NASA SBIR 2009 Phase I Solicitation

S1 Sensors, Detectors and Instruments

NASA's Science Mission Directorate (SMD) (http://nasascience.nasa.gov/) encompasses research in the areas of Astrophysics (http://nasascience.nasa.gov/astrophysics), Earth Science (http://nasascience.nasa.gov/earth-science), Heliophysics (http://nasascience.nasa.gov/heliophysics), and Planetary Science (http://nasascience.nasa.gov/planetary-science). A major objective of SMD instrument development programs is to implement science measurement capabilities with smaller or more affordable spacecraft so development programs can meet multiple mission needs and therefore make the best use of limited resources. The rapid development of small, low-cost remote sensing and in situ instruments is essential to achieving this objective. For Earth Science needs, in particular, the subtopics reflect a focus on instrument development for airborne and Unmanned Aerial Vehicle (UAV) platforms. Astrophysics has a critical need for sensitive detector arrays with imaging, spectroscopy, and polarimetric capabilities which can be demonstrated on ground, airborne, balloon, or suborbital rocket instruments. Heliophysics, which focuses on measurements of the sun and its interaction with the Earth and the other planets in the solar system, needs a significant reduction in the size, mass, power, and cost for instruments to fly on smaller spacecraft. Planetary Science has a critical need for miniaturized instruments with in situ sensors that can be deployed on surface landers, rovers, and airborne platforms. For the 2009 program year, we are actively encouraging proposal submissions for subtopic S1.10 that solicits technology for geodetic instruments and instruments to enable global navigation and very long baseline interferometry. A key objective of this SBIR topic is to develop and demonstrate instrument component and subsystem technologies that reduce the risk, cost, size, and development time of SMD observing instruments and to enable new measurements. Proposals are sought for development components that can be used in planned missions or a current technology program. Research should be conducted to demonstrate feasibility during Phase 1 and show a path towards a Phase 2 prototype demonstration. The following subtopics are concomitant with these objectives and are organized by technology.

Subtopics

S1.01 Lidar and Laser System Components

Lead Center: LaRC

Participating Center(s): GSFC

Accurate measurements of atmospheric parameters with high spatial resolution from ground, airborne, and space-based platforms require advances in the state-of-the-art lidar technology with emphasis on compactness, efficiency, reliability, lifetime, and high performance. Innovative lidar component technologies that directly address the measurements of the atmosphere and surface topography of the Earth, Mars, the Moon, and other planetary bodies will be considered under this subtopic. Frequency-stabilized lasers for a number of lidar applications as well as for highly accurate measurements of the distance between spacecraft for gravitational wave astronomy and gravitational field planetary science are among technologies of interest. Innovative technologies that can expand current measurement capabilities to spaceborne or Unmanned Aerial Vehicle (UAV) platforms are particularly desirable. Development of components that can be used in planned missions or current technology programs is highly encouraged. Examples of planned missions and technology programs are: Deformation, Ecosystem Structure and Dynamics of Ice (DESDynI), Laser Interferometer Space Antenna (LISA), Doppler Wind Lidar, Lidar for Surface Topography (LIST), or earth and planetary atmospheric composition (ASCENDS).

Research should be conducted to demonstrate technical feasibility during Phase 1 and show a path toward a Phase 2 prototype demonstration. For the PY09 SBIR Program, we are soliciting only the specific component technologies described below.

- High speed fiber multiplexers for multimode fiber (200 micron core, 0.22 NA) operating at 1 micron wavelength. We require an N by M de-multiplexer (where M is 32 or greater and N is 2) capable of switching at speeds on the order of 10 microseconds with low insertion loss (
- Space-qualifiable high reliability frequency-stabilized CW laser source with 2 W output power at 1064 nm. A master oscillator power amplifier (MOPA) configuration is desirable since the source must be phase-modulated.
- Fiber-coupled pulse compressor device for 1064 nm and 532 nm for reducing 4-6 ns level pulses to sub-ns (0.4 - 0.6 ns) pulses, capable of input pulse energies > 2 mJ.
- Efficient and compact single frequency, near diffraction limited semiconductor lasers (interband cascade laser or quantum cascade lasers) operating in mid-infrared (3 - 4 Âµm). Requirements include room temperature operation, and pulsed lasers with repetition rates on the order of 10 KHz and pulse energies greater than 0.5 mJ. CW lasers in multiwatt regimes are applicable. Wavelength tunability over 10s of nanometers is desirable for certain applications.
- Efficient and compact single mode solid state or fiber lasers operating at 1.5 and 2.0 micron wavelength regimes suitable for coherent lidar applications. These lasers must meet the following general requirements: pulse energy 0.5 mJ to 50 mJ, repetition rate 10 Hz to 1 kHz, and pulse duration of approximately 200 nsec.
- Single frequency semiconductor or fiber laser generating CW power in 1.5 or 2.0 micron wavelength regions with less than 10 kHz linewidth. Frequency modulation with about 5 GHz bandwidth and wavelength tuning over several nanometers are desirable.
- Development of efficient, compact, and space qualifiable laser absorption spectrometry-related technologies for measuring atmospheric pressure and density. Remote sensing of oxygen in the 1.26 micron or 760 nm spectral region for measuring atmospheric pressure is of particular interest.
- Photon counting detectors (single element and/or multi-element detector array) at near-IR (1 - 1.8 Âµm) and mid-IR (3 - 4 Âµm) with single photon sensitivity.

