NASA SBIR 2015 Phase I Solicitation

S4 Robotic Exploration Technologies

Lead Center: JPL

NASA is pursuing technologies to enable robotic exploration of the Solar System including its planets, their moons, and small bodies. NASA has a development program that includes technologies for the atmospheric entry, descent, and landing, mobility systems, extreme environments technology, sample acquisition and preparation for in situ experiments, and in situ planetary science instruments. Robotic exploration missions that are planned include a Europa Jupiter System mission, Titan Saturn System mission, Venus In-Situ Explorer, sample return from Comet or Asteroid and lunar south polar basin and continued Mars exploration missions launching every 26 months including a network lander mission, an Astrobiology Field Laboratory, a Mars Sample Return mission and other rover missions. Â Â

Numerous new technologies will be required to enable such ambitious missions. The solicitation for in situ planetary instruments can be found in the in situ instruments section of this solicitation. See (http://solarsystem.nasa.gov/missions/index.cfm) for mission information. See (http://mars.nasa.gov/programmissions/technology/) for additional information on Mars Exploration technologies.Â

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Planetary protection requirements vary by planetary destination, and additional backward contamination requirements apply to hardware with the potential to return to Earth (e.g., as part of a sample return mission). Technologies intended for use at/around Mars, Europa (Jupiter), and Enceladus (Saturn) must be developed so as to ensure compliance with relevant planetary protection requirements. Constraints could include surface cleaning with alcohol or water, and/or sterilization treatments such as dry heat (approved specification in NPR 8020.12; exposure of hours at 115C or higher, non-functioning); penetrating radiation (requirements not yet established); or vapor-phase hydrogen peroxide (specification pending).Â Â

Subtopics

S4.01 Planetary Entry, Descent and Landing and Small Body Proximity Operation Technology

Lead Center: JPL

Participating Center(s): ARC, JSC, LaRC

NASA seeks innovative sensor technologies to enhance success for entry, descent and landing (EDL) operations on missions to other planetary bodies, including Earth's Moon, Mars, Venus, Titan, Europa, and proximity operations (including sampling and landing) on small bodies such as asteroids and comets.Â

Sensing technologies are desired that determine any number of the following:Â

- Terrain relative translational state (altimetry/3-axis velocimetry).
- Spacecraft absolute state in planetary/small-body frame (either attitude, translation, or both).
- Terrain point cloud (for hazard detection, absolute state estimation, landing/sampling site selection, and/or body shape characterization).
- Atmosphere-relative measurements (velocimetry, pressure, temperature, flow-relative orientation).Â

NASA also seeks to use measurements made during EDL to better characterize the atmosphere of planetary bodies, providing data for improving atmospheric modeling for future landers or ascent vehicles.Â

Successful candidate sensor technologies can address this call by:

- Extending the dynamic range over which such measurements are collected (e.g., providing a single surface topology sensor that works over a large altitude range such as 1m to >10km, and high attitude rates such as greater than 45 deg/sec).
- Improving the state-of-the-art in measurement accuracy/precision/resolution for the above sensor needs.
- Substantially reducing the amount of external processing needed by the host vehicle to calculate the measurements.
- Significantly reducing the impact of incorporating such sensors on the spacecraft in terms of Size, Weight, and Power (SWaP), spacecraft accomodation complexity, and/or cost.
- Providing sensors that are robust to environmental dust/sand/illumination effects.
- Mitigation technologies for dust/particle contamination of optical surfaces such as sensor optics, with possible extensibility to solar panels and thermal surfaces for Lunar, asteroid, and comet missions.Â

For all the aforementioned technologies, candidate solutions are sought that can be made compatible with the environmental conditions of deep spaceflight, the rigors of landing on planetary bodies both with and without atmospheres, and planetary protection requirements.Â

NASA is also looking for high-fidelity real-time simulation and stimulation of passive and active optical sensors for computer vision at update rates greater than 2 Hz to be used for signal injection in terrestrial spacecraft system test beds. These solutions are to be focused on improving system-level performance Verification and Validation during spacecraft assembly and test.Â

Submitted proposals should show an understanding of the current state of the art of the proposed technology and present a feasible plan to improve and infuse it into a NASA flight mission.Â

S4.02 Robotic Mobility, Manipulation and Sampling

Lead Center: JPL

Participating Center(s): ARC, GSFC, JSC

Technologies for robotic mobility, manipulation, and sampling are needed to enable access to sites of interest and acquisition and handling of samples for in-situ analysis or return to Earth from planetary and solar system small bodies including Mars, Venus, comets, asteroids, and planetary moons.Â

