



NASA SBIR 2016 Phase I Solicitation

S1.02 Microwave Technologies for Remote Sensing

Lead Center: JPL

Participating Center(s): GSFC

NASA employs active (radar) and passive (radiometer) microwave sensors 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, for planetary landing, upper atmospheric monitoring, and global snow coverage, topography measurement and other Earth and planetary science applications. We are seeking proposals for the development of innovative technologies to support these future radar and radiometer missions and applications. The areas of interest for this call are listed below.

Single Pole Double Throw Switch with the following specifications:

- Frequency: 183 GHz, 325 GHz, or 380 GHz.
- Bandwidth: > 15 GHz.
- Insertion Loss: < 2 dB.
- Isolation: > 15 dB.

Calibration of sub-mm wave radiometers is limited in large part to external sources due to the lack of suitable switches for internal calibration. This increases the mass and cost of these instruments. A SPDT switch at 180 or 340 GHz will significantly reduce the cost and complexity of radiometers at these frequencies.

NEW: GaN Schottky diode technology for ultra-high power local oscillator power sources

This includes the development of GaN epi-structures on Si or SiC substrates suitable for millimeter-wave operations (SOA electron mobility >1000 cm²/V·s for 5E16 to 1E17 cm⁻³ epi doping levels, and discrete GaN Schottky diodes (power handling capabilities > 200 mW/diode).

Technology for compact Dual Frequency (Ka and W-band) quasi-optical radar front end

W-band (94 GHz +/- 50 MHz):

- Single Polarization Tx, Dual Polarization Rx using a quasioptical duplexer such as a faraday rotator.

Ka-band (35.5 GHz +/- 100 MHz):

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- Dual Polarization Tx and Rx.
 - Shared beam waist with W-band.
 - Waveguide duplexer and OMT okay.

The Decadal Survey ACE mission calls for a dual-frequency (Ka/W-band) radar for observation of clouds and light precipitation from space. Recently a similar but more compact and low cost radar is considered for operation on the International Space Station (ISS). Compared to traditional ferrite material based radar Tx/Rx front-end, quasi-optical front-end offers significantly low loss and high power handling capability, which have direct impact on radar performance. A compact dual-frequency and dual-polarization quasi-optical radar front-end has not been developed and is in critical need for ISS, ACE and suborbital airborne radars.

Interconnection technologies to enable highly integrated, low loss distribution networks that integrate power splitters, couplers, filters, and/or isolators in a compact package

Technologies are sought that integrate X, Ku, and Ka-bands transmit/receive modules with antenna arrays and/or LO distribution networks for F- and/or G-band receiver arrays.

Dual-frequency (Ka/W-band), dual polarization compact quasi-optical front-end for cloud radars.

- Freq: 35.5 GHz \pm 100MHz.
- 94 GHz \pm 100MHz.
- Loss: < 0.5 dB.
- Polarization Isolation: > 30 dB.
- Polarization: V and H.

640 GHz Heterodyne Polarimeter with I, Q, U Channels

Current 640 GHz polarimetric radiometers are either unsuitably large for space in terms of Mass/Volume/Power, or are direct-detection instruments that lack the ability to reject ozone emission contamination by selectively filtering the signal in the IF stages. This technology would help enable polarimetric measurements to provide microphysical parameterization of ice clouds applicable to ACE.

Low power RFI mitigating receiver back ends for broad band microwave radiometers

NASA requires a low power, low mass, low volume, and low data rate RFI mitigating receiver back end that can be incorporated into existing and future radiometer designs. The system should be able to channelize up to 1 GHz with 16 sub bands and be able to identify RFI contamination using tools such as kurtosis.

Compact 10+ Watt W-band transceiver including:

- SSPA, LNA, Circulator, and receiver protection switches.
- Mixer and 2 GHz Band-Pass Filter.
- 10-Watt SSPA, <1 dB transmit loss, 7 dB Rx Noise Figure.
- Approximately 3.5" x 3.5" x 4" dimensions.

NEW: Compact, highly integrated technologies enabling Altimetry/Velocimetry for space qualified radars

- Frequency: C-band to K-band.
- 0.2% range and 1% velocity accuracies.
- Operating range 6000m to 0 m.
- Compact antenna development.
- Integrated digital backend.
- Highly integrated MMIC for radar systems/subsystems.
- < 3kg and 1U (10 x 10 x 3 cm³) for electronics.

Deployable 1-D Parabolic Antenna

- At least 2 m x 2 m in dimensions.
- Operable up to Ka-band (35.5 GHz).

Deployable 1-D parabolic antenna technology at Ka-band will allow higher gain and better spatial resolution for future flight precipitation measurement missions.

Technology for low-power, rad-tolerant broad band spectrometer back ends for microwave radiometers

Includes - digitizers with 20 Gsps, 20 GHz bandwidth, 4 or more bit and simple interface to FPGA; ASIC implementations of polyphase spectrometer digital signal processing with ~1 watt/GHz. Current FPGA based spectrometers require ~10 W/GHz and are not flight qualifiable. High speed digitizers exist but have poorly designed output interfaces. Specifically designed ASICs could reduce this power by a factor of 10.

A compact, broadband (6-12 GHz or 10-30 GHz), low insertion loss isolator

- < 0.3 insertion loss.
- 20 dB input and output return loss.

The isolator should be compatible with either microstrip or CPW for ease of transition with the rest of the system.

Ka-band Power Amplifier for CubeSats

- $F = 35.7 \text{ GHz} \pm 200\text{MHz}$.
- Volume: <1U (10 x 10 x 10 cm³).
- $P_{\text{sat}} > 32\text{W}$.
- Gain > 35 dB.
- PAE > 20%.
- Pulsed, 12% duty cycle.
- Current state of the art amplifiers are limited to 7W at < 15% efficiencies.

Development of on-wafer high frequency probes above 300 GHz for cryogenic temperatures

Passive or active cooled space missions will benefit from early performance characterization and selection at operating temperatures. The conventional test on individual packaged components is expensive and time consuming.

Advanced Deployable Antennas for CubeSats

- $F = 35.7 \text{ GHz} \pm 200\text{MHz}$ capable of 1D scanning.
- $F = 94.05 \text{ GHz} \pm 50\text{MHz}$.
- Aperture size = 2 m.
- Gain > 48dB @36GHz.
- Sidelobe ratio > 20dB.
- Stowed volume: <2.5U (25 x 10 x 10 cm³).
- Polarization: Linear.

Components for addressing gain instability in LNA based radiometers from 100 and 600 GHz

NASA requires low insertion loss solutions to the challenges of developing stable radiometers and spectrometers operating above 100 GHz that employ LNA based receiver front ends. This includes noise diodes with ENR>10dBm and with better than ±0.01 dB/°C thermal stability when integrated with a proper electrical circuit, Dicke switches with better than 30 dB isolation, phase modulators, and low loss isolators along with fully

integrated state-of-art receiver systems operating at room and cryogenic temperatures.

NEW: Wideband Antenna Technologies for GPRs

- Conformal / planar.
- 0.1 - 3 GHz bandwidth.
- Separate tx/rx with high isolation (> 30 dB).