Proposals should show an understanding of one or more relevant science needs, and present a feasible plan to fully develop a technology and infuse it into a NASA program.

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 (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. 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 or 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.Desired performance specifications include:

- Frequency: 35 - 160 GHz
- Performance at 35 GHz:
  - Interconnect loss:
  - Line loss:

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 or 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 are easily implemented using low-power, high speed ADCs and DACs. Desired performance specifications include:

- Analog Input Bandwidth: 1.3 GHz
- Sampling rate: 500 MS/s
- Resolution 12 bits
- Power consumption: 100 mW

High performance miniature bandpass filters for SMAP, Aquarius follow-on, DESDynI, or Advanced L-band SAR and interferometers. The size of current filters allows for implementation of near-term missions with (with volume and mass penalties) but filter size constrains RF system architectural choices.Desired performance specifications include:

- Center Frequencies: 1.2 - 36 GHz
- Bandwidth:1%
- Loss:
- Isolation: >30 dB
- Volume: 3

High-performance mm-wave integrated circuits (MMICs) for Advanced SAR, advanced interferometer for surface monitoring, ice topography, hydrology, advanced cloud and precipitation radars or Mars landing radars. Besides packaging, performance of MMICs is the main road block to development of electronically scanned arrays at 94 GHz and higher. Desired specifications/technologies include:

- Frequencies: 94 - 350 GHz
- Device types: Lower Noise Amplifiers, Power Amplifiers, Mixers, Oscillators, Phase Shifters, Switches

Ultra-high efficiency L-band power amplifiers for Advanced SAR/Interferometers or geosynchronous SAR for earthquake monitoring. Using lower efficiency amplifiers in large arrays leads to much higher power system requirements and thermal management challenges.Desired performance specifications include:

- Frequency: 1.2 - 1.3 GHz
- Efficiency: >85%

P-band stretch processing imaging radar antennas and transceivers with bandwidth > 100 MHz for airborne SAR applications for Biomass/ecosystems. Wideband P-band radar systems require low power transmitters with high processing gain to avoid interference with other services.Furthermore, achieving fine range resolution will require novel wideband airborne antennas.

Small radar packaging concepts for Unmanned Aerial Systems (UAS) for Biomass (P), soil moisture and ocean salinity (L, and C), or snow water equivalent (X, Ku, and Ka). Miniaturization of radar and radiometer components while maintaining power and performance is a requirement for UAV science.Desired performance specifications include:

- Mass: 1.5 lb - 35 lb
- Frequency: P-band, L-band, C-band, X-band, Ku -band, and Ka-band
- High Efficiency SSPAs: > 70% efficiency (P, L and C), > 20% (ka)

High power/high efficiency Ka-band and W-band solid state and TWT amplifiers for Aerosol/Cloud/Ecosystems (ACE) Mission. Spaceborne applications require higher power and efficiency than currently available. Desired performance specifications include:

- SSPA power: > 10 W (Ka-band) and > 2 W (W-band)
- TWT power: > 1kW (Ka-band) and > 200 W (W-band)
- Efficiency: > 20%.
- Phase Linearity:

Simultaneous, multi-frequency U-band transceivers, frequency converters, and amplifiers for airborne/spaceborne applications for barometric pressure measurements in support of NASA/NOAA hurricane science, NWS/aviation weather or decadal survey missions. Currently available airborne and space-qualified U-band (50 - 60 GHz) transceiver and components do not support simultaneous operation at multiple frequencies within the band.

Wide bandwidth, U-band antennas for airborne/spaceborne applications for barometric pressure measurements in support of NASA/NOAA hurricane science, NWS/aviation weather, or decadal survey missions. Currently available antennas do not compensate for wide bandwidth (50 - 60 GHz) operation; consequently, main beam characteristics (e.g.,beamwidth, gain, pointing angle, polarization, etc.) vary according to frequency. The need is for a light-weight, aviation/space-qualifiable antenna capable of operating over 50 - 60 GHz without significant variation in main beam characteristics.

