NASA SBIR Select 2014 Phase I Solicitation

S20 Science Mission Directorate Select Subtopics

Subtopics

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:Â

- 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.Â

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.Â

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.Â

The specific technologies solicited are:Â

- *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.Â

Phase I Studies Requirements:Â

- 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.Â

Phase II Studies Requirements:Â

- 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.Â

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.Â

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.Â

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.

S20.02 Novel Spectroscopy Technology and Instrumentation

Lead Center: GSFC

Participating Center(s): JPL

In astrophysics, science instruments are â€œphoton starvedâ€. Every photon has to count.

Efficient use of light and maximizing signal-to-noise is critical and there is always room for improvement. In many high-resolution spectroscopy systems as much as 50% of the light is lost in the spectrometer optics before it gets to the detectors. It is far more cost-efficient to improve detection systems in terms of throughput, efficiency, resolution, and noise than to compensate by making the payload larger. Spectroscopy is applicable in the UV, visible, IR. In terms of instrumentation, answers to higher photon efficiency can be answered through entire novel instrument (system designs) to single components (filters, grisms, gratings, etc.)Â

Transit Spectroscopy, multi-object spectrographs, slit and slit-less spectrographs and associated component and subsystem technologies such as grisms, filters, etalons, etc. enable higher performance and more efficient use of the light collected. High-resolution spectroscopy for galaxy evolution, exoplanet spectroscopy for deciphering the chemical composition of exoplanetary atmospheres. High resolution spectroscopy in UV, Visible, and IR.

Specific areas of research include:Â

- Image slicers. Imager slicers are stacks of optics that `slice' a field into separate regions and remap them into a pseudo-slit (or slits) that are then fed into a traditional spectrograph. This design can be used to produce an efficient imaging spectrograph that has a high fill factor. Micromirror and lenslet-based integral field spectrographs have a very low fill factor by comparison (less efficient use of pixels by a factor of 4).
- Micromirror arrays. Micromirror arrays work similarly to lenslet arrays in that they compress the light from a single spatial location into a focused spot. UV wavelengths however require micromirror arrays because refractive optics will not work. In addition, micromirror arrays can operate over broad bandpasses without producing chromatic aberrations.
- Improved dichroic filters. Dichroic filters reflect a certain bandpass and transmit another wavelength. Improved dichroic filters would enable more efficient use of separate science instruments or a single multi-band imaging instrument.
- Lenslet-coupled fiber optics for space flight. Fiber-fed lenslet arrays could also be used to produce a pseudo-slit in a similar way to the image slicers. The fiber-coupling losses and problems with packing the fibers closely due to the cladding have precluded their use.
- Improved Fabry Perot etalons. Fabry Perot etalons are some of the highest resolution spectrometers that are used for instrumentation but they suffer from high loss and large size that make them difficult to implement for space. Improvements in size and efficiency are sought for Fabry Perot etalons.
- Improved gratings.
- On chip hyperspectral imaging systems. Hyperspectral imaging is an area of continued interest in particular to Earth Science for applications such as agriculture and land use. These systems tend to be complex and difficult to implement. Approaches to integrate the hyperspectral filtering with the detector are sought.

S20.03 Radiation Hardened Application Specific Integrated Circuit (ASIC) Platforms

Lead Center: GSFC

Participating Center(s): JPL, MSFC

Ambitious science goals along with budgetary constraints are driving the need to increase the science return from smaller mission classes. This has led to new interest in cubesats and smallsats as viable science platforms. To enable capable science with these smaller missions, there is a critical need to miniaturize instruments, as well as spacecraft subsystems. To this end, this subtopic solicits the development of a radiation hardened structured-ASIC platform to implement flexible instrument processing nodes. This technology would enable integration of all digital functions of an instrument onto a single device, and would also enable similar integration of spacecraft bus digital functions for a cubesat or a smallsat.Â

As flexible instrument processing nodes would reduce board-level assemblies into individual integrated circuits, the overall size/mass/power savings provided to a mission would be dramatic. A sampling of candidate mission applications for this technology includes:Â

- Miniaturized planetary instruments such as magnetometers and imagers.
- Highly capable heliophysics cubesats along with miniaturized instruments to measure field and particles.
- Earth observing smallsats and miniaturized instruments.

- Low power channel readout electronics for astrophysics mission concepts require data acquisition and processing for hundreds or even thousands of individual channels.Â

If broadly applied, the flexible instrument processing nodes may enable currently roadmapped science observations to be implemented in smaller mission classes than are currently planned.Â

To effectively support this broad array of applications, it is imperative that flexible instrument processing nodes be implemented such that customization for specific instruments and missions is both rapid and economical. Historically, the high cost and long development schedule of spaceflight ASICs has largely precluded them from use for mission specific applications. However, the emergence of radiation hardened structured-ASICs has the potential to change this paradigm, and as such, this is the specified platform for the flexible instrument processing node.Â

This processing node will require an aggressive adoption of System-On-a-Chip (SOC) technology, which will provide substantially more resources than are presently available. Target specifications for the platform are; embedded 32-bit processor, 50,000 logic cells, 4Mbit of embedded RAM, 500kbit embedded ROM, and 400 user I/O. While dependent on the user design, maximum clock rates of at least 200MHz and maximum power dissipation of less than 500mW are desirable. As previously stated, it is desired that the node be implemented as a high capacity radiation hardened structured-ASIC platform that can enable highly integrated, instrument specific device implementations, while offering up to a 10x reduction in development cost and schedule as compared to full custom ASICs. Environmental specifications are; radiation hard to at least 1 Mrad TID, latch up Immune to an LET of at least 80, and a device SEE rate of not greater than 0.01 event/day in Adams 90% worst case GEO environment. For descriptions of radiation effects in electronics, the proposer may visit (http://radhome.gsfc.nasa.gov/radhome/background.htm).Â

Proposals should clearly describe:Â

- The top-level device architecture.
- Individual circuit elements.
- The routing scheme.
- Methodologies for radiation hardening.
- Overall device capacity.
- Expected performance and power dissipation.
- Fabrication process and mask programming steps.
- Software tool flow for user designs.

Successful proposal concepts should significantly advance the state-of-the-art. If a Phase II proposal is awarded, the combined Phase I and Phase II developments should produce prototype devices that can be evaluated by NASA.Â

It should be noted that NASA can sponsor fabrication via the Trusted Access Program Office (TAPO) for this effort.