NASA SBIR 2008 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 2008 program year, two new subtopics have been added. One subtopic solicits technology for geodetic instruments and instruments to enable global navigation and very long baseline interferometry. A second new subtopic requests proposals for technology to enable new lunar science instruments. 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 System Components

Lead Center: LaRC

Participating Center(s): ARC, 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. 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 program is highly encouraged. Examples of planned missions and technology programs are: Ice, Cloud and land Elevation Satellite (ICESat, http://icesat.gsfc.nasa.gov), Laser Interferometer Space Antenna (LISA, http://lisa.nasa.gov/index.html), Doppler Wind Lidar, Lidar for Surface Topography (LIST), and 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 this Program year, 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 1064 nm wavelength. We require an N by M multiplexer (where N is 1 or more and M is 10 to 100 or more) capable of switching at speeds on the order of 10 microseconds with low insertion loss (<2 dB). The unit must be small, lightweight, capable of long life, and low power consumption.
- Space-qualifiable high reliability frequency-stabilized CW laser source with 1 W output power. A master oscillator power amplifier (MOPA) configuration is desirable since the source must be phase-modulated.
- Development of polarization-maintaining Er and/or Yb doped optical fiber amplifiers that are optimized for suppression of stimulated Brillouin scattering (SBS). Resulting fiber amplifier must be capable of single frequency (< 1MHz linewidth), peak power of > 1 kW, and M2 beam quality < 1.3.
- Efficient and compact single frequency, near diffraction limited fiber lasers operating in near infrared (1.0 -1.7 Î¼m) and mid-infrared (3 - 4 Î¼m). Requirements include: polarization maintaining output (better than 100:1), M2 beam quality < 1.5, wavelength stability <50 pm over one hour. Both pulsed lasers with repetition rates of the order of 10 KHz and pulse energies greater than 0.5 mJ, and CW lasers in multiwatts 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 50 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. Components of interest include but not limited to fiber based Raman amplifier-based transmitter architecture. Remote sensing of oxygen in the 1.26-micron spectral region for measuring atmospheric pressure is of particular 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.

S1.02 Active Microwave Technologies

Lead Center: JPL

Participating Center(s): GSFC

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 (with applications and/or mission concept names):

- Lightweight deployable L-band antenna structures and deployment mechanisms suitable for large aperture (reflectors or phased array of 50m^2 and larger) systems. (Solid Earth Science , http://solidearth.jpl.nasa.gov/)
- Compact wide bandwidth L-band and S-band (200 MHz) array antennas for airborne real aperture and synthetic aperture radar remote sensing applications.
- Rad-hard, high-efficiency, low-cost, lightweight L- and P-band Transmit/Receive (TR) modules (~250 W peak RF output power at ~100 us pulsewidth and 20% duty cycle) with respective energy storage units to provide pulsed DC power to the power amplifier while minimizing ripple on the primary DC power source. (DESDynI, http://desdyni.jpl.nasa.gov/; SES, hydrology http://www.nasa.gov/topics/earth/features/decadal_missions.html)
- Low Power 10-bit, 1.5 GHz analog bandwidth ADCs and digital filtering with an emphasis on rad-tolerance and space-qualification. (Ice Topography (GLISTIN), planetary landing)
- Lightweight deployable reflectors (Ku-band and Ka-band) and active feed electronics.
- High efficiency Ka-band (34-36GHz) TR modules with output power of 5-10W. The Low Noise Amplifiers (LNAs) should have a NF less than 3dB and gain better than 30dB. Included in the TR module is a low loss phase shifter. (GPM, Clouds and precipitation, planetary landing)
- Power amplifier and associated LNA for a Ka-band (34-36GHz) radar system with a peak output power of 2KW to 10KW (duty cycle of 10%) and system bandwidth of up to 1 GHz and LNA NF of less than 1.5dB. The LNA needs to have enough isolation and power handling capability to operate in this high power transmission environment. (SWOT, GLISTIN, clouds and precipitation)
- 140-160 GHz planar frequency-scanned antenna with scan range +/- 16 degrees, beamwidth 0.5 degrees, and bandwidth 400 MHz per beam. (planetary landing, atmospheric radar)
- Dual or tri-frequency (Ku/Ka/W band), matched beam antennas with high cross-polarization isolation (>32 dB). (Cloud and precipitation)
- Innovative approaches to realizing a low-cost instrument (sub-system).