Membrane materials for large inflatable membrane antennas for remote sensing applications for earth and planetary science missions. Reflectors manufactured from polymer films could enable greater packaging efficiencies due to their low mass, high packaging efficiencies, solar radiation resistance, and cryogenic flexibility.However, these polymer films must also exhibit near zero CTE and stability in the space environment, as well as be deployable wrinkle free. Innovative intrinsically electroactive polymer membrane actuation mechanisms that can reduce the bulk of traditional active control systems are also of interest. Proposals for remote sensing antenna membrane materials technology are being solicited and should be submitted to subtopic "O1.02 - Antenna Technologies" in the Space Operations portion of this solicitation. Such proposals should indicate that they are applicable to remote sensing antennas.

Composite materials for large deployable antenna reflector structures for remote sensing applications for earth and planetary science missions. These antennas will require high specific stiffness composite materials that can be packed compactly and deployed multiple times for ground evaluation of the antenna structure prior to launch and deployment in space. The deployment of these materials should require low energy. Proposals for remote sensing antenna composite materials technology are being solicited and should be submitted to subtopic "O1.02 - Antenna Technologies" in the Space Operations portion of this solicitation. Such proposals should indicate that they are applicable to remote sensing antennas.

Proposals should show an understanding of one or more relevant science needs, and present a feasible plan to fully develop a technology and infuse it into a NASA program.

S1.03 Passive Microwave Technologies

Lead Center: GSFC

Participating Center(s): JPL

NASA employs passive microwave and millimeter-wave instruments for a wide range of remote sensing applications from measurements of the Earth's surface and atmosphere (http://www.nap.edu/catalog.php?record_id=11820) to cosmic background emission. Proposals are sought for the development of innovative technology to support future science and exploration missions employing 450 MHz to 5 THz sensors. Technology innovations should either enhance measurement capabilities (e.g., improve spatial, temporal, or spectral resolution, or improve calibration accuracy) or ease implementation in spaceborne missions (e.g., reduce size, weight, or power, improve reliability, or lower cost). While other concepts will be entertained, specific technology innovations of interest are listed below for missions including decadal survey missions (http://www.nap.edu/catalog/11820.html) such as PATH, SCLP, and GACM and the Beyond Einstein Inflation Probe (Inflation Probe (cosmic microwave background, http://universe.nasa.gov/program/probes/inflation.html).

- Low power >200 Mb/s 1-bit A/D converters and cross-correlators for microwave interferometers. Earth Science Decadal survey missions which apply: PATH, SCLP.
- Automated assembly of 180 GHz direct conversion I-Q receiver modules. This technology applies to both the Beyond Einstein Inflation probe and the Decadal Survey PATH concept.
- Low DC power spectrometer (channelizer) covering >500 MHz with 125 kHz resolution for planetary radiometer missions and covering 4 GHz with 1 MHz resolution for Earth observing missions. Also RFI mitigation approaches employing channelizers for broad band radiometers. Earth Science Decadal Survey mission which applies: GACM
- RF (GHz to THz) MEMS switches with low insertion loss (18 dB), capable of switching with speeds of >100 Hz at cryogenic temperatures (below 10 K) for 10^8 or more cycles. Technology applies to Beyond Einstein Probe.
- High emissivity (>40 dB return loss) surfaces/structures for use as onboard calibration targets that will reduce the weight of aluminum core targets, while reliably improving the uniformity and knowledge of the calibration target temperature. Earth Science Decadal survey missions which apply: SCLP and PATH.

- MMIC Low Noise Amplifiers (LNA). Room temperature LNAs for 165 to 193 GHz with low 1/f noise, and a noise figure of 6.0 dB or better; and cryogenic LNAs for 180 to 270 GHz with noise temperatures of less than 150K. Earth Science Decadal Survey missions that apply: PATH and GACM.

- Low loss, low RF power waveguide SPDT diode switches and active noise sources for frequencies above 90 GHz to support calibration of SWOT and other atmospheric temperature and humidity measurements.

- Broad band 180 - 270 GHz radomes for aircraft borne submillimeter remote sensing instruments.

Proposals should show an understanding of one or more relevant science needs, and present a feasible plan to fully develop a technology and infuse it into a NASA program.

S1.04 Sensor and Detector Technology for Visible, IR, Far IR and Submillimeter

Lead Center: JPL

Participating Center(s): ARC, GSFC, LaRC

NASA is seeking new technologies or improvements to existing technologies to meet the detector needs of future missions, as described in the most recent decadal surveys for Earth science (http://www.nap.edu/catalog/11820.html), planetary science (http://www.nap.edu/catalog/10432.html), and astronomy and astrophysics (http://www.nap.edu/books/0309070317/html).

