# NASA SBIR 2007 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.

# Subtopics

### O3.01 Crew Health and Safety Including Medical Operations

**Lead Center: JSC**

**Participating Center(s): ARC, GRC**

Medical Operations is responsible for all operational activities related to crew health issues during all mission phases, with the specific purpose to optimize crew health and performance and prevent negative health consequences from space flight.

This subtopic seeks innovative technologies for procedure management. In each crew, a crewmember is designated as a crew medical officer. This person is responsible for managing in-flight medical issues with the support of a ground-based flight surgeon as well as reference materials that reside onboard an operational vehicle. The medical checklist is the main in-flight resource for medical procedures. It is a large document with many references to medical hardware and interconnections between procedures. Currently the default form of the document is paper with an electronic version also being available to the crew. Current procedure construction, validation, and maintenance is accomplished through a word processing program. Procedures must comply with a standard format. Software is sought that will enable easy construction and maintenance of the procedures, including changes to procedures, changes to hardware, changes to resulting format of the procedures, and validation of the procedures. The ultimate goal is to be able to merge this software with other elements to create an in-flight medical decision support system, including medical data display that supports decision making and just-in-time training.

## O3.02 In-helmet Speech Audio Systems and Technologies

**Lead Center: GRC**

**Participating Center(s): ARC, JSC, KSC**

The space suit environment presents a unique challenge for capturing and transmitting speech communications to and from a 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 a crewmember'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 skullcap'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 crewmember'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% Intelligibility in the crewmember'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.

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.

## O3.03 Vehicle Integration and Ground Processing

**Lead Center: KSC**

**Participating Center(s): MSFC, SSC**

NASA is concerned with creating new and innovative technology solutions for assembly, test, integration and processing of spacecraft, payloads, and flight science experiments; end-to-end launch services; and research and development, design construction, and operation of spaceport services. These include the following areas:

### Corrosion Control

Corrosion is the deterioration of materials due to reactions with their environment. Corrosion can have catastrophic consequences when it is not prevented, detected, and controlled. New technologies are needed to build/maintain spaceport systems that are cost-efficient, safe, reliable, and easy to inspect. Corrosion can be minimized by proper selection of materials, coatings, detection methods, and maintenance procedures in the design stage. Corrosion detection is important to avoid catastrophic failures. NASA is seeking technologies for prevention, detection, and mitigation of corrosion in spaceport facilities and ground support equipment. Technologies and tools for the evaluation and detection of hidden corrosion, including a system to detect corrosion under paint on either side of the structure without requiring removal of any components or thermal protection system elements covering the structure. Development of new coatings and qualification of existing coatings for corrosion protection.

### Non-Destructive Evaluation/Non-Intrusive Inspection Technologies

Non-destructive evaluation (NDE) technologies for cryogenic foam insulating materials. Tools and techniques for defect detection in composite materials. Non-destructive methods to determine structural integrity of bonded assemblies, especially non-metallic composites and thermal protection system (TPS) materials. Non-intrusive inspection of vacuum-jacketed piping to survey long distances of piping without compromising the vacuum. Nondestructive evaluation/inspection techniques for graphite epoxy composite over-wrapped pressure vessels (COPVs) or Kevlar COPVs. Definitive techniques do not currently exist for determining if there are broken fibers, voids, or delaminations which could result in a decreased safety factor for COPVs. Failure to detect a defect could result in a COPV rupture leading to loss of life, loss of mission, and/or damage to flight hardware, facilities, and ground support equipment (GSE).

### Propellant Loading/Servicing/Storage

Lightweight and versatile cryogenic storage and distribution technologies. Energy-efficient cryogenic insulation approaches to achieve operationally effective, integrated refrigeration and storage systems. Increased propellant quantity requirements for Constellation Systems will require larger storage vessels and longer transfer lines. Advanced cryogenic loading technologies, including systems that combine advances in component health management, automated process control, instrumentation, resource conservation, and improved seals. Advanced propellant system umbilicals and quick-disconnect fittings for a variety of fluid interfaces.

### O3.04 Mission Operations

**Lead Center: ARC**

**Participating Center(s): JSC, MSFC**

The objective of this subtopic is to develop advanced capabilities for mission operations software, with particular emphasis on providing situational awareness and decision-making assistance for mission and flight controllers. Earlier phases of mission operations include pre-planning phases, procedure development, contingency development, and other preparatory tasks. Flight phases include telemetry analysis, state determination, situational assessment, plan revisions, decision-making, commanding, fault responses, and procedure execution. Support phases include data management, plan and procedure revisions, changes to operations practices and rules, etc.

Proposals in the following technical areas are of high interest:

- Situational awareness capabilities for controllers and crew: This subject includes a wide range of capabilities, such as: (1) Methods to determine situational information from multiple data sources, possibly noisy and incomplete, and present those to the user; (2) Methods to track user intent and provide the appropriate situational information; and (3) Methods to track actions of other users or systems, including automated systems, and keep user aware of the situation.
- Mission operations planning and plan management: Methods and tools for creating, validating, evaluating, and revising operations plans, taking into account collaborative aspects, complex flight rules, resource limitations and need for one-time constraints and exceptions.
- Plan, procedure and sequence validation: Techniques for checking or simulating plans, procedures, sequences and other combinations of commands and actions, in order to acquire a level of trust or assurance that the combination is correct and will satisfy desired safety properties in actual execution.
- Telemetry management and visualization: Methods for acquiring, evaluating, and displaying telemetric information, so as to provide users with flexibility and easy access to desired information in desired format.
- Adjustable automation for operations: Development of approaches and supporting tools for adjustable automation in operations. Includes specification of automation information, mechanisms for controlling degree of automated/manual control, and tools for transitioning control between user and automation with minimal loss of context and situational awareness.
- Plug-and-play technologies for operations software: Development of software frameworks or architectures, as well as exemplars of tools, interfaces and applications, that enable re-use of functionality across disciplines and software systems.