Advanced extravehicular activity (EVA) systems are necessary for the successful support of future human space exploration missions. Advanced EVA systems include the space suit pressure garment, the portable life support system, tools and equipment, and mobility aids, such as rovers. Complex missions require innovative approaches for maximizing human productivity and for providing the capability to perform useful work tasks. Top level requirements include reduction of system hardware weight and volume; increased hardware reliability, durability, and operating lifetime (before resupply, recharge and maintenance, or replacement is necessary); reduced hardware and software costs; increased human comfort; and less-restrictive work performance capability in the space environment, in hazardous ground-level contaminated atmospheres, or in extreme ambient thermal environments. Environmental protection, such as space suit radiation protection and dust mitigation technologies, are of particular interest. Innovative and highly reliable EVA communications, avionics and informatics are also of interest. All proposed Phase 1 research must lead to specific Phase 2 experimental development that could be integrated into a functional EVA system.

**Subtopics**

**X4.01 Space Suit Pressure Garment and Airlock Technologies**

*Lead Center: JSC*

*Participating Center(s): GRC*

Innovative technologies are needed to meet the challenging requirements for the exploration space suit pressure garment and surface systems airlock. These technologies should be able to be developed further for application to the lunar missions.

Specifically, the space suit pressure garment requires radiation protection technologies that protect the suited crew member from radiation particles, puncture protection technologies that provide self-sealing capabilities when a puncture occurs and minimizes punctures and cuts from sharp objects, dust and abrasion protection materials to exclude dust and withstand abrasion and prevent dust adhesion, flexible thermal insulation suitable for use in vacuum and low ambient pressure, and space suit low profile bearings that maximize rotation which is necessary for partial gravity mobility requirements, and is also lightweight and low cost.
Due to the expected large number of space walks that will be performed on the lunar surface, innovative technologies and designs for surface airlocks will also be needed. Technology development is needed for minimum gas loss airlocks providing quick exit and entry that can accommodate an incapacitated crew member, suit port/suit lock systems for docking a space suit to a dust mitigating entry/hatch in order for the space suit to remain in the airlock and prevent dust from entering the habitable environment, and active and passive space suit and equipment dust removal technologies inside and outside the airlock.

X4.02 Space Suit Life Support Systems

Lead Center: JSC
Participating Center(s): GRC

Exploration missions will require a robust, lightweight, and maintainable portable life support system. Technology development is needed for long-life and high-capacity chemical oxygen storage systems for an emergency supply of oxygen for breathing; low-venting or non-venting regenerable individual life support subsystem(s) concepts for crew member cooling, heat rejection, and removal of expired water vapor and CO\(_2\); convection and freezable radiators that will be low cost and lightweight for thermal control; innovative garments that provide direct thermal control to crew member; high reliability pumps and fans that will provide flow for a space suit but can be stacked to give greater flow for a vehicle; CO\(_2\) and humidity control devices that, while minimizing expendables, function in a CO\(_2\) environment; and a non-toxic, non-flammable, super cooled below 32°F phase change material that can absorb metabolic heat for an 8 hour duration.

Also for removing metabolic heat from the astronaut, research is needed for a variable conductance flexible suit garment that can function as a radiator for high metabolic loads and as an insulator for low metabolic loads.

X4.03 Space Suit Displays, Cameras, Controls, and Integrated Systems

Lead Center: GRC
Participating Center(s): JSC

Future exploration space suits will require innovative technologies for displaying various types of information. Technology development is needed for space suit mounted displays for use both inside and outside the space suit; outside mounted displays must be compatible with the space radiation, thermal, and vacuum environment. Examples include internally or externally mounted helmet displays and lightweight wrist or arm mounted displays.

The spacesuit will also require research for lightweight CO\(_2\), biomedical, and core temperature sensors with reduced size, increased reliability, and greater packaging flexibility; and camera systems that are lightweight, low power draw, and integrate with the spacesuit. The camera system should allow both motion and still imagery providing compressed digital data output suitable for transmission over IP networks. This camera must provide...
excellent situational awareness for crew members and quality imagery for remote viewing and public relations.

Research is also needed for lightweight, low power consuming general purpose computing platforms that are tolerant to the space radiation environment. Such platforms could be processor or FPGA based to allow the use of on-suit software applications such as biomedical advisory algorithms, procedure displays, navigation displays, and voice recognition. Technology development is needed for low computational overhead voice recognition processing systems capable of performing on lightweight radiation tolerant embedded computing platforms.