The following specific technologies are of interest for instrument concepts such as Scanning Microwave Limb Sounder (http://mls.jpl.nasa.gov/index-cameo.php) on the Global Atmospheric Composition Mission, Climate Absolute Radiance and Refractivity Observatory (http://science.hq.nasa.gov/earth-sun/docs/Volz4_CLARREO.pdf), Methane Trace Gas Sounder, Single Aperture Far Infrared (SAFIR) Observatory (http://safir.jpl.nasa.gov/technologies.shtml), and Inflation Probe (cosmic microwave background, http://universe.nasa.gov/program/probes/inflation.html):

- New or improved technologies leading to measurement of trace atmospheric species (e.g., CO, CH_4, N_2O) from geostationary and low-Earth orbital platforms. Of particular interest are new techniques in gas filter correlation spectroscopy, Fabry-Perot spectroscopy, or improved component technologies.

- Uncooled or passively cooled detectors with specific detectivity (D*) >= 1010 cm Hz1/2/W in the operating wavelength ranges 6-14 Âµm and 10-100 Âµm.

- Efficient, flight qualifiable, spur free, local oscillators for SIS mixers operating in low earth orbit. Two bands: (1) tunable from 200 to 250 GHz, and (2) tunable from 600 to 660 GHz, phase-locked to or derived from an ultra-stable 5 MHz reference.

- Sideband separating SIS mixer with RF band from 580 to 680 GHz, IF band from 6 to 18 GHz, image rejection greater than 10 dB, and receiver noise temperature less than 300 Kelvin. Thermal load on 4 K and 15 K stage must be less than 4 and 30 mW respectively. Application: GACM.

- Quantum cascade laser-based local oscillators for astrophysics applications (2nd generation SOFIA instruments, SAFIR).

- Technologies for calibrating millimeter wave spectrometers for spaceborne missions, including low power, flight qualifiable comb generators and low noise diodes for the bands from 180 to 270 and 600 to 660 GHz; very low return loss (70 dB or better) calibration targets and techniques for quantifying and calibrating out the impact of standing waves in broadband heterodyne submillimeter spectrometers.
- Low power, stable, linear, spectrometers capable of measuring the band from 6-18 GHz with ~120 100 MHz wide channels.
- Digital spectrometers with ~4 GHz bandwidth and 10 MHz resolution. Components for these digital spectrometers including high speed digitizers, efficient spectrometer firmware, and ASIC implementations.
- Spatial Filter Array (SFA) consisting of a monolithic array of up to 1200 coherent, polarization preserving, single mode fibers that operate over a large fraction of the spectral range from 0.4 - 1.0 microns and such that each input and output lenslet is mapped to a single fiber. Uniformity of output intensity and high throughput is desired and fiber-to-fiber placement accuracies of http://planetquest.jpl.nasa.gov/TPF/tpf_index.cfm) and Stellar Imager (http://hires.gsfc.nasa.gov/si/).
- High resolution wedged filters with resolving powers of 1,000 to 5,000 in the visible to short wave infrared spectral region. Of particular interest are filters in the 1 to 3.5 micron range.

Proposals should show an understanding of one or more relevant science needs, and present a feasible plan to fully develop a technology and infuse it into a NASA program.

S1.05 Detector Technologies for UV, X-Ray, Gamma-Ray and Cosmic-Ray Instruments

Lead Center: GSFC

Participating Center(s): JPL, MSFC

This subtopic covers detector requirements for a broad range of wavelengths from UV through to gamma ray for applications in Astrophysics, Earth science, Heliophysics, and Planetary science. Requirements across the board are for greater numbers of readout pixels, lower power, faster readout rates, greater quantum efficiency, and enhanced energy resolution.

The proposed efforts must be directly linked to a requirement for a NASA mission. These include Explorers, Discovery, Cosmic Origins, Physics of the Cosmos, Vision Missions, and Earth Science Decadel Survey missions. Details of these can be found at the following URLs:

General Information on Future NASA Missions: http://www.nasa.gov/missions

Specific mission pages:

EXIST: http://exist.gsfc.nasa.gov/

IXO: http://htxs.gsfc.nasa.gov/index.html

Future planetary programs: http://nasascience.nasa.gov/planetary-science/mission_list

Earth Science Decadel missions: http://www.nap.edu/catalog/11820.html

Helio Probes: http://nasascience.nasa.gov/heliophysics/mission_list

Specific technology areas are listed below:

- Significant improvement in wide band gap semiconductor materials, individual detectors, and detector arrays for operation at room temperature or higher for missions such as EXIST, Geo-CAPE and planetary science composition measurements.

- Highly integrated, low noise (
- Large formal UV and X-ray focal plane detector arrays: microchannel plates, CCDs, and active pixel sensors (>50% QE, 100 Megapixels,
- Advanced Charged Couple Device (CCD) detectors, including improvements in UV quantum efficiency and read noise, to increase the limiting sensitivity in long exposures and improved radiation tolerance. Electron-bombarded CCD detectors, including improvements in efficiency, resolution, and global and local count rate capability. In the X-ray, we seek to extend the response to lower energies in some CCDs, and to higher, perhaps up to 50 keV, in others. Possible missions are future GOES missions and International X-ray Observatory.