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, MSFC

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 (< 0.5 dB), high isolation (>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.

In addition to the technologies listed above, proposals for innovative passive microwave instruments for a wide range of remote sensing applications from measurements of the Earth's surface and atmosphere to cosmic background emission would also be welcome.

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 & astrophysics (http://www.nap.edu/books/0309070317/html/).

The following technologies are of interest for Earth and planetary science instrument concepts such as Scanning Microwave Limb Sounder (http://mls.jpl.nasa.gov/index-cameo.php) on the Global Atmospheric Chemistry Mission, Climate Absolute Radiance and Refractivity Observatory (http://science.hq.nasa.gov/earth-sun/docs/Volz4_CLARREO.pdf), Methane Trace Gas Sounder, and Lunar Atmosphere Dust Environment Explorer:

- New or improved technologies leading to measurement of trace atmospheric species (e.g., CO, CH4, 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*) â‰¥ 10^{10} cm $Hz^{1/2}$/W in the operating wavelength ranges 6-14 Î¼m and 10-100 Î¼m.
- 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 610 to 650 GHz, phase-locked to or derived from an ultra-stable 5 MHz reference.
- Technologies for calibrating millimeter wave spectrometers for spaceborne missions, including low power, flight qualifiable comb generators for gain, linearity, and sideband calibration of microwave spectrometers covering the bands from 180 to 270 GHz and from 600 to 660 GHz; flight qualifiable 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.

Detector technologies for future astrophysics mission concepts, such as the Single Aperture Far Infrared (SAFIR) Observatory (http://safir.jpl.nasa.gov/technologies.shtml), the Space Infrared Telescope for Cosmology and Astrophysics (SPICA) (http://www.ir.isas.ac.jp/SPICA/), and Inflation Probe (cosmic microwave background, http://universe.nasa.gov/program/probes/inflation.html).

- Innovative detector designs, readout electronics, or new sensor materials (e.g. novel dopants for extrinsic Si detectors) are of interest, as is development of a photo-definable version of parylene to aid the fabrication of thermally isolated structures of bolometers (and x-ray microcalorimeters).
- 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 < 2.0 microns are required with < 1.0 microns desired.Ã‚Â Applications include active and passive wavefront and amplitude control, and relevant missions include Terrestial Planet Finder (http://planetquest.jpl.nasa.gov/TPF/tpf_index.cfm) and Stellar Imager (http://hires.gsfc.nasa.gov/si/).

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. As would be expected, requirements across the board are for greater numbers of readout pixels, lower power, faster readout rates, greater quantum efficiency, and enhanced energy resolution. Typical semiconductor devices in this energy range are based on silicon or germanium. However, proposals for other detector materials are welcomed if a compelling case is made.

The proposed efforts must be directly linked to a requirement for a NASA mission. Details of these can be found at the following URLs:

- General Information on Future NASA Missions: http://nasascience.nasa.gov/missions
- Specific Mission pages:
    - ConX: http://constellation.gsfc.nasa.gov
    - LBTI: http://planetquest.jpl.nasa.gov/lbti/lbti_index.cfm
- Future Mars Programs: http://marsprogram.jpl.nasa.gov/missions/future/futureMissions.html
- Solar Probes: http://science.hq.nasa.gov/missions/sun.html

Specific technologies are listed below. Highly desirable are developments that satisfy multiple requested parameters:

- Large-format focal plane detectors for use in UV and X-ray imaging and spectrometry:
    - UV-sensitive CCD and active pixel sensors with large formats: to 6k x 6k abuttable; extended UV response below 0.2 nm;
    - X-ray-sensitive CCD and active pixel sensors: up to 4k x 4k formats, 4-side abuttable; power levels of 0.1 W / megapixel; resolutions less than 120 eV; readout rates of at least 30 Hz; extended x-ray response above 6 keV.

