NASA SBIR 2009 Phase I Solicitation

O1.08 Lunar Surface Communication Networks and Orbit Access Links

Lead Center: GRC

Participating Center(s): GSFC, JPL, JSC

This solicitation seeks to develop a highly robust, bidirectional, and disruption-tolerant communications network for the lunar surface and lunar orbital access links. Exploration of lunar and planetary surfaces will require short-range (~1.6 km line-of sight, ~5.6 km non-line-of-sight) bi-directional, often highly asymmetric, and robust multiple-point links to provide on-demand, disruption and delay-tolerant, and autonomous interconnection among surface-based assets. Minimization of communication asset scheduling, and other ground operation support, is highly desirable. Some of the nodes will be fixed, such as base stations and relays to orbital assets, and some transportable, such as rovers and humans. The ability to meet the demanding environment presented by lunar and planetary surfaces will encompass the development and integration of a number of communication and networking technologies and protocols.

NASA lunar surface networks will be dynamic in nature, and required to deliver multiple data flows with different priorities (operational voice, command/control, telemetry, various qualities of video flows, and others). Bandwidth and power efficient approaches to mobile ad hoc networks are desired. Quality of Service (QoS) algorithms in a Mobile Ad hoc NETwork (MANET) setting will need to be developed and tailored to NASA mission specific needs and for the lunar surface environment. Exploitation of delay/disruption tolerant network (DTN) technology to maximize autonomy of the communication infrastructure and to minimize demands on channel capacity is of significant interest. Advantages and disadvantages associated with parallel DTN and IP networks, and a competing DTN-over-IP network architecture, should be considered. Possible associated considerations include routing, security, and QoS.

These lunar and planetary surface networks will need to seamlessly interface with communications access terminals and orbiting relays that also can provide autonomous connectivity to Earth based assets. The access link communications system will encompass the development and integration of a number of communications and networking technologies and protocols to meet the stringent demands of continuous interoperable communications. Human exploration, therefore, requires the development of innovative communication protocols that exploit persistent storage on mobile and stationary nodes to ensure timely and reliable delivery of data even when no stable end-to-end paths exist. Solutions must exploit stability when it exists to nearly approximate the performance of conventional MANET protocols. The capability of the network to provide infrastructure-based position determination and navigation is of interest to NASA, especially when coverage issues arise and/or orbiter access links are unavailable. The extent to which the network can support localization of mobile nodes should be addressed, and network architecture options that could further support navigation should be identified.

Frequency bands of interest are UHF (401 - 402 MHz, 25 kHz bandwidth), S-band (2.4 - 2.483 GHz), and Ka-band (22.55 - 23.55 GHz). Existing commercial standards for the PHY and MAC layers should be leveraged to the extent possible while meeting other requirements, with modifications considered when necessary. Results from NASA's Lunar Architecture Team, as well as technology trade studies performed for NASA's Constellation Systems, should be referenced for input regarding data flows, coverage, network requirements, etc. EVA study results can be found at:

EVA Technology Development path loss study: http://gltrs.grc.nasa.gov/reports/2007/TM-2007-214825.pdf

Specific Subtopic Capabilities to Address This Year

This year's call intends to focus innovations in 4 key areas. Participants should focus their proposed innovation in one or more of these key areas:

- Differentiated services and QoS support in dynamic wireless networks when safety-of-life and data flows critical to the mission are traversing the network.
- DTN prototype protocol development and demonstration in an emulated operational network.
- Secure data transfers over mobile, dynamic wireless networks with potential interferers and/or interceptors.
- Position determination and navigation based novel uses of the network infrastructure (e.g. utilizing radiometric information from the network signaling).

Proposal should address the following:

- Network traffic models
- Network architecture (both hardware and software)
- Spectrum usage
- Security plan (if the proposal deals with particular innovations in this area)
- Identification of software and/or hardware technologies common to networking components that will have the largest impact on size, weight, and power reduction while not compromising the goals of the network architecture as listed above.

Phase 1 Deliverables

A trade analysis identifying novel software and/or hardware technologies common to networking components that will have the largest impact on size, weight, and power reduction while not compromising the goals of the network architecture is the most important aspect of the Phase 1 deliverable. It is not reasonable to expect that all issues and technologies concerning the network architecture proposed will be developed under a Phase 2 contract. However, the proposer should identify and rank novel hardware/software components based on size/weight/power reduction that will enable the proposed network architecture. The proposer should also identify how they are uniquely qualified to develop the novel technologies to products beneficial to NASA, DoD, and perhaps commercial interests.

The Phase 1 proposal should clearly state the assumptions, proposed network architecture, and innovations regarding the 4 key areas mentioned above.

Phase 2 Deliverables

The novel software and/or hardware component identified in Phase 1 will be developed to a state in which it may be demonstrated and the feasibility of the approach on an actual platform may be quantitatively evaluated by NASA testing at the completion of the Phase 2 contract. (TRL 4 or better).