NASA SBIR 2016 Phase I Solicitation

H4 Extra-Vehicular Activity (EVA)

Extra-Vehicular Activity (EVA) and crew survival systems technology advancements are required to enable forecasted microgravity and planetary human exploration mission scenarios and to support potential extension of the International Space Station (ISS) mission beyond 2020. Advanced EVA systems include the portable life support system (PLSS) and airlock vehicle to suit umbilical system, as well as the power, avionics and software (PAS) systems. PAS includes communications, controls, and informative displays and the common suit system interfaces. More durable, longer-life, higher-reliability technologies for Lunar and Martian environment service are needed. Technologies suitable for working on and around near earth asteroids (NEAs) are needed. Technologies are needed that enable the range and difficulty of tasks beyond state-of-the-art to encompass those anticipated for exploration. Reductions in commodity and life-limited part consumption rates and the size/mass/power of worn systems are needed. All proposed Phase I research must lead to specific Phase II experimental development that could be integrated into a functional EVA system.

NASA is investing in technologies and techniques geared towards advancing the state of the art of spacecraft systems through the utilization of the ISS as a technology test bed. For technologies that could benefit from demonstration on ISS, proposals should be written to indicate the intent to utilize ISS. Research should be conducted to demonstrate technical feasibility and prototype hardware development during Phase I and show a path toward Phase II hardware and software demonstration and delivering an engineering development unit or software package for NASA testing at the completion of the Phase II contract that could be turned into a proof-of-concept system which can be demonstrated in flight.

Subtopics

H4.01 Dust Tolerant, High Pressure Oxygen Quick Disconnect for Advanced Spacesuit and Airlock Applications

Lead Center: JSC

In order to support the Extra Vehicular Activity (EVA) Systems development for more robust operation in LEO as well as enabling operation in the lunar and Martian environments, technology development is required for high pressure oxygen (3750 psia) quick disconnects. The current state of the art space suit ISS EMU Umbilical (IEU) and Service and Cooling Umbilical (SCU) connectors operate at a lower pressure and nearly zero contaminant environment. These next generation of quick disconnects (QDs) will enable the EVA systems to transfer high pressure oxygen between the vehicle and on-board tankage under adverse conditions including vacuum and dust (lunar regolith and Martian soil). Â The QDs expected operating thermal environment range is -50Â° F to 150Â° F. The QDs will limit dust intrusion into the internal flow such that when mated/demated 300 times with the environment per MIL-STD-810G, Method 510.5, Procedure I (Blowing Dust) using lunar soil simulant JSC Lunar-1A or JSC Mars-1A, the internal fluid flow downstream of internal filtration is maintained at Level 100A per JPR 5322.1.

Â After those same mate/demate cycles, the fluid flow range will be 0-12 pph of gaseous oxygen at 2800-3750 psia with an allowable pressure drop of 49 psi. The allowable leakage at 3000 psia is 1 scc/hr oxygen. The QD shall exhibit low mating forces such that it can be mated by crew with gloved hands (wearing a spacesuit with a 4.3 psia or 8.3 psia operating pressure) using simple motions such as push/pull or push-twist/twist-pull. Â Single handed, gloved operation is preferred. A simple means of indicating positive QD engagement is preferred. The use of accessory tools to aid in QD mate/demate should be avoided if possible. The connector shall be capable of reacting a 125 lbf pull force at the strain relief. There are no specific requirements levied upon the exterior size and complexity of the QDs other to state that they are high criticality items that must be safe, practical, reliable; and a device that an exhausted crew member could operate easily and intuitively. Significant work has been done by NASA to identify a mechanical design for the basic size and operation of the device. Â Reference material has been attached describing existing and new designs, which NASA expects to heavily influence the general form, fit, and function of the future high pressure quick disconnect.Â