- Wide band gap semiconductor, radiation hard, visible and solar blind large format imagers for next generation hyperspectral Earth remote sensing experiments. Need larger formats (>1Kx1K), much higher resolution (
- Solar blind, compact, low-noise, radiation hard, EUV and soft X-ray detectors are required. Both single pixels (up to 1cm x 1cm) and large format 1D and 2D arrays are required to span the 0.05nm to 150nm spectral wavelength range. Future GOES missions post-GOES R and T.

- Visible-blind SiC APDs for EUV photon counting are required. The APDs must show a linear mode gain >1E6 at a breakdown reverse voltage between 80 and 100V. The APD's must demonstrate detection capability of better than 6 photons/pixel/s at near 135nm spectral wavelength. See needs of National Council Decadal Survey (NRC, 2007): Tropospheric ozone.

- Imaging from low-Earth orbit of air fluorescence, UV light generated by giant airshowers by ultra-high energy (E >1019 eV) cosmic rays require the development of high sensitivity and efficiency detection of 300 - 400 nm UV photons to measure signals at the few photon (single photo-electron) level. A secondary goal minimizes the sensitivity to photons with a wavelength greater than 400 nm. High electronic gain (~106), low noise, fast time response (2 to 10 x 10 mm^2. Focal plane mass must be minimized (2 g/cm^2 goal). Individual pixel readout. The entire focal plane detector can be formed from smaller, individual sub-arrays.

Proposals should show an understanding of one or more relevant science needs, and present a feasible plan to fully develop a technology and infuse it into a NASA program.

S1.06 Particles and Field Sensors and Instrument Enabling Technologies

Lead Center: GSFC

Participating Center(s): ARC, JPL, MSFC

Advanced sensors and instrument enabling technologies for the measurement of the physical properties of space plasmas and energetic charged particles, mesospheric - thermospheric neutral species, energetic neutral atoms created at high altitudes by charge exchange, and electric and magnetic fields in space are needed to achieve NASA's transformational science advancements in Heliophysics. The Heliophysics discipline (http://sec.gsfc.nasa.gov/) has as its primary strategic goal the understanding of the physical coupling between the sun's outer corona, the solar wind, the trapped radiation in Earth's and other planetary magnetic fields, and the upper atmospheres of the planets and their moons. This understanding is of national importance not only because of its intrinsic scientific worth, but also because it is the necessary first step toward developing the ability to measure and forecast the "space weather" that affects all human crewed and robotic space assets. Improvements in particles and fields sensors and associated instrument technologies will enable further scientific advancement for upcoming NASA missions such as Solar Probe (http://solarprobe.gsfc.nasa.gov/), Solar Sentinels (http://lws.gsfc.nasa.gov/missions/sentinels/sentinels.htm), GEC (http://stp.gsfc.nasa.gov/missions/gec/gec.htm), Magnetospheric Constellation (http://stp.gsfc.nasa.gov/missions/mc/mc.htm), IT-SP and planetary exploration missions. Technology developments that result in expanded measurement capabilities and a reduction in size, mass, power, and cost are necessary in order for some of these missions to proceed. Of special interest are fast high voltage stepping power supplies for charged particle analyzers, electric field booms, self calibrating vector magnetometers, and other supporting sensor electronics.

Specific areas of interest include:

- Low cost, low power, low current, high voltage power supplies which allow ultra-fast stepping (t
- Strong, lightweight, thin, compactly-stowed electric field booms possibly using composite materials that deploy sensors to distances of 10m or more and/or long wire boom (> 50 m) deployment systems for the deployment of very lightweight tethers or antennae on spinning spacecraft.

- Self-calibrating scalar-vector magnetometer for future Earth and space science missions. Performance goals are dynamic range: +/-100,000 nT, accuracy with self-calibration: 1 nT, sensitivity: 5 pT / sqrtHz,Max, max sensor unit size: 6 x 6 x 12 cm, max sensor mass: 0.6 kg, max electronics unit size: 8 x 13 x 5 cm, max electronics mass: 1 kg, and max power: 5 W operation, 0.5 W standby, including, but not limited to "sensors on a chip".

- Low-power cathode for detection of neutral atoms and molecules ionosphere-thermosphere and planetary investigations. Performance goals are thermionic cathodes capable of emitting 1 mA electron current with heater power less than 0.1 W. The largest dimension of the electron emitter surface should not exceed 1 mm; the entire cathode assembly should be small enough so it may be mounted in a shallow channel shaped to match the largest cathode dimension. The assembly should include robust connection leads for heater and cathode surface. Uniformity across the electron beam is not critical.

