NASA SBIR 2015 Phase I Solicitation

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. 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, a significant risk for the development of spacesuit avionics is the non-availability certain ancillary electronic devices that are rated for spaceflight. 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. 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 hours (TBR) for a Mars surface mission. 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. 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). Criticality 1 devices (life support) must be fully mitigated against single event errors (SEE) for all potential mission radiation environments, including solar flares. Lower criticality devices can be less tolerant of SEEs, but must still operate with acceptable error rates in all potential radiation environments. 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 no particular order of priority, key innovations sought include:Â

- Wireless Communication:
    - 802.11n baseband processor that supports channel bonding and possibly multiple RF channels.

    - Low-power (<5W), low-rate (500-1000kbps) baseband software-defined radio that is, at the very least, capable of supporting the existing Space-to-Space Communications System (SSCS) wireless suit interface.
    - Dual-band WLAN-class RF front-end module capable of supporting the SSCS (410 to 420 MHz) and a channel-bonded 802.11n system (40MHz of bandwidth) operating at the 2.4GHz ISM band. Consideration will also be given to devices capable of supporting the 802.11n system operating in the 900MHz region. Consideration for supporting multiple antennas for the 802.11n system will be given, but this is not required.
- Human-Machine Interface (HMI) for Informatics:
    - Input device technologies that provide mouse-like functionality or a minimum of directional control to navigate display menu system. In general devices need to minimize hand use. Technologies that require hand use must be limited to operation with a single gloved EVA hand. Devices must minimize SWAP and computing power needed for final implementation. Solutions must be reliable and robust enough for vacuum space environments.Â
- Safety Critical Switches and Controls:
    - Very low profile switches and controls for EVA Criticality 1 systems. 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. Switches and controls must still be sized for easy operation with EVA gloves.
- Audio:
    - Simultaneously sampled, deep bit-width, low rate Analog to Digital Converter (ADC) circuits and/or Pulse Density Modulator (PDM) circuits. Requirements are for devices with dynamic range greater than 90 dB (threshold) and as much as 110 dB (goal) with sampling rates > 24 kS/s (threshold) and as high as 48 kS/s (goal). Requirements exist for 8 channel devices (threshold) simultaneously sampled (< 1 ps jitter) with a goal of 16 channels. Devices should support a Least Significant Bit (in Pulse Code Modulation) of 1 micro-Volt or less with a noise floor of 10 micro-Volts or less.
    - Highly linear, high Signal to Noise Ratio (SNR) Micro Electro Mechanical System (MEMS) microphones with PDM output. Microphones should exhibit < 1% THD at 105 dBSPL (threshold) and 115 dBSP (goal). Microphones should have frequency response of +/-10 dB from 80 Hz to 12 kHz and SNR > 50 dB (threshold) and > 60 dB (goal).
    - High dynamic range, audio frequency Digital to Analog Converters (DACS). Converters should provide>100 dB spur free dynamic range (TBR).
    - High efficiency, low power (< 1 W output), audio frequency power amplifiers.
    - High efficiency, audio frequency pre amplifiers with adjustable gain (0 to 30 dB).
    - High speed (> 100 Mb/s) serial communications transceivers suitable for protocols such as Ethernet, Low Voltage Differential Signal (LVDS) and Rocket-IO.

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