NASA SBIR 2008 Phase I Solicitation

S3 Spacecraft and Platform Subsystems

The Science Mission Directorate will carry out the scientific exploration of our Earth, the planets, moons, comets, and asteroids of our Solar System and beyond; chart the best route of discovery; and reap the benefits of Earth and space exploration for society. A major objective of the NASA science spacecraft systems development programs is to implement science measurement capabilities using small, affordable spacecraft enabling a single spacecraft to meet multiple mission requirements thus making the best use of our limited resources. To accomplish this objective, NASA is fostering innovations in propulsion, power, and guidance and navigation systems (including advanced avionics for low cost small spacecraft and technology) that significantly reduce the mass and cost while maximizing the scientific return for future NASA missions. Innovations are sought in the areas of power generation, energy storage, guidance, navigation, command/control, on-board propulsion (electric propulsion, advanced chemical and propellantless propulsion), propulsion technologies related to sample return missions, and on-board power management and distribution (power electronics and packaging). Also sought for NASA Science Missions are thermal control technologies for spacecraft, piloted and unpiloted aircraft, and terrestrial and planetary balloons.Â

Subtopics

S3.01 Avionics and Electronics

Lead Center: GSFC

Participating Center(s): ARC, GRC, JPL, JSC, LaRC

NASA's space based observatories, fly by spacecraft, orbiters, landers, and robotic and sample return missions, require robust command and control capabilities. Advances in technologies relevant to guidance, navigation, command and data handling are sought to support NASA's goals and several missions and projects under development (http://nasascience.nasa.gov/search?SearchableText=missions+under+development, http://www.nap.edu/catalog.php?record_id=10432).

The subtopic goals are to: (1) develop high-performance processors and memory architectures and reliable electronic systems, (2) develop an avionics architecture that is flexible, scalable, extensible, adaptable, and reusable, (3) develop precision line-of-sight sensing for large telescopes and spacecraft formations, and (4) mass and technology improvements in guidance, navigation and control for low cost small spacecraft use. The subtopic objective is to elicit novel architectural concepts and component technologies that are realistic and operate effectively and credibly in environments consistent with the future vision of the Science Mission Directorate.

Successful proposal concepts will significantly exceed the present state-of-the-art. Proposals will clearly (1) state what the product is; (2) describe how it targets the technical priorities listed below; and (3) outline the feasibility of the technical and programmatic approach. If a Phase 2 proposal is awarded, the combined Phase 1 and Phase 2 developments shall produce a prototype that is testable by NASA. The technology priorities sought are listed below.

Command and Data Handling

- Processors - General purpose (processor chips and radiation-hardened by design synthesizable IP cores) and special purpose single-chip components (DSPs) with sustainable processing performance and power efficiency (>500 MIPS at >100 MIPS/W for general purpose processing platforms, >5 GMACs at >5 GMACS/W for computationally-intensive processing platforms), and tolerance to total dose and single-event radiation effects. Concepts must include tools required to support an integrated hardware/software development flow.
- Radiation-hardened non-volatile low power memories and Ethernet physical layer components.
- Tunable, scalable, reconfigurable, adaptive fault-tolerant avionics.

Guidance, Navigation and Control

- Navigation systems (including multiple sensors and algorithms/estimators, possibly based on existing component technologies) that work collectively on multiple vehicles to enable inertial alignment of the formation of vehicles (i.e., pointing of the line-of-sight defined by fixed points on the vehicles) on the level of milli-arcseconds relative to the background star field.
- Light-weight sensors (gyroscopic or other approach) to enable milli-arcsecond class pointing measurement for individual large telescopes and low cost small spacecraft.
- Isolated pointing and tracking platforms (pointing 0.5 arcseconds, jitter to 5 milli-arcsecond), targeted to placing a scientific instrument on GEO communication satellites that can track the sun for > 3 hours/day.
- Working prototypes of GN&C actuators (e.g., reaction or momentum wheels) that advance mass and technology improvements for small spacecraft use. Such technologies may include such non-contact approaches such as magnetic or gas. Superconducting materials, driven by temperature conditioning may also be appropriate provided that the net power used to drive and condition the "frictionless" wheels is comparable to traditional approaches.

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.

The Small Spacecraft Build effort highlighted in Topic S4 (Low-cost Small Spacecraft and Technologies) of the solicitation participates in this subtopic. Offerors are encouraged to take this in consideration as a possible flight opportunity when proposing work to this subtopic.