- A compact electronics box to enable the operation of one Wind Temperature Spectrometer (WTS), one Ion-Drift Spectrometer (IDS), one Neutral Mass Spectrometer (NMS) and one Ion Mass Spectrometer (IMS), all based on the new generation charged-particle spectrometer SDEA. The electronics should be housed in a volume with dimensions not exceeding 3.2x3.2x3.2 inches with power requirement not exceeding 1.1 W. The EB must provide: (a) electronics for MCP detector pulse handling, (b) minimum of 64 detector pulse channels for WTS and IDS, (c) 2 channels devoted to TOF pulse processing with 2 ns time resolution or faster for NMS and IMS, (d) two ion source power supplies (1V/0.1A cathode supply floating at -100VDC) for WTS and NMS, (e) two energy scan supplies (0 to 5 V) for WTS and IMS, (f) two rectangular-wave supplies (0 to 1 V with 1 microsec rise time) for NMS and IMS, (g) ion accelerator optics voltage supplies (3 outputs @ 200 VDC max) for NMS and IMS, (h) MCP voltage supply (one lead/2700VDC max @ 50 microAmp max), and (i) micro-controller with buffer memory and telemetry link.

Proposals should show an understanding of one or more relevant science needs, and present a feasible plan to fully develop a technology and infuse it into a NASA program.

S1.07 Cryogenic Systems for Sensors and Detectors

Lead Center: GSFC

Participating Center(s): ARC, JPL, MSFC

Cryogenic cooling systems often serve as enabling technologies for detectors and sensors flown on scientific instruments as well as advanced telescopes and observatories. As such, technological improvements to cryogenic systems (as well as components) further advance the mission goals of NASA through enabling performance (and ultimately science gathering) capabilities of flight detectors and sensors. Presently, there are six potential investment areas that NASA is seeking to expand state of the art capabilities in for possible use on future programs such as IXO (http://ixo.gsfc.nasa.gov/), Safir (http://safir.jpl.nasa.gov/), Spirit, Specs (http://geons.gsfc.nasa.gov/live/Home/SPECS.html) and the Europa Science missions (http://www.nasa.gov/multimedia/podcasting/jpl-europa20090218.html). The topic areas are as follows:

Extremely Low Vibration Cooling Systems

Examples of such systems include pulse tube coolers and turbo brayton cycles. Desired cooling capabilities sought are on the order of 20 mW at 4K or 1W at 50 K. Present state of the art capabilities display

Advanced Magnetic Cooler Components

An example of an advanced magnetic cooler might be Adiabatic Demagnetization Refrigeration systems. Specific components sought include:

- Low current superconducting magnets;
- Active/Passive magnetic shielding (3-4 Tesla magnets);
- Superconducting leads (10K - 90K) capable of 10 amp operation with 1 mW conduction;
- 10 mK scale thermometry.

Continuous Flow Distributed Cooling Systems

Distributed cooling provides increased lifetime of cryogen fluids for applications on both the ground and spaceborne platforms. This has impacts on payload mass and volume for flight systems which translate into costs (either on the ground, during launch or in flight). Cooling systems that provide continuous distributed flow are a cost effective alternative to present techniques/methodologies. Cooling systems that can be used with large loads and/or deployable structures are presently being sought after.

Heat Switches

Current heat switches require detailed procedures for operational repeatability. More robust (performance wise) heat switches are currently needed for ease of operation when used with space flight applications.

Highly Efficient Magnetic and Dilution Cooling Technologies

The desired temperature range for proposed systems is

Low Temperature/Power Cooling Systems

Cooling systems providing cooling capacities approximately 0.3W at 35 K with heat rejection capability to temperature sinks upwards of 150 K are of interest. Presently there are no cooling systems operating at this heat rejection temperature. Input powers should be limited to no greater than 10W. Study of passive cooler in tandem with low power, low mass cryocooler satisfying the above mentioned requirements is also of interest.

Proposals should show an understanding of one or more relevant science needs, and present a feasible plan to fully develop a technology and infuse it into a NASA program.

S1.08 In Situ Airborne, Surface, and Submersible Instruments for Earth Science

Lead Center: GSFC

Participating Center(s): ARC, JPL, LaRC, MSFC, SSC

New, innovative, high risk/high payoff approaches to miniaturized and low cost instrument systems are needed to enhance Earth science research capabilities. Sensor systems for a variety of platforms are desired, including those designed for remotely operated robotic aircraft, surface craft, submersible vehicles, and balloon-based systems (tethered or free). Global deployment of numerous sensors is an important objective, therefore cost and platform adaptability are key factors.

