NASA STTR 2016 Phase I Solicitation

T6.01 Space Suit Environmental Protection Garment Materials and Technologies

Lead Center: JSC

Pressure garments designed for long-duration exploration missions require new Environmental Protection Garments (EPGs) to address the environments and use conditions to which they will be subjected. The EPG on the Apollo A7LB spacesuit was required to only tolerate a few days of working in a dusty environment whereas the surface mission on Mars will last for up to 500 days with routine EVAs.

An EPG is a lay-up of materials that protect the inner layers (bladder and restraint) of the pressure garment. Environmental protection functions of the EPG include protection from: thermal extremes; secondary ejecta; cuts and punctures; abrasion and wear from dust; durability with respect to cycle fatigue and radiation exposure; and resistance to chemical corrosion. The layers of the EPG work together as a system to address all of these functions.

To date, very limited effort has been focused on developing the EPG. If new materials are required it is anticipated that a development effort of up to 10 years may be necessary to reach TRL 6, making EPG technology a schedule driver for exploration. Materials that are immediately applicable will be offered to the ISS space EMU subsystem manager for potential incorporation.

The challenges being addressed with this call include dust mitigation, cut and puncture resistance, and cycle life:

- *Dust Mitigation* - Dust mitigation can be addressed on one or both of two fronts: dust repellant (keep dust from penetrating) and dust resistance (dust doesn't degrade performance). Protection from both lunar and Martian regolith and from the full range of particle sizes of the regolith is of interest. Materials that are resistant to the potentially corrosive chemical products resulting from Mars regolith combining with oxygen and/or water vapor. Unique methods of fabrication and of design to limit the intrusion of dust at breaks between sections of the EPG (such as between the lower arm and shoulder sections of the EPG) are included.
- *Cut and punctures* - Current ISS EMU materials have proven susceptible to cuts from sharp edges on hand rails. Exploration suits will be handling rocks, dirty tools, and other abrasive and rough surfaces.
- *Durability* - EPGs will see hundreds of thousands to millions of cycles as the joints of the space flex as crewmembers walk, grasp, and use tools. Materials need to be highly durable to withstand the cycles of joint flexion in the thermal, dust and radiation environments on planetary surfaces.

Additionally, the goal of the EPGs design is to improve performance on all fronts. When the ISS EMU glove design was changed to increase durability against sharp edges, its mobility was reduced. The EPG dust mitigation, for example, that protects the suit bladder from dust will also have minimal impact (less than 10%) on suit range of motion and torque.

This call seeks innovative materials and creative approaches for both individual layers of the EPG as well as full EPG lay-ups, as well as, EPG system level dust mitigation approaches.

Research done in Phase I of these efforts should focus on technical feasibility with an emphasis on hardware development that can be further expanded in a future Phase II award cycle. Phase II products must include a demonstration unit suitable for testing by NASA. Prototyping should be tailored to applications to ongoing HEO Mission Directorate missions and possible collaborative use in both the governmental and commercial manned spaceflight disciplines. Minimum deliverables at the end of Phase I are analysis and/or test reports, with priority given to functional hardware prototypes for further evaluation. Technical maturation plans should be submitted with Phase I submittals, as well as any expected commercial applications both internal and external to the manned spaceflight enterprise.