Advanced Extra-Vehicular Activity (EVA) systems are necessary for the successful support of the International Space Station (ISS) beyond 2020 and future human space exploration missions for in-space microgravity EVA and for planetary surface exploration. Advanced EVA systems include the space suit pressure garment, airlocks, the Portable Life Support System (PLSS), Avionics and Displays, and EVA Integrated Systems. Future human space exploration missions will require innovative approaches for maximizing human productivity. Advanced EVA system must also provide the capability to perform useful tasks safely, such as assembling and servicing large in-space systems and exploring surfaces of the Moon, Mars, and small bodies. Top-level requirements for advanced EVA systems include reduction of system weight and volume, minimization of consumables usage, increased hardware reliability, durability, operating life, increased human comfort, and less restrictive work performance in the space environment. All proposed Phase I research must lead to specific Phase II experimental development that could be integrated into a functional EVA system.

**Subtopics**

**H4.01 Space Suit Pressure Garment and Airlock Technologies**

*Lead Center: JSC*

*Participating Center(s): GRC*

Advanced space suit pressure garment and airlock technologies are necessary for the successful support of the International Space Station (ISS) and future human space exploration missions for in-space microgravity EVA and planetary surface operations. The space suit pressure garment requires innovative technologies focused on performance, environmental protection, and mass reduction. Two of the critical performance characteristics of a suit are mobility and durability. Improved mobility typically competes against durability and suit component life. Materials that enable both highly mobile and durable designs would negate the need for compromise in one of these areas. Other key suit performance enhancements include materials that enable improved fit and sizing, such as shape change materials that increase the ease of suit don/doff or facilitate adaptable fit for specific functional tasks. Space suit environmental protection includes protection from thermal extremes, vacuum, cuts, abrasion and micrometeoroid and orbital debris (MMOD). Additional environmental protection is desired for plasma, radiation, electrical shock, antimicrobials and dust. It is desirable to provide protection in as few material layers as possible; therefore, multi-functional materials are desired. Self-healing materials and materials that alert the inspector to wear/maintenance needs are also of interest. Mass reduction of the space suit system is highly desirable for many reasons, with arguably the biggest drivers being launch mass and on-back mass during EVA. New materials that can lead to reductions in suit component mass, for example, lightweight materials for bearings and hard structures, are therefore desirable.
Due to the expected large number of space walks that will be performed on the ISS beyond 2020 and during future human space exploration missions, innovative technologies and designs for both microgravity and surface airlocks will be needed. Technology development is needed to decrease the time associated with egressing and ingressing the vehicle or habitat, reducing the gas loss during depressurization, and decreasing the potential of contaminating the cabin due to bringing in dust or CO$_2$. These enhancements could be achieved with a suitport, suitlock or some type of advanced airlock.

Technology Readiness Levels (TRL) of 4 to 6 or higher are sought.

Potential NASA Customers include:

- EVA Project Office.
- International Space Station.
- Office of Chief Technologist.

**H4.02 Space Suit Life Support and Avionics Systems**

*Lead Center: JSC*
*Participating Center(s): GRC*

**Space Suit Life Support Systems**

Advanced space suit life support systems are necessary for the successful support of the International Space Station (ISS) and future human space exploration missions for in-space microgravity EVA and planetary surface operations. Exploration missions will require a robust, lightweight, and maintainable Primary Life Support System (PLSS). The PLSS attaches to the space suit pressure garment and provides approximately an 8 hour supply of oxygen for breathing, suit pressurization, ventilation and CO$_2$ removal, and a thermal control system for crew member metabolic heat rejection. Innovative technologies are needed for high-pressure O$_2$ delivery, crewmember cooling, heat rejection, and removal of expired CO$_2$ and water vapor.

**Space Suit Avionics Systems**

Future generations of advanced space suit avionics will be far superior to those on the current generation of space
suits. They will be more capable, configurable, lightweight, and low power with a footprint that will rival current consumer electronic devices, but survive the harsh space environment. They must be self-contained, so that maintenance on the devices can be performed on-orbit or they can be easily swapped for functioning or upgraded devices. Those considered will be radio, displays, and cameras.

Future advanced radios will be configurable and, potentially, software-defined and/or re-configurable to support future communications network-based architectures in addition to the point-to-point communications links that are prevalent today. The next-generation EVA radios will need to support voice, telemetry, and standard/high definition video data flows (up to 20 Mbps) and the radio architecture will need to be lightweight and power efficient while managing data in a seamless and lossless manner between multiple interfaces. Radios should support space-based or terrestrial-based protocols to enable communications between multiple entities across a communications link and have an open and modular architecture.

The current generation of Head-Mounted Displays (HMDs) and Near-to-Eye (NTE) Displays are not viable, since it is desirable for the display to be decoupled from the user's head for improved safety, comfort, and alignment. The decoupling makes the specifications for the eyebox (tolerance to misalignment before image goes out of focus), field of view (angle of the image created by the optics), and eye relief (working distance from the eye to the last optical element) difficult. Key performance targets include:

- Graphical Data Presentation: SXGA @ 40 °FOV (possibly biocular).
- Decoupled from User's Head - Large Eyebox: 100 mm x 100mm x 50mm (D).
- Sunlight Readability: 500 fL inside visor, 1800 fL outside visor (>10 to 1 contrast).

Display technologies must ensure that suit displays can operate outside the suit environment in thermal, radiation, and vacuum as well as internally without imposing ignition hazards due to 100% oxygen environment.

Cameras will not only provide the crewmember the ability for still and motion image, but also situational awareness, which enhances safety for the crewmember. The cameras should be capable of recording high definition motion and high-resolution imagery with the ability to compress the data for transmission over a variety of RF transmissions and/or IP networks with varying bandwidths. Hemispherical and dynamic cameras are desired. Dynamic cameras can take still images and motion video in variable bandwidths, capture images based on link quality, and change frame rates. Hemispherical cameras record 360 ° video views of a crewmember, distort views through optics and then undistort the views via software on the ground to pan/zoom for total situational awareness. Cameras should be low-power and lightweight with a number of mounting options for optimal placement on the suit.

Technology Readiness Levels (TRL) of 4 to 6 or higher are sought.

Potential NASA Customers include:

- EVA Project Office.
- International Space Station.
• Human Exploration Operations Mission Directorate.

• Office of Chief Technologist.