NASA SBIR Select 2014 Phase I Solicitation

S20.01 Array Technologies for Microwave Remote Sensing

Lead Center: JPL

Participating Center(s): GSFC

Two of the key challenges for microwave remote sensing (active and passive) of the Earthâ€™s environment are:

- Obtaining measurements of sufficiently high resolution such that in-pixel averaging affects do not introduce errors or otherwise obscure the phenomena being measured.
- Providing wide-area coverage such large scale systems can be studied synoptically and revisit times are sufficiently small to study phenomena with relatively rapid changes.

Unfortunately, both are generally at odds with each other. For traditional fixed-beam antenna systems, improvement of resolution necessarily leads to a reduction in coverage. In order to achieve desired coverage and resolution array antenna and sensor technologies can be employed. This may take different forms, depending upon the application. For radar systems, active, electronically-steered phased arrays can provide beam agility that can be used to cover wide swaths with high resolution and can also be used to dynamically target phenomena of interest, maximizing the value of sampling time and on-orbit assets. For passive remote sensors, highly-thinned correlating radiometer arrays can provide high spatial resolutions over a wide areas and focal-plane arrays can be used to bring camera-like properties usually associated with visible-light and IR measurements to sub-millimeter wavelengths.

The range of techniques described above will enhance and enable a variety of important Earth science measurements including: Surface deformations (volcanos, fault motion, subsidence), ice sheet thickness and dynamics, atmospheric phenomena such as precipitation, clouds and atmospheric water vapor.

The specific technologies solicited are:

- *Ku/Ka-band electronically-scanned linear arrays* - The impacts of clouds and precipitation represent some of the greatest uncertainties in current climate models. The complex interactions in cloud and precipitation systems dictate that they be studied as a whole, whereas previous mission have only been able to study clouds and precipitation separately. To study the complete system at the appropriate spatial scales with adequate resolution requires simultaneous scanning array technology at a range of microwave and millimeter-wave wavelengths.
    - Frequencies (simultaneous): 13.4, 35.6, 94 GHz
    - Array element spacing (typ.): 0.65 wavelengths
    - Transmit power per element (Ku/Ka): 25/5/1 W
    - Transmit efficiency: as high as possible consistent with state-of-the-art

    - Front-end losses as low as possible
    - Manufacturing scalable to 2-3 m long arrays.
- *Low Frequency RF Tomography Technology for Global Biomass and Ice Sheet Investigations* - Global biomass and ice sheet investigations require a simple space borne low frequency (100-500 MHz) multi-channel altimeter that can measure 3-D tomography images of the Earth above ground biomass and ice sheet thickness. Doppler beam sharpening (SAR processing) will be used to obtain high spatial resolution along the track and multi-channel altimeters along the cross track will be used for obtaining high resolution in the cross track direction.

Phase I Studies Requirements:

- Design and feasibility study of low frequency array antenna mounted along the wings of NASAs P3 like aircraft. Design must satisfy both electromagnetic and aerodynamic performances. Frequency of operation: 300 MHz, Bandwidth 50 MHz, Linear/Dual polarized.
- Design of RF front end and base band processing units for each altimeter channel that are phase locked with each other.
- Feasibility study of using multi-channel altimeter for 3-D tomography imaging of biomass and ice sheets through simulated data.

Phase II Studies Requirements:

- Hardware realization of design completed in Phase I studies.
- Integration of antenna and other electronics with the selected aircraft (need not be NASAs P3).
- Field campaign to advance technology to TRL 6.
- P-, L-band Array Antennas:
    - Innovative designs for deployable lightweight antenna arrays for airborne and space borne SAR applications are required. The array designs should meet flatness requirements, minimize stowed volumes and provide robust deployment mechanisms. The array RF performance should support < 20% bandwidth, dual-polarization, high polarization isolation (> 30 dB) phased array radar applications. The use of composite materials that can reduce the antenna weight and maintain surface flatness is desirable.
- Low Power Digital Correlator Systems for Synthetic Aperture Arrays:
    - Currently this is the key required element for the array on PATH. Several technology programs are under way, but a working, high TRL system is not yet available.

Phase I - Design and feasibility study of crosscorrelators with 2-bit resolution operating at 1 GHz clock speed. This includes the digitization and digital crosscorrelation functionality for correlation of 3x128 I-Q receiver outputs from three arms of the instrument.

Power consumption is a major driver for the system, most likely only to be achieved by using ASIC chips. The correlator design will include housing and thermal design to demonstrate feasibility for operation in vacuum.

Phase II - Implementation and testing of the correlator system. This includes desing, manufacture and functional and thermal testing of the correlator system. Testing of the system in a interferometer system, such as JPL GeoSTAR testbed will demonstrate the performance in a real instrument.