



## NASA STTR 2007 Phase I Solicitation

### 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  $\mu\text{m}$ ), or at chromosome level (~1  $\mu\text{m}$ ), contemporary radiobiological concepts elicit differential measurements at the sub-micron scale of chromatin fiber (~25 nm) or even DNA molecule (2 nm).

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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:

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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.