



NASA STTR 2007 Phase I Solicitation

T5 Innovative Technologies and Approaches for Space

To accomplish the Agency's goals and objectives for a robust space exploration program, innovative technologies and approaches are needed to meet these major challenges for human space explorers. This topic solicits advancing the technologies in communication systems' filters and antennas; new dynamic radiation sensors; better and longer range no-power radio frequency (RF) sensors-tag for identification, position and sensor data; and highly effective algorithms for autonomous robotic handling to increase the flexibility and efficacy of robots deployed to the surface of the Moon and Mars missions. The new technologies being solicited include means to improve operational capabilities; improve crew safety; increase human productivity; reduce the size, weight and power; reduce the Extravehicular Activity (EVA) time required to setup and deploy outposts, habitats, science packages, and others; and abilities to enhance the success of future human exploration missions. The anticipated proposed technologies shall have a dramatic impact on achieving these goals of the Space Exploration Vision.

Subtopics

T5.01 MEMS-Enabled Filters, Antennas, and Sensors

Lead Center: JSC

Given the great demands placed upon communication transceivers to assure crew safety and robustness in mobile environments, NASA seeks to develop novel techniques to reduce the size, weight, and power (SWAP) for long duration manned missions. Such high analog-to-digital conversion power consumption, large form factor, and expensive components pose challenges for power and weight constrained in software defined radios. Thus, significant technical advances are needed in the area of high performance channel select filter banks, tunable filters with low-loss and high-rejection, and reconfigurable and multi-band antennas.

First, this solicitation seeks substantial improvements over state-of-the-art technologies and aims at the development of banks of low loss and high rejection filters in the UHF (401 - 402 MHz, 25 kHz bandwidth), S-band (2.4 - 2.483 GHz), and Ka- bands (25.25 - 27.5 GHz). Closely spaced (in frequency) narrow band (50 dB) and low insertion loss (

Second, to complement an existing software programmable radio, NASA needs to develop a compact, lightweight, multi-band (UHF, S-band, and Ka-band - see above frequencies) antenna solution that enables robust surface-to-surface communications among mobile and fixed nodes (rovers, astronauts, lander, habitat) at operational range

10 km.

Assume audio, telemetry, and high-rate video delivery transmission, bi-directional link, and 20 Mbps data rate. Assume omnidirectional and multi-band RF communications and simultaneously links to suit/vehicle and RF contingency voice on UHF - half-duplex. MEMS-enabled reconfigurable, multi-band antennas promise significant reductions in form factor, lower power consumption, and enhanced reliability. This new class of miniaturized antennas should provide high antenna gains with small aperture sizes. Smart antenna technologies with self-monitor and calibration capability are also of interest for adapting to harsh environmental threats including dust storms.

Third, this solicitation seeks to develop robust radiation sensors capable of omni-directional micro-dosimeter measurements and discriminating both charged particles and neutrons that simulate tissue volumes spanning a few 10nm to monitor crew radiation exposure in space. While current Tissue Equivalent Proportional Counters (TEPCs) are limited to measuring integral radiation effects at the cell nucleus scale (~10 μm), or at chromosome level (~1 μm), contemporary radiobiological concepts elicit differential measurements at the sub-micron scale of chromatin fiber (~25 nm) or even DNA molecule (2 nm).

Fourth, NASA needs to demonstrate robust no-power RF sensor-tag systems capable of providing identification, position and sensor data in and on aerospace vehicles through wireless interrogation and receivers up to several meters away. Systems must provide additional vehicle capability and modularity, increasing redundancy while decreasing cost and schedule as they minimize cabled connectivity to sensors. Projects must demonstrate and compare standard instrumentation approaches to no-power RF sensor-tag approaches over a vehicle life-cycle for the following: ground and flight test instrumentation, operational health and status monitoring, and control of systems.

Below are expected outcomes corresponding to the four tasks:

Phase 1:

(1) Propose a reconfigurable multi-band MEMS tunable filter solution for the above frequency bands. Develop notional architecture, conceptual approach, and implementation strategy, anticipating insertion into a future frequency-agile EVA software defined radio. Compared with traditional approaches, assess MEMS RF tunable filter trade-offs with mass, power, size, flexibility, and complexity. Offer solutions to vibration, temperature, and gravitational changes commonly associated with MEMS devices for long-duration missions.

