



NASA STTR 2016 Phase I Solicitation

T6 Human Health, Life Support and Habitation Systems

Human Health, Life Support and Habitation Systems, includes technologies necessary for supporting human health and survival during space exploration missions and consists of five technology subareas: environmental control and life support systems and habitation systems; extravehicular activity systems; human health and performance; environmental monitoring, safety, and emergency response; and radiation. These missions can be short suborbital missions, extended microgravity missions, or missions to various destinations, and they experience what can generally be referred to as “extreme environments” including reduced gravity, high radiation and UV exposure, reduced pressures, and micrometeoroids and/or orbital debris.

Subtopics

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 repellent (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.

T6.02 Space Radiation Storms: Monitoring, Forecasting and Impact Analysis

Lead Center: GSFC

Radiation hazards constitute one of the most serious risks to future human and robotic missions beyond Low-Earth Orbit, and particularly to long-duration, long-distance space missions. The main contributors to space radiation are Galactic Cosmic Rays (GCRs) and Solar Particle Events (SPEs). The latter is the more unpredictable of the two and is associated with most energetic solar eruptions: flares and coronal mass ejections; at the same time, SPEs are capable of inducing acute and profound effects on humans and on spacecraft components. The goal of the current opportunity is to help address the challenges by focusing on investigations that can potentially lead to longer-range (2-3 days) forecasting of SPEs (or at least an improved all-clear SPE forecasting capability), as well as those which couple radiation environment models with engineering models of radiation effects so that single-event effects on specific hardware and instruments can be predicted.

State of the Art

Many questions regarding space radiation have yet to be answered, and numerous challenges remain, such as improving the forecasting capability of the dynamic radiation environment (particularly SPEs), coupling the radiation environment models with engineering models of radiation effects on specific instruments or spacecraft hardware, and achieving a quantitative measure of human or space assets' response to radiation storms.

What is the compelling need for this Subtopic?

Penetrating particle radiation from SPEs adversely affect aircraft avionics, communication and navigation, and potentially the health of airline crews and passengers on polar flights. SPEs also constitute major hazards for astronauts performing EVAs (Extra-Vehicular Activities) on board the International Space Station (ISS). Characterizing and predicting the dynamic variation of the radiation environment is a crucial capability, enabling personnel to take preventive measures to mitigate the potential risks, and facilitating adoption of the proper mitigation strategy.

STMD/NASA/NARP/National: Identified as an NRC High Priority Technology Area.

T6.03 Sustainability in Space

Lead Center: JSC

Survival in remote locations such as another planet requires conservation, smart utilization and reuse of resources and resilience, especially in the event of a failed resupply ship. Closed loop living systems such as this are also important for Earth as world population grows and natural resources decrease. This STTR subtopic seeks to advance the state-of-the-art for spacecraft habitats by “closing the loop” on materials needed to sustain life and provide energy on exploration missions, while simultaneously reducing the environmental impact of aerospace processes. Air, water and waste all need to be regenerated with highly reliable systems to reduce or eliminate the need to launch more materials into space as missions become longer. Energy for life support and other systems can also be obtained from renewable energy sources or waste streams. Many current cleaning, manufacturing and testing processes for spacecraft also create an environmental burden that could be mitigated by new technologies. All these “green” technologies will improve sustainability in space and on Earth.

Technical innovation and unique approaches are solicited for the development of new technologies that will lower mission cost and environmental impact by conserving resources and closing the materials loop. This will enable self-sufficiency and thus longer space exploration missions. Also, technologies that conserve resources or reduce negative impact during spacecraft development are solicited to improve sustainability at NASA. Real world demonstration of the technologies should be emphasized, even in Phase I. Many areas of research are possible, but preference will be given to those that address gaps in the following areas and lead to early applications and dual use partnerships:

- *Waste Water Treatment and Reuse* - Reuse/recycling of waste water from gray and black water sources with minimal mass, power, volume and expendables is needed. A particular challenge is treatment of urine to prevent odor and fouling of systems without the use of hazardous chemicals. NASA would like to extract nearly 100% of the water from any brine that may be created by a primary processor. Easy regeneration of filter and resin elements is desirable to reduce expendables.
- *Waste Processing* – Technologies for stabilization, safening, recycling or creation of energy or useful products from feces or trash are sought. Proposed technologies must take into account relevant factors for space exploration such as resource scarcity, planetary protection and human factors.
- *Renewable Energy and use of Waste Heat* – Solar and other renewable energy technologies that apply to “closing the loop” in space and on Earth are sought. This could include high efficiency and regenerative fuel cell technologies and technologies that combine waste and water treatment with energy production. Also included are technologies that make use of waste heat from one process for another purpose.
- *Greener Ground Processing* – Many aerospace processes require chemicals that are not environmentally friendly or result in lots of waste. NASA seeks technologies that will significantly reduce environmental impacts for NASA as well as others who use similar processes. Technologies are sought that: reduce or eliminate solvent waste from precision cleaning and validation processes; improve particle removal efficiency when cleaning with supercritical fluids; combine multi step processes (such as metal cleaning and passivation) into one step with reduction of waste.

T6.04 Closed-Loop Living System for Deep-Space ECLSS with Immediate Applications for a Sustainable Planet

Lead Center: ARC

NASA’s plans to explore space beyond Low Earth Orbit will push the performance of life support systems toward closed loop living systems. Deep space missions will require life support systems that will be self-sustaining since we cannot expect to carry enough spares and consumables for year-long missions. Achieving the development of such systems will provide the understanding for managing limited availability of resources. The parallel with earth planetary resources management is ideal as the world population grows and resources and infrastructure availability decreases. We expect that technologies developed for closed loop living systems will be immediately available and applicable to provide planetary sustainability as well.

State of the Art

An immediate example of such endeavors exists in the form of the NASA Ames Sustainability Base where technologies for deep space exploration have been used to create one of the greenest buildings in the federal building inventory. These technologies include power generation with fuel cells, water recovery systems, advanced HVAC, environmental control, recyclable materials and use of local resources. Even though these technologies are readily available for deep space travel, each has its own set of challenges for adaption to earth application along with integration challenges.

Closed-loop living systems are mostly based on the thermodynamics laws of the conservation of mass and energy. We expect to maximize the conservation so that only a minimal amount of resources needs to be taken on a deep space mission.

Innovations are sought to enable:

- Transfer of deep space exploration technologies to earth applications.
- Development of integrated self-sustainable systems.
- Development of the most effective processes to allow for closed loop living applications.
- Application to so-called “off-the-grid” habitation in remote areas where infrastructure is inexistent.

Potential deliverables may include a demo of ECLSS concept(s) with clear applications to earth, enhanced control techniques of multiple life support subsystems (e.g., environment, water recovery, power usage, etc.), or prototype hardware and/or software to enable sustainability.