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.
Â

ISS EMU UMBILICAL (IEU)Â

The ISS EMU Umbilical (Item 498) is an interface between the ISS Umbilical Interface Assembly (UIA) and the Extravehicular Mobility Unit (EMU). It provides electrical power and communication, water fill/drain, and water cooling capability from the International Space Station (ISS) for the EMU. The IEU consists of the following items: three water lines of which two are used for water cooling of the LCVG and one for feedwater charging and condensate draining of the PLSS, one oxygen line, one electrical harness assembly for power and communication, a tether restraint and the TMG. The Common Multiple Connector, Item 410, provides a single interface point for connecting and disconnecting the IEU from the DCM. An Umbilical Connector Manifold (UCM), which is government furnished equipment (GFE), provides a single IEU attachment point to the ISS UIA. The IEU provides recharge capability for the PLSS oxygen tank, water reservoir, and battery. In the event a decontamination EVA is needed, the umbilical is designed to withstand environments external to the Airlock.Â

The EMU umbilical terminates at each end with a ganged multiple connector that requires only a single operation to connect or disconnect the umbilical.Â

The outer layer of the IEU is a multi-layer Thermal Micrometeoroid Garment (TMG) to provide thermal insulation and protection from micrometeoroid impacts. The IEU includes a protective pouch that will provides thermal and impact protection for the IEU common multiple connector while disconnected from the EMU.Â

The Umbilical contains a strain relief strap which, during IV operations, attaches via a GFE tether hook to one of the Lower Torso Assembly (LTA) D-rings at the EMU end and to a separate tether ring on the Crew Lock (CL) wall. For EV operations, the hook is disengaged from the UIA panel ring and is secured to a D-ring near the UIA panel. In the event that an EVA decontamination bake out of the EMU is required, this tethering scenario will serve to ensure that UIA design loads are not exceeded.Â

While not in service (i.e., when completely disconnected from the UIA and EMU), the umbilical is stowed in the equipment lock. While attached to the UIA, the umbilical is restrained against the CL wall by GFE provided restraint straps.

The useful life (combination of the operational life and shelf life) of the Umbilical is 15 years from the date of PDA. The dry weight of the Umbilical does not exceed 30 lbm. This weight includes all GFE provided hardware (2 tether hooks and the UCM). Â

Service and Cooling Umbilical (SCU)Â

The Service and Cooling Umbilical (Item 400) is an 11-ft umbilical consisting of three water hoses, a high-pressure oxygen hose, electrical harness, bacteria filter assembly, and a strain relief tether. The SCU supplies the PLSS with electrical power, communications, oxygen, waste water drainage and water cooling from the Orbiter during pre- and post-EVA operations. It also supplies the EMU with recharge of the oxygen tanks, water tanks, and battery.Â

The end of the SCU that connects into the airlock panel, otherwise known as the vehicle end of the SCU, consists of the four fluid ECLSS connections in addition to one electrical connector that attaches the SCU to the Orbiter airlock service panel AW82. The connections remain intact between flights and do not require crewmember operation. The vehicle waste water drain and potable water fill lines are connected to the bacteria filter housing located on the airlock wall. On both the drain side and the potable water fill side, a bacteria filter of iodine-impregnated epoxy resin spheres is incorporated, along with a particulate filter made of sintered stainless steel. These filters are used to prevent contamination from passing between the Orbiter ECLSS and the EMU. During normal IVA operations, the Orbiter Waste System is off and there is no ability to dump excess condensate. Approximately one pound of water is drained from the EMU water tanks after filling to allow room for condensate while IVA.Â

The common connector on the EMU end of the SCU combines the four fluid connections and one electrical circuit connector into a single unit operated by the crewmember. Disengagement of the connector is accomplished by pulling out on the SCU connector cam T-handle to retract a locking pin and then rotating the cam handle from the â€œlockedâ€ position approximately 180Âº to a detent, which is the â€œopenâ€ position. This rotation of the SCU connector cam disengages two pins on the mating is accomplished by pulling out on the SCU connector cam T-handle to retract a locking pin and then rotating the cam handle from the â€œlockedâ€ position approximately 180Âº to a detent, which is the â€œopenâ€ position. This rotation of the SCU connector cam disengages two pins on the mating connector. Engagement of the connector is accomplished by rotating the SCU connector cam T-handle to the â€œopenâ€ position, engaging the two pins on the mating connector with the cam, and then rotating the cam handle from the â€œopenâ€ position approximately 180Âº to the â€œlockedâ€ position, where a cam locking pin is engaged.Â

