H4.07  Low Volume, Power and Mass CO2 and Humidity Control for xEMU

Lead Center: JSC

Scope Title: Spacesuit CO2 and Humidity Control for xEMU (SBIR)

Scope Description:

This solicitation is seeking to identify sorbent candidates that will compete with or outperform the current baseline sorbent technology used within the Exploration Extravehicular Mobility Unit (xEMU) for carbon dioxide (CO\textsubscript{2}) and humidity control. It is desired that sorbent candidates meet or exceed the characteristics and goals listed below.

Key goals for sorbent characteristics and performance:

- 600- to 1,000-µm-sized beads.
- Vacuum desorb technology (desorb at a pressure of 140 Pa).
- CO\textsubscript{2} loading uptake (noncyclic) 25 °C, 8 mmHg CO\textsubscript{2}, 10 °C dewpoint, 6.0 g CO\textsubscript{2}/100 g sorbent.
- H\textsubscript{2}O loading uptake (noncyclic) 25 °C, 15 °C dewpoint, 7.0 g H\textsubscript{2}O/100 g sorbent.
- Uptake (cyclic) 25 °C, 8 mmHg CO\textsubscript{2}, 10 °C dewpoint, 2.0 g CO\textsubscript{2}/100 g sorbent at 2 to 3 minute half-cycle timing (e.g., adsorb for 2 minutes/desorb for 2 minutes).

In order to ensure the safe operation of the xEMU, CO\textsubscript{2} and humidity levels need to be controlled to levels in accordance with requirements established by the NASA medical community. The technology currently baselined for the xEMU is the Rapid Cycle Amine (RCA) technology and information on the RCA is also available in the reference section below. New technology alternatives to the RCA are desired in order to have a robust suit program that is able to fall back on alternate technologies if the need arises.

For the majority of an extravehicular activity (EVA), the CO\textsubscript{2} partial pressure required at the breathing gas inlet to the helmet of the spacesuit needs to be maintained at or below 2.2 mmHg when the astronaut is generating 2.44 g/min of CO\textsubscript{2}. The flow rate of the oxygen ventilation loop that circulates the breathing gas from the suit, through the CO\textsubscript{2} and humidity removal unit and back to the helmet of the suit is maintained at 6 ft\textsuperscript{3}/min.

The driving humidity requirement is to maintain the relative humidity of the breathing gas flowing into the helmet between 5 and 45% with the water vapor production level of 0.2 lb/hr and 6 ft\textsuperscript{3}/min ventilation flow rate through the suit. The CO\textsubscript{2} and humidity control unit should also be able to handle situations where the generation rates are higher during shorter periods as described in the detailed requirements listed in the references section.

The goals for the mass of alternate technology units to be less than 14 lb, the volume to be less than 0.4 ft\textsuperscript{3}, and the power consumption to be less than 1.4 W on average.

This subtopic is relevant to the xEMU, International Space Station (ISS), Gateway, and human landing system (HLS), as well as other endeavors currently in development by commercial space companies. The goal is to have...
proposed solutions to be designed, built, integrated and tested at Johnson Space Center and integrated into the xEMU. These solutions have the potential for a direct infusion path as the xEMU is matured to meet the design and performance goals.

**Expected TRL or TRL Range at completion of the Project:** 3 to 5

**Primary Technology Taxonomy:**
Level 1: TX 06 Human Health, Life Support, and Habitation Systems
Level 2: TX 06.2 Extravehicular Activity Systems

**Desired Deliverables of Phase I and Phase II:**

- Prototype

**Desired Deliverables Description:**

Phase I products: By the end of Phase I, it would be beneficial to have candidate sorbent(s) identified that meet the goals listed for this solicitation. Testing of sorbent candidate is required at this Phase.

Phase II products: By the end of Phase II, testing of sorbent in the xEMU equivalent application and conditions is desired. Vendors may collaborate with research institutes if desired.

**State of the Art and Critical Gaps:**

The current state-of-the-art utilized on the ISS EMU is a metal oxide technology that requires astronauts to remove the unit from the PLSS, regenerate it in an oven, and reinstall it into the PLSS prior to the subsequent EVA.

The baseline xEMU technology provides regenerative CO₂ and humidity removal via a pressure swing adsorption system with a high-capacity sorbent that desorbs upon exposure to vacuum and requires little to no maintenance by the astronaut. This technology is well developed, but unparalleled. Ultimately, this solicitation is an attempt to lead to an alternate CO₂ and humidity removal system with regenerable capabilities requiring minimal astronaut maintenance to provide options for the new xEMU should unforeseen issues arise with the current technology. Additionally, xEMU has goals of reducing power draw, volume envelope, and mass while maintaining the current CO₂ and humidity removal capacity at the conditions described previously.

**Relevance / Science Traceability:**

It is relevant to the new xEMU, ISS, as well as commercial space companies. As the xEMU is being designed, built, integrated, and tested at Johnson Space Center, solutions will have a direct infusion path as the xEMU is matured to meet the design and performance goals.

**References:**

1. ICES-2016-073 Design and Development Comparison of RCA 1.0, 2.0, and 3.0 ([Design and Development Comparison of Rapid Cycle Amine 1.0, 2.0, and 0](tdl.org))
2. ICES-2019-400 RCA Testing History ([Rapid Cycle Amine Testing History](tdl.org))