Very-large-area X-ray detectors for survey instruments: square-meter area capability; response from 3-30 keV; ultra-low power (10 microW/channel).

- Significant improvements in wide band gap materials, individual detectors, and detector arrays for UV and X-ray applications.
- Photon counting detectors with capability to resolve single photon arrival for use in space applications.
- Mega-to-giga-channel analogue electronic systems for very-large-area X- and gamma-ray detectors as follows: up to 108 channel capability; less than 10 microW/channel power requirement; less than 100 electron rms noise level with interconnects.
- Technology to accomplish X-ray and gamma-ray imaging spectroscopy and polarimetry at the arcsecond level in the energy range from 1 keV to 20 MeV.

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 by charge exchange, and electric and magnetic fields in space are needed to achieve NASA's transformational science advancements in Heliophysics. The Heliophysics discipline 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 to 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 Orbiter (http://www.rssd.esa.int/index.php?project=SOLARORBITER), Solar Sentinels (http://www.lws.nasa.gov/missions/sentinels/solar_sentinels_orbiter.htm), GEC, Magnetospheric Constellation (http://stp.gsfc.nasa.gov/missions/mc/mc.htm), IT-SP (http://www.lws.nasa.gov/missions/geospace/geospace.htm) and some 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 magnetometers, fast high voltage stepping power supplies for charged particle analyzers, electric field booms 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 < 100- Î¼s) over the full voltage range (0 < V < 5-15 kV).
- Self-calibrating scalar-vector magnetometer for future Earth and space science missions. Performance goals: dynamic range: +/-100,000 nT, accuracy with self-calibration: 1 nT, sensitivity: 5 pT / sqrtHz, 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".
- Strong, lightweight, thin, compactly-stowed electric field booms possibly using composite materials that deploy sensors to distances of 10 m or more and/or long wire boom (> 50 m) deployment systems for the deployment of very lightweight tethers or antennae on spinning spacecraft.
- Low power charge sensitive preamplifiers on a chip.
- Radiation hardened ASIC spectrum analyzer module that determines mass spectra using fast algorithm deconvolution to produce ion counts for specific ion species.

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 are often enabling technologies for cutting edge science from infrared imaging and spectroscopy to x-ray calorimetry. Improvements in cryogenic technologies enable further scientific advancement at lower cost, lower risk, reduced volume, and/or reduced mass. Lifetime, reliability, and power requirements of the cryogenic systems are critical performance concerns. Of interest are cryogenic technologies for cooling detectors for scientific instruments and sensors on advanced telescopes and observatories (http://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20070018750_2007018830.pdf) as well as on instruments for lunar and planetary exploration such as missions to Europa, Titan, or Enceladus (http://sci.esa.int/science-e/www/object/index.cfm?fobjectid=42337). Active coolers should have long life, low vibration, low mass, low cost, and high efficiency. Specific areas of interest include:

- Essentially vibration-free cooling systems such as Pulse Tube or reverse Brayton cycle cooler technologies with cooling capability of 20 mW at 4K.
- Low temperature cooling systems, operating and rejecting heat at 150K, providing 0.3W of cooling at 35K with input power on the order of 10W.
- Distributed cooling systems using circulators for larger systems including helium circulators. The temperature range is 20-100K, with flowrates of up to 1 gram/sec and a maximum pressure drop of 50 psi.
- Heat switches for redundant cryocoolers with a temperature range of 20-100K and a capacity of 20W.
- Highly efficient magnetic and dilution cooling technologies under 1 Kelvin.
- Components for advanced magnetic coolers (adiabatic demagnetization refrigerators) including:
    - Small (few cm bore), lightweight, low current (under 10A, goal under 5A) superconducting magnets capable of producing at least 3 Tesla central field while operating at least 10 Kelvin. Higher temperature superconductor (HTS) magnets operating at significantly higher temperatures are of particular interest.
    - Lightweight (relative to standard ferromagnetic flux guides) active and/or passive magnetic shielding for 3 to 4 Tesla magnets that reduces the stray field to tens of microTesla at a distance of several cm from the outside of the shield.
    - Large (>1 cubic cm) single crystal or polycrystalline magnetocaloric materials.
    - Superconducting current leads operating between 90 Kelvin down to 10 Kelvin, capable of carrying up to 10 amperes while allowing only approximately 1 mW of heat to be conducted.
    - Compact, accurate, easy to use thermometers that operate down to 10 milliKelvin.