Novel methods to minimize the operational labor requirements and improve reliability are desired. Long endurance (days/weeks/months) autonomous/unattended instruments with self/remote diagnostics, self/remote maintenance, capable of maintaining calibration for long periods, and remote control are important. Use of data systems that collect geospatial, inertial, temporal information, and synchronize multiple sensor platforms are also of interest.

Priorities include:

- Atmospheric measurements in the troposphere and lower stratosphere: Aerosols, Cloud Particles, Water, and chemical composition: Carbon Dioxide ($12CO_2$ and $13CO_2$), Carbon Monoxide, Methane, Reactive and Trace Gases, Radicals, Ozone, Three-dimensional Winds and Turbulence.

- Oceanic, coastal, and fresh water measurements including inherent and apparent optical properties, temperature, salinity, currents, chemical and particle composition, sediment, and biological components such as phytoplankton, harmful algal blooms, fish or aquatic plants.

- Instrument systems for hazardous environments such as volcanoes and severe storms.

- Instrument systems for difficult to access areas such as sub-glacial waters.

Instrument systems to support field studies of fundamental processes are of interest, as well as for satellite measurement calibration and validation. Applicability to NASA's Airborne Science, Atmospheric Composition and Radiation Sciences, Ocean Biology and Biogeochemistry, and Applied Sciences programs is a priority. Support of the Integrated Ocean Observing System (IOOS) and regional coastal research is also desired.

Proposals should show an understanding of one or more relevant science needs, and present a feasible plan to fully develop a technology and infuse it into a NASA program.

S1.09 In Situ Sensors and Sensor Systems for Planetary Science

Lead Center: JPL

Participating Center(s): ARC, GSFC, JSC, LaRC, MSFC

This subtopic solicits development of advanced instruments and instrument components that are tailored to the demands of planetary instrument deployment on a variety of space platforms (orbiters, flyby spacecraft, landers, rovers, balloon or other aerial vehicles, subsurface penetrators or impactors, etc.) accessing the wide variety of bodies in our solar system (inner and outer planets and their moons, comets, asteroids, etc.). These instruments must be capable of withstanding operation in space and planetary environmental extremes, which include temperature, pressure, radiation, and impact stresses. For example missions see:

http://science.hq.nasa.gov/missions/solar_system.html

Specifically, this subtopic solicits instrument development that provides significant advances in the following areas:

- Improved science return and/or reduced mass, power, volume, data rates for instruments or instrument components (e.g., lasers and other light sources from UV to microwave, X-ray and ion sources, detectors, mixers, seismometers, etc.) or electronics (e.g., FPGA and ASIC implementations, advanced array readouts);

- Instrument technologies for detecting inorganic and organic biomarkers on future Mars missions;

- Improved robustness and g-force survivability for rough landings on planetary bodies;
- Radiation mitigation strategies, radiation tolerant detectors, and readout electronics components for candidate instruments for the Europa-Jupiter System Mission;
- Advanced sample acquisition and processing technologies, including fluid and gas storage, pumping, and manipulation, to support analytical instrumentation, sample return, or planetary protection.
- Sensors, mechanisms, and environmental chamber technologies for operation in Venus's high temperature, high pressure environment with its unique atmospheric composition. Venus test chambers that can support evaluation of 50 to 100 cm sensors, instruments, and related structures are particularly requested.

Proposers are strongly encouraged to relate their proposed development to (a) future planetary exploration goals of NASA; and (b) existing flight instrument capability to provide a comparison metric for assessing proposed improvements. Proposed instrument architectures should be as simple, robust, and reliable as possible while enabling compelling science.

Proposals should show an understanding of one or more relevant space science needs, and present a feasible plan to fully develop a technology and infuse it into a NASA program.

S1.10 Space Geodetic Observatory Components

Lead Center: GSFC

Participating Center(s): JPL

NASA is working with the international community to develop the next generation of geodetic instruments and networks to determine the terrestrial reference frame with accuracy better than one part per billion. These instruments include Global Navigation Satellite System (GNSS) receivers, Very Long Baseline Interferometry (VLBI) systems, and Next Generation Satellite Laser Ranging (SLR) stations. The development of these instruments and the needed integrating technology will require contributions from a broad variety of optical, microwave, antenna and survey engineering suppliers. These needs include but are not limited to:

- Broadband feeds capable of receiving GNSS signals, Ka-band feeds integrated with broadband feeds, and matching antennas that meet or exceed the slewing and duty cycle requirements of the IVS VLBI2010 specifications.
- VLBI system components including > 4 Gbps recorders, phase/cable calibrators, and frequency standards / distribution systems that meet or exceed the requirements of the IVS VLBI2010 specifications.
- Cost-effective data transmission for e-VLBI from a global network of 30 VLBI stations operating up to 8 Gbps.
- Compact, low mass, space-qualified for MEO, SLR retroreflector arrays with greater than 100 million square meter lidar cross section, with a design that assures the ability to determine the array center to the

center of mass of the spacecraft to a millimeter.