(2) Delineate through a combination of analysis and demonstrated prototypes that the multi-band compact, lightweight, and flexible multi-band antenna solutions can achieve robust, high performance operation in a mobile environment. Conduct antenna trades on power consumption, sensitivity, form factor, weight, and reliability for a EVA UHF, S-band, and Ka- multi-band helmet-mounted option.

(3) Validate through a combination of analysis and demonstrated prototypes that the proposed TEPC detection solution can achieve robust, high performance omni-directional operation in radiation environment. Assess detectors performance and compare it with traditional approaches. Develop feasible concepts and assess technical

pitfalls/challenges of infusing this technology into the Exploration radiation monitoring program.

(4) Submit report and recommendations for follow-on applications based on test results and life-cycle cost analyses that compare the application of various no-power RF sensor-tag technologies against standard wired approaches for at least one relevant vehicle/vehicle test in NASA's Exploration Program.

Phase 2:

Leverage results in Phase 1 and demonstrate feasibility on actual hardware prototype units for space applications. To ensure robust operation and MEMS reliability, conduct testing across harsh temperature, vibration, shock, and other conditions similar for space operations and survivability.

Commercial Potential:

Broad commercial applications for channel select filter banks span cellular and wireless LAN communication links, cognitive radios, and ultra-wide band ADCs.

TEPC detectors can be harnessed in nuclear facilities; no-power RF sensor tags in aerospace industry, replacing cables between data acquisition systems and sensors.

T5.02 Algorithms for Autonomous Robotic Materials Handling

Lead Center: JSC

The focus of this subtopic is to solicit new technologies that will increase the flexibility and efficacy of robots deployed to the surface of the Moon and Mars. Robots are expected to make an important contribution to future Moon and Mars missions by decreasing the EVA time required to set up and deploy outposts, habitats, science packages, etc. An important part of this robot activity will be autonomously or semi-autonomously handling a variety of materials such as cables, connectors, solar arrays, inflatable modules, samples, payloads, and trusses. Semi-autonomous robot handling will allow these activities to be controlled from Earth so that they can take place before astronauts arrive and to continue after they leave.

Based on the above planetary applications, proposals are solicited for the development of algorithms that address one of the following:

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- Autonomous robotic grasping, manipulation, and dexterity;
 - Tool use; or
 - Combining mobility and manipulation.

Emphasis should be placed on techniques that can be effective in unmodeled or unplanned for situations. Some important issues related to autonomous robotic grasping, manipulation, and dexterity include: positioning of the manipulator and grasp contacts relative to the object, determining good manipulator configurations for grasping, adhering to grasp and task constraints on action sequencing during grasping and manipulation, using whole-arm/body contact surfaces, sensing relevant data, simultaneous sensing and action, and the control of forces during manipulation. Some important issues relating to tool use are: representing and utilizing the affordances of tools, representing the task constraints on grasp, modeling the interactions between the tool and the environment, representing the function of the tool in a larger (planetary repair) task, and using tools to adapt to contingencies imposed by the task or environment. Some important issues related to combining mobility and manipulation are: coordinating the use of mobility and manipulator DOFs to achieve a common manipulation purpose, coordinating multiple mobile manipulators so as to achieve a common goal, grasping or manipulating an object so that it can be transported.

Some areas of research and development that are expected to be relevant to the above problems are:

- Continuous or discrete control;
- Machine vision or tactile sensing; and
- Machine learning and robot development.

The proposal should target advancements in aspects of the above areas of research and development that are relevant to robotic materials handling. The proposed approach should take advantage of the specific constraints and simplifications that result from the materials handling problem.

Proposals should identify the specific problem(s) that are to be addressed and a brief outline of the proposed approach. In addition, proposals should outline a plan for testing key aspects of the approach on robotic hardware. Preference will be given to approaches that appear to be practical given realistic sensor and hardware limitations.

