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

NASA SBIR 2021 Phase I Solicitation

H4.05 Advancements in Water and Air Bladder Assemblies and Technology

Lead Center: JSC

Scope Title:

Advancements in Feedwater Supply Assembly Technology

Scope Description:

The current technology for the Feedwater Supply Assembly (FSA) has many challenges to overcome including material durability and water capacity. Therefore, new innovative ideas and solutions are sought. The FSA will be integrated into the Exploration Extravehicular Mobility Unit (xEMU) Portable Life Support System (PLSS) and contained in the suit hatch compartment. The hatch volume is not a uniform shape and the current design uses cylindrical bladders which are not capable of optimizing water volume quantities. Additionally, many challenges exist in the material currently used for the FSA bladders. This material is known for its ability to maintain cleanliness and sterility; however, when made into these particular bladders, material failure and leakages are common at low cycle counts when tested as a pressurized system. NASA has plans to go to the Moon and as the mission extends further out of low Earth orbit, durability and extensibility will become some of the most important requirements as well.

The FSA shall be a sterile compliant bladder, capable of storing ultrapure feedwater with a relatively high-cycle life when pressurized. In order for the thermal control loop to operate properly, a water source is needed. A volumetrically adaptable, sterile, and durable feedwater bladder is essential. The suit pressure acts on this bladder and as water evaporates, the bladder resupplies the loop. The bladder must be clean and not leak particulates or polymer chains into the water over long periods of quiescence. The maximum design pressure (MDP) for the system will be 35 psid with a nominal operating pressure of 15 psid. These bladders will be reused in a fill-drain-refill = 1 cycle environment. The current cycle life requirement is 696 cycles per bladder. Additional requirements are captured in the reference located at the following link: https://ntrs.nasa.gov/search.jsp?R=20190033446. Having a bladder with these qualities not only buys down the safety risk of rupture, it promotes reliability at higher pressures and provides an avenue to extend Extravehicular Activity (EVA) length.

This subtopic is relevant to the xEMU, International Space Station (ISS), as well as commercial space companies. The goal is to have proposed solutions to be designed, built, integrated, and tested at the Johnson Space Center and integrated into the xEMU. These solutions have the potential for a direct infusion path as the PLSS 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 a concept design for infusion into the Exploration Portable Life Support System (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 PLSS is desired.

State of the Art and Critical Gaps:

As the design for the new xEMU is developed, there are obvious gaps in technologies, which need to be fulfilled to meet the new exploration requirements. The FSA is at a stall in technology development and requires new innovative ideas. This solicitation is an attempt to seek new technologies for the FSA. NASA has plans to go to the Moon and as the mission extends further out of low Earth orbit, durability and extensibility will become some of the most important requirements.

Relevance / Science Traceability:

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

References:

Feedwater Supply Assembly Requirements are located at the following links:

1. Feedwater Supply Assembly (FSA 431) requirements are located at the following link: https://ntrs.nasa.gov/search.jsp?R=20190033446
2. Auxiliary Feedwater Supply Assembly (FSA 531) requirements are located at the following link: https://ntrs.nasa.gov/search.jsp?R=20190033446

Note to offeror: The following two drawings referenced in the requirements shall be provided if offeror is selected for award.

1. Feedwater Supply Assembly (FSA 431) Drawing SLN 13102397
2. Auxiliary Feedwater Supply Assembly (FSA 531) Drawing SLN 13102398

Scope Title:

Advanced Pressure Garment Bladder Materials

Scope Description:

The current pressure garment bladder in the legacy space suit is a urethane-coated Oxford-weave nylon. This bladder material serves as the gas bladder of the space suit and, along with the restraint material, comprises the pressure garment bladder/restraint assembly which is sized and patterned to accommodate both anatomical movement and a range of sizing. The bladder is patterned using heat sealing or radio-frequency (RF) welding techniques. While this material has been acceptable for many years, there are known deficits. The urethane coating has high tack and can result in excessive friction against the skin. Embossing or flocking of the bladder, while not significantly increasing weight, may be viable solutions to this issue, although there may be others.

In addition, the current bladder needs to be manually wiped with biocide after each Extravehicular Activity (EVA) to prevent microbial growth. This contributes to crew overhead time and may be challenging with advanced suit architectures on the Moon which inhibit routine access to all bladder locations. An antimicrobial treatment or coating on the air-tight side of the pressure bladder will improve long-term performance of the Pressure Garment System (PGS) and reduce crew time and consumables.

Lastly, while the bladder material is sufficiently strong to contain the pressurization loads of the suit in the event that the restraint layer experiences catastrophic failure, it is not impervious to damage itself through puncture from a sharp edge/corner or from an incoming micrometeorite, impacting mission success and/or crew safety. As such, a self-healing bladder could mitigate this risk and provide a more robust bladder/restraint system in the next-generation suit assembly.

In addition to one or more of the aforementioned design goals, a successful solution should also meet all of the following requirements:

1. The bladder material is capable of being bonded together into gore or convolute patterns without the use of an adhesive;
2. The bladder material bonded seams shall have a bond strength of at least 85 lb/in;
3. The bladder material shall not leak more than 3.9×10^{-8} lbm/hr-in^2 of oxygen at 4.3 psid.

This subtopic is relevant to the Exploration Extravehicular Mobility Unit (xEMU), International Space Station (ISS), as well as commercial space companies. The goal is to have proposed solutions to be designed, built, integrated, and tested at the Johnson Space Center (JSC) 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 a concept design for infusion into the xEMU. 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 xEMU or specific to Pressure Garment Bladder is desired.

State of the Art and Critical Gaps:

As the design for the new xEMU is developed, there are obvious gaps in technologies, which need to be fulfilled to meet the new exploration requirements. This solicitation is an attempt to seek new technologies for the Pressure Garment Bladder. NASA has plans to go to the Moon and as the mission extends further out of low Earth orbit, durability and extensibility will become some of the most important requirements.

Relevance / Science Traceability:

This may be relevant to the xEMU, ISS, as well as commercial space companies. As a new xEMU PGS is being designed, built, and tested at JSC, solutions will have a direct infusion path as the xEMU is matured to meet the design and performance goals.

References:

Note to offeror:

Sample drawings of patterned gore and/or convolute bladder assemblies shall be provided if offeror is selected for award.