Mobility technologies are needed to enable access to steep and rough terrain for planetary bodies where gravity dominates, such as the Moon and Mars. Tethered systems, non-wheeled systems, and marsupial systems are examples of mobility technologies that are of interest. Technologies to enable mobility on small bodies in micro-gravity environments and access to liquid bodies below the surface such as in conduits and deep oceans are needed. Manipulation technologies are needed to enable deployment of sampling tools and handling of samples. Small-body mission manipulation technologies are needed to deploy sampling tools to the surface and transfer samples to in-situ instruments and sample storage containers, as well as hermetic sealing of sample chambers. On-orbit manipulation of a Mars sample cache canister is needed from capture to transfer into an Earth Entry Vehicle. Sample acquisition tools are needed to acquire samples on planetary and small bodies through soft and hard material. A drill is needed to enable sample acquisition from the subsurface including rock cores to 3m depth and icy samples from deeper locations. Minimization of mass and ability to work reliably in the harsh mission environment are important characteristics for the tools.Â

Component technologies for low-mass and low-power systems tolerant to the in-situ environment are of particular interest. Technical feasibility should be demonstrated during Phase I and a full capability unit of at least TRL 4 should be delivered in Phase II. Proposals should show an understanding of relevant science needs and engineering constraints and present a feasible plan to fully develop a technology and infuse it into a NASA program. Specific areas of interest include the following:Â

- Tethers and tether play-out and retrieval systems.
- Small body anchoring systems.
- Subsurface sampling systems.
- Low mass/power vision systems and processing capabilities to enable fast surface traverse.
- Abrading bit providing smooth surface preparation.
- Sample handling technologies that minimize cross contamination and preserve mechanical integrity of samples.Â

S4.03 Spacecraft Technology for Sample Return Missions

Lead Center: JPL

Participating Center(s): GRC

NASA plans to perform sample return missions from a variety of scientifically important targets including Mars, small bodies such as asteroids and comets, and outer planet moons. These types of targets present a variety of spacecraft technology challenges.Â

Some targets, such as Mars and some moons, have relatively large gravity wells and will require ascent propulsion. Includes propellants that are transported along with the mission or propellants that can be generated using local resources.

Other targets are small bodies with very complex geography and very little gravity, which present difficult navigational and maneuvering challenges.Â

In addition, the spacecraft will be subject to extreme environmental conditions including low temperatures (-270Â°C), dust, and ice particles.Â

Technology innovations should either enhance vehicle capabilities (e.g., increase performance, decrease risk, and improve environmental operational margins) or ease sample return mission implementation (e.g., reduce size, mass, power, cost, increase reliability, or increase autonomy).Â

S4.04 Extreme Environments Technology

Lead Center: JPL

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

NASA is interested in expanding its ability to explore the deep atmosphere and surface of giant planets, asteroids, and comets through the use of long-lived (days or weeks) balloons and landers. Survivability in extreme high-temperatures and high-pressures is also required for deep atmospheric probes to planets. Proposals are sought for technologies that are suitable for remote sensing applications at cryogenic temperatures, and in-situ atmospheric and surface explorations in the high-temperature high-pressure environment at the Venusians surface (485 Â°C, 93 atmospheres), or in low-temperature environments such as Titan (-180 Â°C), Europa (-220 Â°C), Ganymede (-200 Â°C), Mars, the Moon, asteroids, comets and other small bodies. Also Europa-Jupiter missions may have a mission life of 10 years and the radiation environment is estimated at 2.9 Mega-rad total ionizing dose (TID) behind 0.1 inch thick aluminum. Proposals are sought for technologies that enable NASA's long duration missions to extreme wide-temperature and cosmic radiation environments. High reliability, ease of maintenance, low volume, low mass, and low out-gassing characteristics are highly desirable. Special interest lies in development of following technologies that are suitable for the environments discussed above: Â Â Â Â Â Â Â Â Â Â Â Â Â Â Â Â Â Â