- A very high quantum efficiency (>50% at 532nm), low instrument noise, multi-pixilated detector for SLR use in the automated tracking.
- Wide band GNSS antenna and RF front-end technologies accommodating all expected GNSS signals in the next decade, and offering at least an order of magnitude improvements over COTS devices in terms of multipath rejection, and stability of output relative to temperature.
- Continuous, reliable co-location monitoring and control system for the relative 3-D displacement of geodetic instruments within a geodetic observatory to better than 1 mm.

Proposals should show an understanding of one or more relevant science needs, and present a feasible plan to fully develop a technology and infuse it into a NASA program.

S1.11 Lunar Science Instruments and Technology

Lead Center: MSFC

Participating Center(s): ARC, GSFC, JPL, JSC

NASA lunar robotic science missions support the high-priority goals identified in the 2007 National Research Council report, The Scientific Context for Exploration of the Moon: Final Report (http://www.nap.edu/catalog.php?record_id=11954). Future missions will characterize the lunar exosphere and surface environment; field test new equipment, technologies, and approaches for performing lunar science; identify landing sites and emplace infrastructure to support robotic and human exploration; demonstrate and validate heritage systems for exploration missions; and provide operational experience in the harsh lunar environment.

Space-qualified instruments are required to perform remote and in situ lunar science investigations, to include measurements of lunar dust composition, reactivity and transport, searching for water ice, assessing the radiation environment, gathering long period measurements of the lunar exosphere, and conducting surface and subsurface geophysical measurements.

In support of these requirements, this subtopic seeks advancements in the following areas:

Geophysical Measurements

Systems, subsystems, and components for seismometers and heat flow sensors capable of long-term continuous operation over multiple lunar day/night cycles with improved sensitivity at lower mass and reduced power consumption compared to the Apollo Lunar Surface Experiments Package (ALSEP) instruments (http://www.hq.nasa.gov/alsj/frame.html). Instrument deployment options include robotic deployment from soft Landers, as well as emplacement by hard landers or penetrators. Also of interest are portable surface ground penetrating radars with antenna frequencies of 250-MHz, 500-MHz, and 1000-MHz to characterize the thickness of the lunar regolith. Also of interest are accurate, low mass, thermally stable hollow cubes and retroreflector array assemblies for lunar surface laser ranging.

In Situ Lunar Surface Measurements

Light-weight and power efficient instruments that enable elemental and/or mineralogy analysis using techniques such as high-sensitivity X-ray and UV-fluorescence spectrometers, UV/fluorescence flash lamp/camera systems, scanning electron microscopy with chemical analysis capability; time-of-flight mass spectrometry, gas chromatography and tunable diode laser (TDL) sensors for in situ isotopic and elemental analysis of evolved volatiles, calorimetry, and Laser Induced Breakdown Spectroscopy (LIBS). Instruments shall have the potential to provide isotope ratio measurements and/or hydrogen distributions to Â±10 ppm locally. Characterizing the meteoroid and subsequent eject flux environment and measurements of surface and deep dielectric charging on the lunar surface should be considered. Also, self calibrating instruments to measure surface and deep dielectric charging on a variety of materials encompassing conductors, semi-conductors, and insulators are another area. Instrument deployment options include robotic deployment from soft Landers, as well as emplacement by hard Landers or penetrators.

Lunar Atmosphere and Dust Environment Measurements

Low-mass and low-power instruments that measure the local lunar surface environment which includes but is not limited to the characterization of: the plasma environment, surface electric field, and dust concentrations and its diurnal dynamics. Instrument deployment options include robotic deployment from soft Landers, as well as emplacement by hard Landers or penetrators.

Lunar Regolith Particle Analysis

A substantial portion of the particles in the Lunar Regolith are smaller than the integration volume of e-beam analytical equipment, making automated quantitative analysis extremely difficult using available approaches. Therefore, software development is sought that would automate integration of suites of multiple Back Scatter Electron images acquired at different operating conditions, as well as permit integration of other data such as cathode luminescence and EDS X-ray. The said software would then use standard image processing tools to resample to common scales, perform appropriate discriminant analysis using the high resolution data, mixed pixel inversion, image segmentation to extract particles, and correlate chemistry with products of the discriminant analysis.

Research should be conducted to demonstrate technical feasibility during Phase 1 and show a path toward a Phase 2 hardware and software demonstration, and when possible, deliver a demonstration unit or software package for NASA testing at the completion of the Phase 2 contract.

Proposals should show an understanding of one or more relevant science needs, and present a feasible plan to fully develop a technology and infuse it into a NASA program.