S3.02 Thermal Control Systems

Lead Center: GSFC

Participating Center(s): ARC, GRC, JPL, MSFC

Future Spacecraft and instruments for NASA's Science Mission Directorate will require increasingly sophisticated thermal control technology (http://nasascience.nasa.gov/search?SearchableText=missions+under+development, http://www.nap.edu/catalog.php?record_id=10432). Some of these requirements include:

- Optical systems, lasers (ICESAT 2), and detectors which require tight temperature control, often to better

than +/- 1Â°C. Some new missions such as CON-X and LISA, and upcoming Earth Science missions require thermal gradients held to even tighter micro-degree levels.
- Exploration science missions to the Moon and Mars present engineering challenges requiring systems which are more self-sufficient and reliable.
- The introduction of low-cost, small, rapidly configured spacecraft as described in Topic S4 requires the development of new thermal technologies to reduce the time and costs typically required for analysis, design, integration, and testing of the spacecraft. The Small Spacecraft Build effort highlighted in Topic S4 (Low-cost Small Spacecraft and Technologies) participates in this subtopic and offerors are encouraged to take this in consideration as a possible flight opportunity when proposing work to this subtopic.

Innovative proposals for the cross-cutting thermal control discipline are sought in the following areas:

- Methods of precise temperature measurement and control to tight temperature levels.
- High conductivity, vacuum-compatible interface materials to minimize losses across make/break interfaces.
- High conductivity materials to minimize temperature gradients and provide high efficiency light-weight radiators, including interfaces to heat pipes and fluid loops that overcomes issues with CTE mismatch.
- Advanced more efficient thermoelectric coolers capable of providing cooling at ambient and cryogenic temperatures.
- Advanced thermal control coatings or process technologies including variable emittance surfaces applicable to small spacecraft.
- Single and two-phase mechanically pumped fluid loop systems which accommodate multiple heat sources and sinks, and long life, lightweight pumps for these systems. Also includes advanced fluid system components such as accumulators, valves, pumps, flow rate sensors, etc. optimized for improved reliability, long life, and low resource needs.
- Efficient, lightweight, oil-less, high lift vapor compression systems for cooling up to 2 KW.
- Advanced thermal modeling techniques that can be easily integrated into existing codes, emphasizing inclusion of two-phase systems and mechanically pumped system models.
- Integration of standardized formats into existing codes for the representation and exchange of Thermal Network Models and Thermal Geometric Models and results.

Research should be conducted to demonstrate technical feasibility during Phase 1 and show a path toward a Phase 2 hardware and software demonstration. Phase 2 should 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.Â

S3.03 Power Generation and Storage

Lead Center: GRC

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

Future NASA science missions will employ Earth orbiting spacecraft, planetary spacecraft, balloons, aircraft, surface assets, and marine craft as observation platforms.

(http://nasascience.nasa.gov/search?SearchableText=missions+under+development, http://www.nap.edu/catalog.php?record_id=10432)

Proposals are solicited to develop advanced power conversion, energy storage, and power electronics to enable or enhance the capabilities of future science missions. The requirements for the power systems for these missions are varied and include long life capability, high reliability, significantly lower mass and volume, higher mass specific power, and improved efficiency over the state of practice (SOP) components/systems. Other desired capabilities are high radiation tolerance, and ability to operate in extreme environments (high and low temperatures and over wide temperature ranges).

Advanced Photovoltaic Energy Conversion

Photovoltaic cell, blanket, and array technologies that lead to significant improvements in overall solar array performance (i.e. efficiency (>30%), mass specific power (>300W/kg), decreased stowed volume, reduced initial and recurring cost, long-term operation in high radiation environments, high power arrays, and a wide range of space environmental operating conditions):

- Photovoltaic cell and blanket technologies capable of low intensity, low-temperature (LILT) operation applicable to the Outer Planets Mission;
- Photovoltaic cell, blanket and array technologies for high intensity high-temperature operation applicable to the Solar Probe mission;
- Thermophotovoltaic technologies applicable to the Outer Planets Mission;
- Component technologies of interest include advanced solar cell designs, space-durable coatings, designs capable of high voltage operation within the space environment, and technologies that reduce fabrication/testing costs while maintaining high reliability;
- Array technologies of interest include concentrators, large reliably-deployable arrays, ultra-lightweight arrays for use with flexible, lightweight cells. Of particular interest are lightweight array technologies that are electrostatically-clean and can operate at voltages up to 1000 volts, enabling direct drive electric propulsion for deep space missions.

Stirling Power Conversion

Novel methods or approaches for radiation-tolerant, sensorless, autonomous control of the Stirling converters with very low vibration and having low mass, size, and electromagnetic interference (EMI). Other technologies of interest include:

- High-temperature, high-performance regenerators;
- High-temperature, lightweight, high-efficiency, low EMI, linear alternators;
- High-temperature heater heads (> 850Â°C) and joining techniques and regenerators applicable to Venus surface missions (~1200Â°C);
- Combined electrical power generation and cooling systems applicable to Venus surface missions (~1200Â°C).