- Wide temperature range precision mechanisms i.e., beam steering, scanner, linear and tilting multi-axis mechanisms.
- Radiation-tolerant/radiation hardened low-power low-noise mixed-signal mechanism control electronics for precision actuators and sensors.
- Wide temperature range feedback sensors with sub-arc-second/nanometer precision.
- Long life, long stroke, low power, and high torque/force actuators with sub-arc-second/nanometer precision.
- Long life Bearings/tribological surfaces/lubricants.
- High temperature energy storage systems.
- High-temperature actuators and gear boxes for robotic arms and other mechanisms.
- Low-power and wide-operating-temperature radiation-tolerant /radiation hardened RF electronics.
- Radiation-tolerant/radiation-hardened low-power/ultra-low-powerwide-operating-temperature low-noise mixed-signal electronics for space-borne system such as guidance and navigation avionics and instruments.
- Radiation-tolerant/radiation-hardened power electronics.
- Radiation-tolerant/ radiation-hardened electronic packaging (including, shielding, passives, connectors, wiring harness and materials used in advanced electronics assembly).Â

Research should be conducted to demonstrate technical feasibility during Phase I and show a path toward a Phase II hardware demonstration, and when possible, deliver a demonstration unit for functional and environmental testing at the completion of the Phase II contract.Â

S4.05 Contamination Control and Planetary Protection

Lead Center: JPL

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A need to develop technologies to implement Contamination Control and Planetary Protection requirements has emerged in recent years with increased interest in investigating bodies with the potential for life detection such as Europa, Enceladus, Mars, etc. and the potential for sample return from such bodies. Planetary Protection is concerned with both forward and backward contamination. Forward contamination is the transfer of viable organisms from Earth to another body. Backward contamination is the transfer of material posing a biological threat back to Earth's biosphere. NASA is seeking innovative technologies or applications of technologies to facilitate meeting portions of forward and backward contamination Planetary Protection requirements as well as analytical technologies that can ensure hardware and instrumentation can meet organic contamination requirements in an effort to preserve sample science integrity.Â

For contamination control efforts, analytical technologies and techniques for quantifying submicron particle and organic contamination for validating surface cleaning methods are needed. In particular, capabilities for measuring Total Organic Carbon (TOC) at <<40 ppb or <<20 ng/cm^2 on a surface and detection of particles <0.2 microns in size are being sought. In addition, techniques for detection of one or more of the following molecules and detection level are being needed:Â

- DNA (1 fmole).
- Dipicolinic acid (1 pg).
- N-acetylglucosamine (1 pg).
- Glycine and alanine (1 pg).
- Palmitic acid (1 pg).
- Sqalene (1 pg).
- Pristane (1pg).
- Chlorobenzene (<1 pg).
- Dichloromethane (<1 pg).
- Naphthalene (1 pg).Â

For many missions, Planetary Protection requirements are often implemented in part by processing hardware or potentially entire spacecraft with one or more sterilization processes. These processes are often incompatible with particular materials or components on the spacecraft and extensive effort is made to try to mitigate these issues. Innovative new or improved sterilization/re-sterilization processes are being sought for application to spacecraft hardware to increase effectiveness of reducing bio-load on spacecraft or increase process compatibility with hardware (e.g., toxicity to hardware, temperature, duration, etc.). Accepted processes currently include heat processing, gamma/electron beam irradiation, cold plasma, and vapor hydrogen peroxide. Options to improve materials and parts (e.g., sensors, seals, in particular, batteries, valves, and optical coatings) to be compatible with currently accepted processes, in particular heat tolerance, are needed. NASA is seeking novel technologies for preventing recontamination of sterilized components or spacecraft as a whole (e.g., biobarriers). In addition, active in situ recontamination/decontamination approaches (e.g., in situ heating of sample containers to drive off volatiles prior to sample collection) and in situ sterilization approaches (e.g., UV or plasma) for surfaces are desired.Â

Missions planning sample return from bodies such as Mars, Europa, Enceladus are faced with developing technologies for sample return functions to assure containment of material from these bodies. Thus far, concepts have been developed specifically for Mars sample return but no end-to-end concepts have been developed that do not have technical challenges remaining in one or more areas. Options for sample canisters with seal(s) (e.g., brazing, explosive welding, soft) with sealing performed either on surface or in orbit and capability to verify seal(s), potentially by leak detection are needed. In addition, capability is needed for opening seals while maintaining sample integrity upon Earth return. These technologies need to be compatible with processes the materials may encounter over the lifecycle of the mission (e.g., high temperature heating). Containment assurance also requires technologies to break-the-chain of contact with the sampled body. Any native contamination on the returned sample container and/or Earth return vehicle must be either be fully contained, sterilized, or removed prior to return to Earth, therefore, technologies or concepts to mitigate this contamination are desired. Lightweight shielding technologies are also needed for meteoroid protection for the Earth entry vehicle and sample canister with capability to detect damage or breach to meet a 10-6 probability of loss of containment.Â