NASA SBIR 2017 Phase I Solicitation

H9.04 Advanced RF Communications

Lead Center: JPL

Participating Center(s): GRC, GSFC, MSFC

Technology Area: TA5 Communication and Navigation

This subtopic is focused on development of innovative Advanced RF Platform technologies, at the physical layer, supporting the needs of space missions in the areas of both communications and RF sensors.

In the future, robotic and human exploration vehicles with increasingly capable instruments producing large quantities of data will be investigating Earth, extraterrestrial moons, planets and asteroids. These vehicles, especially those that visit the surfaces of these myriad destinations, will be tightly constrained in the areas of mass, volume and energy. Our historical method of implementing single function elements such as short and long?range data and voice radios as well as short?range radar sensors does not lend itself to mass, volume or energy efficiencies that can support future resource challenged platforms.

One method of enhancing limited resources is to leverage recent advances in the areas of Reconfigurable Software Defined Radio (SDR) Digital Signal Processing (DSP) technologies as well as RF components, materials and packaging to create advanced multifunction RF platforms. Recent advances in high speed digital electronics, especially where clock speeds exist in the range of several GHz, have blurred the lines between what was traditionally considered “analog” and digital”. Digital signal processing techniques with multi?GHz clock rates can generate arbitrary user?defined analog waveforms at RF frequencies as never before. These waveforms, when coupled with advanced RF electronics focused on S?Band through Ka?Band frequencies, greatly improve the functionality, performance and utility of space?based communications devices. This naturally leads to advanced multi?function RF platforms; platforms that serve more than one user or function and are reconfigurable, on?demand, by the user for arbitrary applications. The commercial cellphone and wireless industries have been highly successful in developing multifunction RF and wireless platforms that serve a broad range of customers. NASA can leverage these techniques, hardware, algorithms and waveforms developed by industry for use in space applications. However, in order to leverage this increased level of configurability, functionality and performance, NASA needs to further invest in technologies for two key areas:

- Advanced waveform development in the digital domain. Specifically: the foundation has been laid through prior NASA investments in the area of generating the infrastructure for software?based algorithms. These investments led to the development and demonstration of the Space Telecommunication Radio System (STRS) architectural standard for software?defined radios. Now that the architecture has been instantiated, the next logical step in NASA’s investment portfolio is the development of actual application backend platforms and waveforms that meet this architectural standard. Advanced backend platforms generate (for transmission) or process (from reception) the appropriate waveform at a common Intermediate Frequency (IF) for transmission to, or reception from, an appropriate RF front?end. In addition, the backend processor is reconfigurable, by the user, for a specific application at a given time (radar vs. short range communications link, etc.).

- The development and demonstration of advanced RF Front?Ends that cover NASA RF bands of interest; specifically, S?Band, X?Band and/or Ka?Band. These RF front?ends may support time multiplexed waveforms such as radar or (digitized) half?duplex voice transmissions as well as frequency duplexed waveforms such as full?duplex two?way navigation and data communications. Specifically, these front?ends are expected to leverage state?of?the?art RF materials (e.g., GaN, SiC, CMOS, etc.), packaging (e.g., MIC, SMT, etc.), device (e.g., MMIC, MEMS, etc.) and component techniques to minimize mass, volume and energy resource usage while supporting multi?functionality. In implementing these multifunction RF Front?Ends, we must note that there are three key functions embedded within these front?ends that require further development:

    - *High Efficiency Microwave Power Amplifiers* - Compact, lightweight, space qualifiable Ka?band solid?state power amplifiers (SSPAs) with integrated electronic power conditioner that can deliver an output power on the order of 10 to 20 Watts (CW) with bandwidth on the order of 1% to 2% and mass less than 1 kg is of interest to NASA. In addition, low?noise amplifiers (LNAs) with noise figures on the order of a dB or less is of interest to NASA. Since overall efficiency is of paramount importance for low dc power consumption, efficiency enhancement techniques are of interest. Furthermore, SSPAs with good linearity and capable of functioning in tandem with software defined radios (SDRs) for amplifying spectrally efficient digital modulation format signals are also of interest.
    - *Electronically Steered Antennas* - Electronically steered antennas, especially at Ka?Band, are of interest. Applications include large, high?performance electronicallysteered antennas required for a dedicated communications relay spacecraft with multiple simultaneous connections, advanced multifunction antennas to support science missions that utilize a multifunction antenna to both communicate and conduct science, and small, lightweight antennas for communications only that provide moderate gain without the use of mechanical steering. Antennas that are reconfigurable in frequency, polarization, and radiation pattern that reduce the number of antennas needed to meet the communication requirements of NASA missions are desired.
    - *Ultrawideband (UWB) Antennas and Electronics* - Recent developments in commercial chipsets and antennas that implement UWB modulation techniques are of interest to NASA. Advanced signal processing techniques that can leverage investments made in the commercial communications industry for space applications as well as UWB antennas that function in the standard NASA S/X/Ka?Band frequency ranges are of interest to NASA. This includes modulation and demodulation techniques and algorithms for UWB signal transmission and reception.

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

Phase I Deliverables - Feasibility study, including simulations and measurements, proving the proposed approach to develop a given product (TRL 3?4). Verification matrix of measurements to be performed at the end of Phase II, along with specific quantitative pass-fail ranges for each quantity listed.

Phase II Deliverables - Working engineering model of proposed product, along with full report of development and measurements, including populated verification matrix from Phase I (TRL 5?6). Opportunities and plans should also be identified and summarized for potential commercialization.