powered operation.
- *Small hermetic micro switch* - Current state of the art is 3-5 times larger than needed. Honeywell MicroSwitch HM-1 series is a typical state of the art. Combining Single Pole Double Throw (SPDT) circuits that add additional toggle mechanisms would further grow the size of the switch. Hermetic is defined as leakage <10-8 atm-cc/sec. Switching currents for these switches are signal level at <500mA.
- *Multi-gas monitoring within the suit* -Multi-gas monitoring: Advanced suit could benefit from measuring Oxygen (O_2), carbon dioxide (CO_2), water (H_2O), ammonia (NH_3), carbon monoxide (CO), formaldehyde (CH_2O), methanethiol (also known as methyl mercaptan) (CH_3SH), etc. The measurement of trace contaminants becomes even more important if an alternate approach (e.g., pressure or temperature swing adsorption) to the traditional activated charcoal cartridge is used. There is a need to measure the following major constituents and trace contaminants ranges in the gas stream across a total pressure range of 3.5 – 23.5 psia and temperature range of 35-125F: O_2 = 20-100%; CO_2 = 0-30 torr over 3.5-23.5 psia; H_2O = 5-90% RH; NH_3 = 0-50 ppm; CO = 0-400 ppm; CH_2O = 0-5 ppm; and CH_3SH = 0-5 ppm.
- *Power* -Current state of the art is lithium-ion batteries with cell level energy densities of 200 W-h/kg but

packaged energy densities of ~130W-h/kg after addressing mitigation for thermal runaway. Safe, high-energy density power sources are needed which are rechargeable post-EVA.

- *Heat Transport Improvements* - Several improvements are needed in this focus area including:
  - Improvement in the Liquid Cooling and Ventilation Garment (LCVG) state of the art.
  - Improvement in the UA such that warmer water can be used to sink the waste heat from the human and hence reduce the evaporator size.
  - Drastically alter the human-to-cooling loop interfaces such as a fluid-filled suit with directly pumped cooled water.
  - Alter the Thermal Micrometeoroid Garment (TMG) such that the emissivity/absorptivity can be dynamically altered to improve thermal.
- *Human-Machine Interface Improvements* - Current state of the art for this focus area includes mechanical switches and a 16 x 2 Liquid Crystal Display (LCD). Low power, wide thermal range, rad tolerant high definition graphics displays that can be integrated with the suit soft goods or hard goods such as heads-displays.

These technology gaps were detailed during the 2017 SBIR/STTR Industry Day (https://sbir.nasa.gov/events/sbir-industry-day).

Phase I Products - By the end of Phase, it would be beneficial to have a concept design for infusion into the Advanced PLSS. 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 PLSS or in a representative loop of the PLSS is desired.