The SCU is stowed on the airlock wall when it is not being used. The common connector (SCU side) is attached to a mating stowage connector on the EMU mount (AAP). The SCU is unstowed and connected to the DCM during EMU donning to provide vehicle consumables for the suited EVA preparation activities in the airlock until life support from the EMU is initiated. Nominally, the SCU is disconnected at an airlock pressure of zero psia during airlock depressurization prior to an EVA and reconnected at an airlock pressure of zero psia during airlock re-pressurization after an EVA. The life support from the SCU is maintained during the suited post-EVA activities until the start of EMU doffing. The SCU is also connected to the EMU to supply Orbiter consumables for recharge of the EMU oxygen, the water tanks, and the battery.Â

ITAR restricted background on exploration space suit umbilical design requirements and expectations may be found at the following website (in cases where the solicitation requirements disagree with the references, the solicitation takes precedence.):Â

- Contract NNJ09T40C, Constellation Space Suit Systems ISS Umbilical Assembly, CSSS-T-002 Rev. DRAFT X-2, 7 July 2015.(http://sbir.gsfc.nasa.gov/SBIR/solicitations/2016/CSSS-T-002_LSS_CEI_ISS_Umbilical_Assembly_Specification.pdfÂ)
- Contract NNJ09T40C, Constellation Space Suit Systems ISS Umbilical Assembly, Exploration EVA Space Suit Design Status Review, 26 August 2015.(http://sbir.gsfc.nasa.gov/SBIR/solicitations/2016/Umbilical_and_Connector_Section_CSSS_DSR_Day_2_PM.pptx)Â

Â

H4.02 Trace Contaminant Control for Advanced Spacesuit Applications

Lead Center: JSC

Participating Center(s): MSFC

This subtopic is in search of a trace contaminant control (TCC) technology to remove trace contaminants in an advanced spacesuit atmosphere, specifically considering power, size, and removal capability. The advanced spacesuit portable life support system (PLSS) performs the functions required to keep an astronaut alive during an extravehicular activity (EVA) including maintaining thermal control, providing a pressurized oxygen (O_2) environment, and removing carbon dioxide (CO_2). The PLSS ventilation subsystem performs the transport and provides the conditioned O_2 to the suit for pressurization and astronaut breathing. It circulates O_2 through the ventilation loop using a fan and recycles the ventilation gas, removing CO_2 and providing humidity control. The ventilation subsystem is also responsible for removing trace contaminants from the spacesuit atmosphere. The International Space Station extravehicular mobility unit uses an activated charcoal bed inside the CO_2 removal bed (lithium hydroxide (LiOH) and metal oxide (MetOx) canisters). The charcoal in the MetOx canisters can be regenerated on-orbit. The selection of the rapid cycle amine (RCA) swingbed for CO_2 removal in the baseline advanced spacesuit PLSS has added a risk for removing trace contaminants. The trace contaminants in the PLSS ventilation subsystem and their predicted concentrations (mg/m^3) at the end of an 8-hour EVA without suit leakage include the following: acetaldehyde (0.181), acetone (0.301), ammonia (564), n-Butanol (1.13), carbon monoxide (74.4), ethyl alcohol (9.03), formaldehyde (0.902), furan (0.676), hydrogen (113), methyl alcohol (3.16), methane (1352), and Toulene (1.36). The predictions are based on EVA-specific generation rates.1 Based on these predictions ammonia and formaldehyde are the two contaminants most likely to exceed Spacecraft Maximum Allowable Concentration levels if no TCC device is in the PLSS ventilation loop. It would be beneficial for the technology to be regenerable such as vacuum swing regeneration. In particular, a vacuum-regenerable TCC device that can be regenerated in real time on the suit using a vacuum swing with 1 to 3 min of exposure would be optimum. Additional items for optimization include: reduction in expendables and incorporation into integrated CO_2 removal/reduction system. The desire is for the TCC system to be an immediate knock-down of inlet contaminants such as aldehydes which react irreversibly with the RCA sorbent. This will decrease the likelihood of losing capacity over the life of the system to these types of reactions.Â

