NASA SBIR 2008 Phase I Solicitation

O3 Processing and Operations

The Space Operations Mission Directorate (SOMD) is responsible for providing mission critical space exploration services to both NASA customers and to other partners within the U.S. and throughout the world: from flying the Space Shuttle, to assembling the International Space Station; ensuring safe and reliable access to space; maintaining secure and dependable communications between platforms across the solar system; and ensuring the health and safety of our Nation's astronauts. Each of the activities includes both ground-based and in-flight processing and operations tasks. Support for these tasks that ensures they are accomplished efficiently and accurately enables successful missions and healthy crew.Â

Subtopics

O3.01 Crew Health and Safety Including Medical Operations

Lead Center: JSC

Participating Center(s): ARC, GRC

Determining the probability of certain types of events (such as medical conditions) can be tricky. Often there is not enough space-flight data to make a good determination and so other types of evidence are used such as expert opinion, analog data, controlled studies, etc. Each source of evidence must be documented (e.g., as a publication citation, or as a data pull against some data source along with the query parameters used). The source is also characterized as to its â€œlevel of evidenceâ€ using the Cochrane methodology as documented in the National Guideline Clearinghouse (http://www.guideline.gov/summary/summary.aspx?doc_id4913). There are many methods for combining these evidence pieces. A software system is sought that can be used to collect the evidence (references to evidence sources such as journal publications, population statistics, analog study, etc.) and which facilitates the evidence level assignment (providing a place to record the evidence level and definitions of each level). Furthermore the system should provide a model for combining these evidence sources in a principled manner that characterizes the certainty of the conclusion reached, e.g., a weighted equation where the weights may be adjusted by the users of the system.

Relevance: Evidence of events drives risk assessment. Depending on the risks identified, decisions can be made as to whether to mitigate the risk via pre-flight activities or in-flight capabilities. Such a system supports â€œwhat would happen ifâ€ type reasoning that enables exploration of different mission options.

Challenge Addressed: Capturing the evidence base in one place along with additional categorization (level of evidence, uncertainty, quality of evidence, etc.) is invaluable in preserving decision-making rationale such that the decisions can be revisited if additional evidence/information is added later. Determining where to spend limited resources wisely is supported â€“ e.g., balance funding between development of pre-flight mitigation strategies, in-flight capability development, investigation of knowledge gaps (uncertainties), and risk acceptance decisions.

Research should be conducted to demonstrate technical feasibility during Phase 1 and show a path toward Phase 2 hardware and software demonstration and delivering a demonstration unit or software package for NASA testing at the completion of the Phase 2 contract.Â

O3.02 Human interface systems and technologies for spacesuits

Lead Center: GRC

Participating Center(s): ARC, JSC, KSC

The primary medium for sending and receiving information from a crewmember is two-way voice communications. The function of the voice communications system may be extended to include data entry through the inclusion of a Automatic Speech Recognition (ASR) systems. Recent developments in ASR have lead to systems that are capable of connected word identification or speaker-independent word identification. These systems rely on very high fidelity audio link to the talkerâ€™s speech.

While speech recognition technology has enjoyed significant advances in recent decades, alternate technologies for data entry exist. Such systems may enjoy advantages over speech recognition for the spacesuit application in areas such as overall Size, Weight and Power (SWaP) or system robustness.

The focus of this subtopic is on the development of systems and technologies in support of high fidelity speech and data entry for space suits. In addition to providing the necessary audio fidelity for ASR, the high fidelity audio systems also result in better voice communications for human-to-human communications. The topic therefore includes the related areas of inbound audio systems and hearing protection systems.

High Fidelity, In-Helmet Audio Systems

The space suit environment presents a unique challenge for capturing and transmitting speech communications to and from an crewmember. The in-suit acoustic environment is characterized by highly reflective surfaces, causing high levels of reverberation, as well as spacesuit-unique noise fields. Known sources of noise within the suit are both stationary and transient in nature. Noise within the suit can be acoustically borne or it can originate from structure-borne vibration. Noise originates from suit machinery, footfalls, suit arm and hip bearing, body movement noise and turbulent flow noise from devices such as oxygen spray bars and breath noise. Static pressure levels within the spacesuit can range from a small fraction of an atmosphere during Extravehicular Activity (EVA) operations to strong hyperbaric conditions that exist during terrestrial field-testing. These changes in static pressure level have significant effects on acoustic transduction. Additionally, in some spacesuits, the crewmember is afforded a wide range of motion within the torso of the suit. The wide range of motion means that the acoustic path between an crewmemberâ€™s mouth or ear and the microphone or helmet mounted speaker varies significantly with movement, resulting in decreased sound pressure levels at the microphone and/or increased interference from competing background noise sources. In addition, vehicular operations can generate high levels of noise that are not fully attenuated by the spacesuit, helmet or headsets. Due to these factors, the quality of speech delivered to and from the inside of a spacesuit helmet can be low and can have a negative effect on inbound and outbound speech intelligibility and the performance of Automatic Speech Recognition (ASR) systems.

