O1.03 Game Changing Technologies

Lead Center: GRC

Participating Center(s): ARC, JSC

NASA seeks revolutionary, highly innovative, game changing technologies that have the potential to enable order of magnitude performance improvements for space communications and navigation. Fundamental, strategic R&D is a critical element in developing innovative and superior technologies for space communication and navigation systems by addressing deficiencies in the current space communications network infrastructure to enhance performance, improve efficiency and reduce cost.

Research is geared towards emphasizing research and space technologies that are far-term focused in (but not limited to) the following areas:

- **Low SWAP Transceivers**: Develop novel techniques to reduce the size, weight, and power (SWAP) requirements for communications transceivers and software-defined radios for space missions. Address SWAP challenges by addressing digital processing and logic implementation tradeoffs, static vs. dynamic power, voltage and frequency scaling, hardware and software partitioning such that operational modes are effectively managed. Use of open, interoperable standards is encouraged.

- **Ka-band RF Devices and Components**: Investigate novel RF (especially Ka-band) communications technologies and innovative approaches for high bandwidth, Ka-band devices and components (transceivers, modulators, highly efficient amplifiers, etc.). Approaches to significantly reducing size, mass, and power requirements for these components are paramount as well.

- **High Performance Ultra Low-Power ADCs and DACs**: The high power consumption and lack of flexibility to reconfigure on-the-fly make off-the-shelf analog-to digital converters (ADCs) devices ill-suited for digital radio applications. To enable next-generation radios and support the ever-increasing user demands of high resolution (6 GSPS) and input bandwidths (2.5 GHz), breakthroughs in high-speed, low power ADCs are needed. Assume dynamically adjustable resolution up to 16 bits and on-board ultra-low jitter clock circuit to enhance spectral power distribution. A deep sleep mode feature is highly desirable to conserve power. Currently, state-of-the-art high rate digital-to-analog converters (DACs) are power prohibitive. To increase robustness, spectral efficiency, and compactness, NASA seeks to develop complementary DACs. For example, at a scant total power budget of 4 watts, ADCs and DACs will facilitate breakthroughs in S-band digital transceivers with fewer parts, smaller form factors, and greater design flexibility.

- **Nanotechnology**: High-performance, multi-functional, nano-structured materials for communications applications. Single wall carbon nano-tubes exhibit extraordinary mechanical, electrical, and thermal properties at the nano-scale level and possess exceptionally high surface area to volume ratio. The development of nano-scale communication devices and systems including nano-antennas, nano-transceivers, etc. are of interest for nano-spacecraft applications.

- **Quantum Entanglement**: Innovative breakthroughs in quantum information physics has sparked interest to specifically address this phenomenon and the critical unknowns relevant to revolutionary improvements in
communicating data, information or knowledge. Methods or techniques that demonstrate extremely novel means of effectively packaging, storing, encrypting, and/or transferring information are sought.

- **RF MEMS Integrated Components**: RF micro-electromechanical systems (MEMS) offer exceptional RF performance and power characteristics that can lead to dramatic advantages for novel radio applications. Such as wireless filter banks, switching matrices, and instrumentation. Although low-power, high efficiency charge pumps can be integrated into advanced communication systems that employ novel MEMS devices (e.g. switches or varactors) or circuits (e.g. tunable filters or power amplifiers), there are some long-term challenges with power handling and non-linear behavior for power levels of 1 Watt. Because high-Q varactors and filters are not well understood, NASA seeks to advance revolutionary MEMS devices and architectures that are immune to bias noise.

- **Trans-Horizon Communications**: Innovative approaches to use of medium to high frequency (300 KHz-30MHz) bands for applications benefiting future surface landing missions. Concepts, studies, development of key technologies are needed to perform non-line-of-sight communication for potential use on the surfaces of celestial bodies. For example, the lunar exosphere may have the ability to support such communications, if fully understood. Modulation and coding techniques, antennas, solid-state amplifiers, digital baseband circuitry, etc. are required to be developed and/or validated to enable over the horizon communication and communications into craters for robotic and human missions. Range of communications on the order of 10-20 kilometers at a data rate of 128 kbps is envisioned to support many of these types of surface communications links.

- **Navigation**: In adopting any proposed game-changing technologies, the capability for provision of high-quality metric tracking observables for orbit determination and other tracking services must be considered. Proposers should recognize that NASA may not be able to adopt certain game-changers in communications and navigation technology if they do not support at least NASA's current needs for metric tracking data services. Proposals in this area should document any potential performance enhancements, and especially any foreseeable compatibility issues associated with metric tracking data services.

- **Low-Power High Stability Reference Sources**: Highly stable clocks and oscillators play a pivotal role in a myriad of space communications and navigation applications. Atomic (cesium) clocks used today have time measurement accuracies on the order of 2 nanoseconds per day. New research (optical, quantum) into improving time measurement accuracy, size, reliability for space communications and navigation are of interest. Highly stable clock sources for wireless communications devices can improve network synchronization and channel selection to enhance security and anti-jamming capabilities.

For all above technologies, research should be conducted to demonstrate technical feasibility during Phase I and show a path toward Phase II hardware and software demonstration and delivering a demonstration unit or software package for NASA testing at the completion of the Phase II contract.

**Phase I Deliverables**: Deliverables expected at the end of Phase I include trade studies, conceptual designs, simulations, analyses, reports, etc. at TRL 1-2.

**Phase II Deliverables**: Demonstrate performance of technique or product through simulations and models, hardware or software prototypes. It is expected that at the end of the Phase II award period, the resulting deliverables/products will be at or above TRL 3.