NASA SBIR 2010 Phase I Solicitation

S1.02 Active Microwave Technologies

Lead Center: JPL

Participating Center(s): GSFC, LaRC

NASA employs active sensors (radars) for a wide range of remote sensing applications (for example, see: http://www.nap.edu/catalog/11820.html). These sensors include low frequency (less than 10 MHz) sounders to G-band (160 GHz) radars for measuring precipitation and clouds and for planetary landing. We are seeking proposals for the development of innovative technologies to support future radar missions and applications. The areas of interest for this call are listed below:

- **High-density low-loss millimeter-wave packaging and interconnects** for Advanced Cloud and Precipitation Radars and Mars Landing Radars. These packing and interconnect technologies are critical to achieving the density and RF signal performance required for scanning millimeter-wave array radars.
  - Frequency: 35 - 160 GHz
  - Interconnect loss: <0.05 dB @35 GHz
  - Line loss: <0.1 dB/cm @35 GHz

- **High-speed, low-power analog-to-digital converters (ADCs) and digital-to-analog Converters (DACs)** for Advanced SAR, Advanced Interferometer for Surface monitoring, ice topography, and hydrology. Digital beam forming (DBF) systems require an array of ADCs. The power consumption of current ADC chips prohibits implementation of large DBF arrays. Furthermore, large arrays require true time delays, which can be implemented using low-power high speed ADCs and DACs. Ideal ADCs are modeled with perfectly linear input-output transfer functions. In addition to seeking novel devices, we are seeking innovative methods to correct for both differential and integral nonlinearities (DNL and INL) in ADCs to increase ADC ENOB. Proposed methods should be adaptable to a wide range of sampling rates, input frequencies, and device types; furthermore, they should be amenable to realtime operation on an FPGA.
  - Bandwidth: 1.5 GHz
  - Sampling rate: 500 MS/s
  - ENOB: 12 bits
  - Power consumption: 100 mW

- **Compact True-Time Delay Beamformers** for Advanced Cloud and Precipitation Radars, Mars Landing Radars, and Advanced SAR. Large, wideband scanned arrays require true-time-delay beamforming to avoid beam squint over operating frequency range.
  - Center Frequencies: 35, 94, 160 GHz
  - Inputs: 128
- **Loss**: <6dB
- **Mass**: < 250g

**Dual frequency Millimeter-wave transmit/receive MMICs** for Advanced SAR, Advanced Interferometer for surface monitoring, ice topography, hydrology, Advanced Cloud and Precipitation Radars, and Mars Landing Radars. Monolithic integration of TR function is required to meet space constraints for high-density arrays and to reduce assembly costs.
  - **Frequencies**: 35/94 GHz
  - **Transmit Power**: 5W@35GHz, 1W@94 GHz
  - **TX PAE**: >25%
  - **TX Gain**: >20 dB
  - **TX/RX Switch Isolation**: 40 dB
  - **RX NF**: <3 dB
  - **RX Gain**: > 20 dB
  - **Phase Shifter**: 360 deg, 6-bits

**Ultra - high efficiency P-band and L - band power amplifiers** for Advanced SAR / Interferometers, Geosynchronous SAR for earthquake monitoring, and Mars subsurface sounding. Using lower efficiency amplifiers in large arrays leads to much higher power system requirements and thermal management challenges.
  - **Frequency**: 400-500 MHz, 1.2-1.3 GHz
  - **Efficiency**: >85%

**High Efficiency Ka-band and W-band Vacuum Device Amplifiers** for Advanced Cloud and Precipitation Radars, Advanced SAR, Telecommunications. Using lower efficiency amplifiers leads to much higher power system requirements and thermal management challenges.
  - **Center Frequencies**: 35, 94 GHz
  - **Power output**: 1-5 kW (for pulsed operation); 25 W (for CW operation)
  - **Efficiency**: >50%

**Frequency selective surface at Ka and W-band** for Clouds and Precipitation, ACE Decadal Survey Mission. A Ka/W frequency selective surface will enable the development of compact dual frequency radar using a shared single aperture antenna, significantly reducing the dual radar beam pointing error, and radar development cost.
  - **High reflection at Ka-band** (35GHz) and high pass (low loss) at W-band (94 GHz).
  - **Power handling requirement**: 2 kW (peak), 100 W (average)

**FPGA based Radar Pulse Compression Technology and techniques** for Clouds and Precipitation, and ACE Decadal Survey Mission. Cloud and precipitation radars require very high system sensitivity that can be achieved using pulse compression. However, conventional pulse compression techniques cannot be used in downward-looking spaceborne and airborne radar applications due to poor range sidelobe performance.
  - **Achieves low range side lobe levels** (<-70dB), and low SNR loss. Must include methods to compensate for all sources of noise, distortion and drift in radar transmitter and receiver.
• **Radar Receiver Protector** for Clouds and Precipitation and ACE Decadal Survey Mission. Spaceborne and airborne cloud/precipitation radars require medium to high peak power transmitters in order to achieve the desired system sensitivity. High speed, low loss receiver protector is necessary to prevent RF damage of the receiver components.
  - W-band (94 GHz), Ka-band (35GHz), low loss (< 0.5 dB), high speed (transition time < 500 ns) switching radar receiver protector.

• **Technologies and techniques for noise assisted data analysis of I-Q ensemble detection** for Clouds and Precipitation, ACE Decadal Survey. Radar receiver technologies that mix in-phase and quadrature components of radar returns with calibrated-correlated noise references and noise assisted data analysis algorithms are sought to reduce the effects of platform motion on Doppler measurement and retrieval of hydrometeor drop size distribution. Pulse pair and spectral processing drive the need for a large aperture to reduce the effect of platform motion on Doppler estimates.

• **Multi-frequency compact, light weight electronically tunable antennas and radar systems** for Ice sheet sounding, subsurface exploration of planetary and near-Earth objects. Low, multi-frequency active radars are often used for ice sounding and subsurface exploration of planets, moons and near-Earth objects/bodies. The large size and narrow bandwidth of HF/VHF antennas and radars make them unsuitable for many applications. Compact, light weight electronically tunable antennas and radar systems will enable a range of missions.
  - Compact, light weight, electronically tunable antennas, and radars units to make up basic building blocks of transmission-reflection tomography radars.
  - Tunable Frequency Ranges:
    - 3-30 MHz, 25-100 MHz
    - VSWR: <2:1
    - Length: <6m, conformable to aircraft or spacecraft
    - Gain: >0 dBi
    - Power handling: >200W