The traditional approach to overcome the challenges of the spacesuit acoustic environment is to use a skullcap-based system of microphones and speakers. Cap-based solutions mitigate many of the acoustic problems associated with in-helmet communications systems through the very short and direct acoustic transmission paths between the crewmember and the speakers and microphones. The skullcapâ€™s headsets and noise canceling microphones can also afford some degree of acoustic isolation for the crewmember from noise generated inside the spacesuit. Cap-based systems are less successful, however, in attenuating high noise levels generated outside the spacesuit (e.g., during launch, descent, burn activities, or emergency aborts), even when coupled with the launch/entry helmet. The use of noise canceling microphones can improve speech intelligibility, but only if the microphones are in close proximity to the crewmemberâ€™s mouth. Many logistical issues exist for head-mounted caps. Crewmembers are not able to adjust the skullcap, headset or microphone booms during EVA operations (which can last from four to eight hours) or during launch/entry operations. Interference between the protuberances of the cap and other devices such as drinking/feeding tubes is a recognized issue during EVA. Comfort, hygiene, proper positioning and dislocation are major concerns for head-mounted caps. Wire fatigue and blind mating of the connectors are also problems with the cap-based systems. In order to accommodate anthropometric variations in crew heads, multiple cap sizes are required. Issues have recently been identified with existing communications systems regarding adjustment of microphone boom lengths, proper function over the wide ranges of static pressure experienced during suited operations, flow noise over the microphone elements, and integration with advanced helmet designs.

NASA is seeking systems, subsystems and/or technologies in support of improvements in speech intelligibility, speech quality, listening quality and listening effort for in-helmet aural and vocal communications. In addition, improvements in hearing protection are sought to protect the crew during all mission phases, in case hazardous acoustic levels and conditions occur.

The specific focus of this SBIR subtopic is on improving the interface between crewmember and the acoustic pickup (i.e., microphones) and generation (i.e., speaker) systems. Systems and devices are sought to improve or resolve acoustic, physical and technical problems (listed above) that have been associated with skullcap-mounted speakers and microphones, or allow for the elimination of skullcap-mounted speakers and microphones. In particular, voice communications systems are sought that have provided crewmembers with adequate speech intelligibility over background noise within, and external to, the spacesuit. Overall system performance must provide Mean Opinion Score (MOS) for Listening Quality (Lq) and Listening Effort (Le) of 3.9 or greater, or Articulation Index (AI) of .7 or better or 90% Speech Intelligibility (SI) in the crewmemberâ€™s native language for both inbound and outbound speech communication. Specific technologies of interest include, but are not limited to:

- Acoustic modeling of the in-suit acoustic environment, including the ability to model structure-borne vibration in helmet and suit structures as well as transduction to and from the acoustic medium.
- Low-mass, low-volume, low-distortion, space-qualified speakers with low variation in sensitivity with static pressure. Changes in speaker sensitivity should be less than 2 dB over the speech band with changes in static pressure between 3 and 18 psia.
- Low-mass, low-volume, low-distortion high-sensitivity (> 5 mV/Pa), space-qualified noise canceling microphones with low variation in sensitivity with static pressure. Changes in microphone sensitivity should be less than 2 dB over the speech band with changes in static pressure between 3 and 18 psia.
- Attenuation of external noise by passive hearing protection that is comfortable for crewmembers during extended use.
- Development of theories, experiments and analysis in support of decomposition of end-to-end SI and/or MOS requirements to the spacesuit portion of EVA-to-Mission Operations Center (MOC), EVA-to-EVA or EVA-to-habitat voice loops. Comparison of SI system fidelity metrics to MOS system fidelity metrics.

In-helmet devices will need to be compatible with high humidity, low humidity and pure oxygen environments. Devices should be able to fit a wide anthropometric range of head and physical features found within the astronaut corps.

Additionally, demonstrations of novel system concepts for in-helmet audio communication are of strong interest. A partial list of such concepts includes:

- Near-field beamforming systems;
- Optical microphone systems;
- Highly directive sound production systems such as parametric sound systems;
- Active noise cancellation systems for hearing protection;
- Bone conduction microphones.

Systems and devices must include appropriate computer processing systems. The expectation is that a working and fully functional system or device will be delivered at the end of Phase 2.

