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 and long 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 electronics. 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 and Ka-band frequencies, greatly improve the functionality, performance and utility of space-based communications devices. This naturally leads to advanced multifunction RF 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-defined radio 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 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
electronically steered 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 3-5). 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.