NASA SBIR 2005 Phase I Solicitation

O1.07 Extravehicular (EVA) Radios

Lead Center: JSC

Participating Center(s): GRC

Human exploration of the Martian environment demands radio technology that tolerates extreme conditions. The harsh environment of the Martian atmosphere contains not only increased radiation, which is damaging to semiconductors, but also dust and ionic storms, which are disruptive to communications. Frequency agility will be necessary during periods of disruption due to these storms. Small volume and low mass are always sought for any space mission; they are critical for systems embedded in EVA spacesuits, which seek to enhance the astronaut's mobility on the planet's surface.

The focus of this activity is to develop radio methodologies that ensure increased reliability and fault-tolerance in the processor electronics and performance of EVA radios for human interplanetary missions. Exploring unknown worlds with unforeseeable threats is understandably stressful for the most intrepid astronaut. By providing a system that is even less likely to fail and easier to use, this can be mitigated. In a human exploration mission, loss of communications is not merely inconvenient; it can be deadly.

The radio systems design must reflect the very special human factors requirements imposed by the mission and the protective spacesuit. While these latter provide a pressurized atmosphere, temperature control, protection from micrometeoroids, communications, and a myriad of other functions essential to the survival of an astronaut, the best designs add bulk and inhibit natural movements. EVA radio systems must be designed to be easily operable in any circumstance.

This solicitation seeks to develop an EVA radio that notionally consists of limited front-end complexity hardware combined with a signal processing back end while minimizing traditional radio analog system components in order to maintain waveform flexibility and reconfigurability. The communication bands of interest are the space allocations from UHF to Ka; the precise band used will be dictated by bandwidth needs and the specific application. The radio should support multiple bandwidths of data transmission to support telemetry, voice, and video, and should have automatic adaptive techniques to handle changing propagation and interference. The radio should have an upper mass limit of 300g, a peak transmission power of 5W, and a receive mode which consumes no more than 10 mW.
Additionally, this radio must be configurable for many applications, with a goal of reducing radio inventory management. Ka-band is the most appropriate for high data rate video links, while UHF bands can be used for low-rate telemetry and voice applications. Operational scenarios will dictate the exact requirements, but it is envisioned that EVA radios will need to transmit both audio and video to surface rovers, landers, and habitats. An EVA-Ka proximity link will be needed to track the rover should it travel outside the astronaut's field of view. Astronauts will need to communicate with each other while performing maintenance or service tasks either on the ground or in orbit, so an EVA-to-EVA video link will be needed. It is possible that the EVA radio will need the capability to relay communications through a satellite to maintain constant contact with landers, habitats, or astronauts that are obscured or whose signals are otherwise blocked.

Ideally, one radio type will be suitable for many applications, without extensive configuration efforts, through the use of automatic self-configuration or adaptation to the application environment. It is intended that the dual goals of flexibility and survivability can be met with a modular architecture and operational paradigm. New and innovative solutions are sought that provide provable performance and survivability improvements.

The radio should underscore design of both hardware and software for failure tolerance and slow and soft degradation upon component or gate failure. Operation should be maintained following any single point failure in a discrete component or logic gate, even if in diminished capacity. Handling multiple failures with degradation is preferred. Methods that address space hardening of critical components are envisioned. Designs should also consider fallback schemes where the goal is to maintain communications even at the cost of quality, bandwidth, or functionality.

Phase 1: The Phase 1 proposal should address the technical challenges posed by the design considerations enumerated above. During the Phase 1 effort, the EVA radio requirements definition, the initial design, and the method of testing the EVA radio will be developed. Because testing needs to include both ground testing and space testing, the proposal should address both of these elements as well as the proposed migration path between the two. Deliverables should include a prototype simulation of the design demonstrating the EVA radio’s ability to reconfigure between bands/applications and a hardware prototype demonstrating some degree of fault survivability or reconfiguration.

Phase 2: During Phase 2, prototype integrated hardware and software comprising the EVA radio will be developed, finalized, and tested based on the designs developed in Phase 1. Design changes will be finalized in this phase as a result of testing according to the guidelines developed in Phase 1.

Phase 3: EVA radios suitable for early lunar missions will be fabricated, tested, and demonstrated according to the testing guidelines developed in Phase 1 and the prototypes fabricated in Phase 2.

Commercialization: Fire, police, and other civil and law enforcement agencies would benefit from radios that could be reconfigured on-the-fly to interoperate with each other. Currently, police and fire officials must usually be routed through a central hub and precious time is lost in the attempt to communicate between agencies. Major disasters have shown a need for a universal communication system that is adaptable.