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, MSFC, SSC

There are new platform systems that have the potential to benefit Earth science research activities. To capitalize on these emerging capabilities, proposals are sought for the development of in situ instruments for use on radiosondes, dropsondes, tethered balloons, kites, Unmanned Aerial Vehicles (UAVs), Unmanned Surface Vehicles (USVs), or Unmanned Underwater Vehicles (UUVs). Both miniaturization of current techniques, as well as innovative new methods that lead to compact and lightweight systems are important. Details of complete instrument systems are desired, including data acquisition, power, and platform integration. Instrument performance goals such as resolution, accuracy, and response time should be discussed, as well as maintenance and reliability considerations. An outline of potential use by NASA and a plan for commercial production and marketing should be included as well. Technology innovation areas of interest include:

- Atmospheric measurements including aerosol properties, temperature, humidity, solar radiation, clouds, liquid water, ice, precipitation, and chemical composition (carbon dioxide, methane, reactive gases and radicals, dynamical tracer species).
- Three-dimensional wind measurements near the Earth's surface, and within the troposphere and lower stratosphere.
- Oceanic and coastal measurements including inherent and apparent optical properties, temperature, salinity, chemical composition, nutrient distribution, and currents.

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, Ocean Biology and Biogeochemistry, and Applied Sciences programs, including support of the Integrated Ocean Observing System (IOOS), is a priority.

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.). 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:

- Reduced mass, power, volume, data rates for instruments or instrument components that could be achieved in optomechanical components (e.g., room temperature lasers, detectors, mixers, microvalves, optical components and structures, gas and liquid pumps, ion sources, light sources from UV to microwave, seismometers, etc.) or electronics (e.g., FPGA, ASIC implementations, advanced array readouts);
- Improved g-force survivability for rough landings on Mars, Moon, or comet/asteroid bodies;
- Mitigation strategies for tolerance to high-radiation environments like that around Europa;
- High temperature and/or high pressure lifetime improvement for instruments landed on Venus;

- Low temperature survivability or lifetime improvement for instruments landed on cryogenic outer planet bodies or deployed to the subsurface;
- Advanced sample handling and manipulation technologies for challenging environments and planetary protection.

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.

Instruments for both remote sensing and in situ investigations are required for NASA's planned and potential solar system exploration missions. Instruments are required for the characterization of the atmosphere, surface, and subsurface regions of planets, satellites, and small bodies. These instruments may be deployed for remote sensing, on orbital or flyby spacecraft, or for in situ measurements, on surface landers and rovers, subsurface penetrators, and airborne platforms. In situ instruments cover spatial scales from surface reconnaissance to microscopic investigations. These instruments must be capable of withstanding operation in space and planetary environmental extremes, which include temperature, pressure, radiation, and impact stresses.

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, LaRC

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 (http://science.hq.nasa.gov/strategy/roadmaps/surface.html). 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 (2 - 14 GHz) feeds capable of receiving GNSS signals, Ka-band (32 - 36 GHz) 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.
- Geodetic GNSS software receivers and antenna systems capable of receiving all signals from the GPS, GLONASS, Galileo and Beidou/Compass GNSS.
- 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 (hwttp://ww.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.

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. 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.

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.