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.Â

References:Â

- Paul, H., Jennings, M., and Waguespack, G., â€œRequirements and Sizing Investigation for Constellation Space Suit Portable Life Support System Trace Contaminant Controlâ€, 40th International Conference on Environmental Systems, Barcelona, Spain, July 2010.(http://sbir.gsfc.nasa.gov/SBIR/solicitations/2016/AIAA-2010-6065_TCC_CES_Paper_Paul-Jennings-Waguespack.pdf)
- James, J., â€œSpacecraft Maximum Allowable Concentrations for Airborne Contaminants,â€ JSC-20584, Houston: NASA/Johnson Space Center, November 2008.(http://sbir.gsfc.nasa.gov/SBIR/solicitations/2016/Spacecraft_Maximum_Allowable_Concentrations_SMAC_JSC-20584.pdf)

H4.03 EVA Space Suit Power, Avionics, and Software Systems

Lead Center: JSC

Participating Center(s): GRC

Space suit power, avionics and software (PAS) advancements are needed to extend EVA capability on ISS beyond 2020, as well as future human space exploration missions. NASA is presently developing a space suit system called the Advanced Extravehicular Mobility Unit (AEMU). The AEMU PAS system is responsible for power supply and distribution for the overall EVA system, collecting and transferring several types of data to and from other mission assets, providing avionics hardware to perform numerous data display and in-suit processing functions, and furnishing information systems to supply data to enable crew members to perform their tasks with autonomy and efficiency.Â Current space suits are equipped with radio transmitters/receivers so that spacewalking astronauts can talk with ground controllers and/or other astronauts. The astronauts wear headsets with microphones and earphones. The transmitters/receivers are located in the backpacks worn by the astronauts only operate in the UHF band.

While a sufficient amount of radiation hardened electronics are available in areas such as serial processors, digital memory and Field Programmable Gate Arrays,Â certain ancillary electronic devices present a significant risk for the development of rad-hard spacesuit avionics. NASA is, therefore, seeking flight rated electronic devices needed to complement the existing inventory of flight rated parts so as to enable the creation of an advanced avionics suite for spacesuits.Â The suit and its corresponding avionics should be capable of being stowed inside a spacecraft outside the low-Earth orbit (LEO) environment for periods of up to 5 years (TBR). Devices should also be capable of supporting EVA sorties of at least 8 hours and total lifetime operational durations of at least 2300 hoursÂ (TBR) for a Mars surface mission.Â Assumptions may be made for inherent radiation shielding provided by the primary life-support system (PLSS) and possibly the power, avionics, and software (PAS) subsystem enclosure, but proposers are welcome to include shielding technologies at the board and individual part level to reduce the radiation requirements of the actual device.Â Â Devices should be immune to single event latch-up (SEL) for particles with Linear Energy Transfer (LET) values of at least 75 Mev-cm^2/mg. and maintain full functionality for total ionizing doses of at least 20 Krad (Si).Â Criticality 1 devices (life support) must be fully mitigated against single event errors (SEE) for all potential mission radiation environments, including solar flares.Â Lower criticality devices can be less tolerant of SEEs, but must still operate with acceptable error rates in all potential radiation environments.Â Power consumption should be no more than 2X similar COTS or mil-spec devices. Devices should be vacuum compatible and need to support conduction cooling. Need currently exists for a number of devices, as described below. However this list should not be considered to be exhaustive and proposals will be considered for other devices that are peculiar to a spacesuit avionics suite. Additionally, proposals are invited for simplified, low-cost and low-impact methods to adapt or test commercial or military-spec devices so as to yield a flight-rated part to the above levels. In order of priority, two key innovations are sought this round:

- *Safety Critical Switches and Controls* - Very low profile switches and controls for EVA Criticality 1 systems.Â Â Highly reliable and robust devices that provide traditional toggle switch, rotary dial, and linear slider control functionality in a very low profile package which permits higher packaging density compared to traditional solutions for vacuum space operations.Â Switches and controls must still be sized for easy operation with EVA gloves.
- *Wireless Communication* - Dual-band WLAN-class RF front-end module capable of supporting the SSCS (410 to 420 MHz) and the ISS External Wireless Communications system (5.25-5.35GHz).Â This module is expected to contain all RF components plus data converters.Â This module will interface with a baseband processing unit via high-speed digital interface.Â Consideration for supporting multiple antennas on the EWC band will be given, but this is not required.Â The front-end must be able to operate in the ISS environment.

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.