Advanced Data/Text Entry for Spacesuits

The space suit environment presents a unique and challenging environment for control of suit-mounted processing equipment. Terrestrial user-interface devices for controlling portable processing equipment such as laptop computers typically rely on keyboard or touchpad input. Such devices are problematic in the space environment since a suited crewmember must interact with the processing equipment while wearing a pressurized glove. Speech recognition technologies have been proposed and investigated to provide user input, but alternative methods are also desired.

Currently, a suitâ€™s processing system has been primarily for providing life-support data-acquisition, monitoring, telemetry, and crewmember alerts. The traditional approach to interact with the EVA processing system is with suit-mounted toggle switches optimally sized for a gloved hand and located in the suitâ€™s chest area. NASA envisions future generations of suits to contain advanced communication, navigation, and information processing capabilities that will require better ways of interacting with the suited crewmember. It is likely that the processing unit(s) will be installed within the suitâ€™s backpack-mounted portable life support unit or in close proximity.

Crewmember usability and efficient operation are prime features of the next-generation input device. The device must operate robustly in the space and lunar environment and be tolerant of dust, vacuum, and radiation exposure. During Extra-Vehicular Activity (EVA), a suited crewmember needs to achieve as high a level of mobility as possible, so a suit-mounted computer-input device must not impede the movements of the suited crewmember or unduly burden the suit system with weight, volume, or electrical power constraints.

NASA is seeking systems, subsystems and/or technologies in support of improvements in suit-mounted computer system user-interface devices. Particular interest is in areas allowing the suited crewmember to control a computer processing system and provide text input accurately, at high speed, without little or no user fatigue for purposes such as note taking or control of the computer display screen. Possible approaches include chording keyboards, suit or glove mounted fabric keyboards or touch-pads or other technologies. Other technologies will also be considered. Concepts may consider both solutions installed internally (within the pure-oxygen pressurized envelop of the suit), externally (mounted on the exterior of the suit), or a combination of the two.

Techniques for routing wires or connections between the user interface device and the computer processing unit are also of interest. Techniques for routing the wires past bearings or avoidance of such will be considered.

Research should be conducted to demonstrate technical feasibility during Phase 1 and show a path toward Phase 2 hardware and software demonstration and delivering a demonstration unit or software package for NASA testing at the completion of the Phase 2 contract.

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O3.03 Vehicle Integration and Ground Processing

Lead Center: KSC

Participating Center(s): MSFC, SSC

This solicitation seeks to create new and innovative technology solutions for assembly, test, integration and processing of the launch vehicle, spacecraft and payloads; end-to-end launch services; and research and development, design, construction and operation of spaceport services. The following areas are of particular interest:

Propellant Servicing Technologies Enabling Lower Life Cycle Costs

Technologies for advanced cryogenic fluid storage and transfer, servicing of chilled/densified fluids and advances in state-of-the-art ground insulation are needed to reduce launch operation costs by minimizing consumable losses. Solutions in support of helium conservation and recovery; recapture, reduction, and elimination of cryogenic propellants vented to atmosphere (zero boil-off); insulation for improved storage and distribution minimizing thermal losses; fire resistant liquid oxygen pumping systems; and instrumentation advances to enable high efficiency operations. Providing solutions with higher efficiency, lower maintenance and longer life while improving safety and improving liquid quality delivery.

Corrosion Control

Technologies for the prevention, detection and mitigation of corrosion/erosion in spaceport facilities and ground support equipment including refractory concrete. Solutions for: damage responsive coatings with corrosion inhibitors; poor-performing refractory concrete; protective coatings for non-painted surfaces; and new environmentally friendly protective coating options to replace products lost due to EPA regulation changes. Providing coating/protection solutions that meet current and emerging environmental restrictions and can endure the corrosive and highly acidic launch environment.

Spaceport Processing Systems Evaluation/Inspection Tools

Technologies in support of defect detection in composite materials; methods for determining structural integrity of bonded assemblies; and non-intrusive inspection of COPV, heat shield tiles and painted surfaces. Solutions for detecting and pinpointing corrosion; predicting remaining coatings effectiveness/life expectancy; identifying composite defects and evaluating integrity; non-destructive measurement and evaluation of composite overwrapped pressure vessels; and damage inspection and acceptance testing of Orion heat shield. Providing solutions that reduce inspection times and provide higher confidence in system reliability and safety concerns and lower life cycle costs.

Research should be conducted to demonstrate technical feasibility during Phase 1 and show a path toward a Phase 2 hardware and software demonstration and delivering a demonstration unit or software package for NASA testing at the completion of the Phase 2 contract.Â