Energy Storage

Future science missions will require lithium-based or other advanced rechargeable electrochemical battery systems that offer greater than 40,000 charge/discharge cycles (7 year operating life) for low-Earth-orbiting (LEO) spacecraft, 20 year life for geosynchronous (GEO) spacecraft, and as low as -80Â°C storage and operation temperatures for planetary missions. Energy storage technologies that enable one or more of the above requirements combined with very high specific energy and energy density are of interest.

Power Management and Distribution

Advanced electrical power technologies are required for the electrical components and systems on future platforms to address the size, mass, efficiency, capacity, durability, and reliability requirements. In addition to the above requirements, proposals must address the expected improvements in energy density, speed, efficiency, or wide-temperature operation (-125Â°C to 200Â°C) with a high number of thermal cycles. Advancements are sought in power electronic devices, components, and packaging. Technologies of interest include:

- Power electronic components and subsystems;
- Power distribution;
- Fault protection;

- Advanced electronic packaging for thermal control and electromagnetic shielding.

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.Â

S3.04 Propulsion Systems

Lead Center: GRC

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

The Science Mission Directorate (SMD) needs spacecraft with ever-increasing propulsive performance and flexibility for ambitious missions requiring high duty cycles and years of operation. Planetary spacecraft need the ability to rendezvous with, orbit, and conduct in situ exploration of planets, satellites and other solar system bodies (http://www.nap.edu/catalog.php?record_id=10432). Platforms, satellites, and satellite constellations have high-precision propulsion requirements, usually in volume- and power-limited envelopes. This subtopic seeks innovations to meet SMD propulsion requirements, reflecting the goals of NASAâ€™s In-Space Propulsion Technology program to reduce the travel time, mass, and cost of SMD spacecraft. Propulsion areas include chemical and electric propulsion systems, propulsion technologies related to sample return missions to asteroids, comets, and other small bodies, propellantless options (such as aerocapture and solar sails), and less developed but emerging propulsion concepts such as advanced plasma thrusters and momentum exchange/electrodynamic reboost (MXER) tethers.

Specific sample return propulsion technologies include, but are not limited to, ascent vehicle propulsion, pumps for pressure-fed propulsion systems, long-term storage capable solid rocket propulsion technologies, lightweight propulsion components, Earth-return propulsion systems, Earth-EDL systems, and Earth Entry Vehicle heat shield materials.

This subtopic also seeks proposals that explore uses of technologies that will provide superior performance in attitude control and overall orbit control. The Small Spacecraft Build effort highlighted in Topic S4 (Low-cost Small Spacecraft and Technologies) of the solicitation participates in this subtopic. Offerors are encouraged to consider this possible flight opportunity when proposing work to this subtopic.

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.

S3.05 Balloon Technology, Terrestrial and Planetary

Lead Center: GSFC

Participating Center(s): JPL

Innovations to advance terrestrial (http://sites.wff.nasa.gov/code820/) and planetary balloons and aerobots are being solicited. The technologies proposed shall have a clear path for infusion into the current flight systems within the next few years.

Currently, NASA is developing a superpressure terrestrial vehicle targeting 100 day duration missions in midlatitude. This added capability will greatly enable new science investigations. The design of the current pumpkin shape vehicle utilizes light weight polyethylene film and high strength tendons made of twisted ZylonÂ® yarn. The in-flight performance and health of the vehicle relies on accurate information on a number of environmental and design parameters. Therefore, NASA is seeking innovations in the following specific areas:

Devices or methods to accurately and continuously measure individual axial loading on an array of up to 200 separate tendons during a superpressure balloon mission. Tendons are the load carrying member in the pumpkin design. During a typical mission, loading on individual tendons should not exceed a critical design limit to insure structural integrity and survival. Tendons are typically captured at the fitting via individual pins. Loading levels on the tendons can range from ~20 N to ~8,000 N and temperature can vary from room temperature to the troposphere temperatures of -90Â°C or colder. The devices of interest shall be easily integrated with the tendons or fittings during balloon fabrication and shall have minimal impact on the overall mass of the balloon system. Support telemetry and instrumentation is not part of the this initiative; however, data from any sensors (devices) that are selected from this initiative must be able to be telemetered in-flight using single-channel (two-wire) interface into existing NASA balloon flight support systems.

Devices or methods to accurately and continuously measure ambient air, helium gas, and balloon film temperature. The measurements are needed to accurately model the balloon performance during a typical flight at altitudes of approximately 120,000 feet. The measurement must compensate for the effects of direct solar radiation through shielding or calculation. Minimal mass and volume are highly desired. For film measurement, a non-invasive and non-contact approach is highly desired for the thin polyethylene film, with film thickness ranging from 0.8 to 1.5 mil, used as the balloon envelope. Devices for measurement of helium gas and balloon film temperature must be compatible with existing NASA balloon packaging, inflation and launch methods. Devices and/or methods must be able to interface with existing NASA balloon flight support systems or alternatively, a definition of a telemetry solution be provided.

Innovations in materials, structures, and systems concepts have also enabled buoyant vehicles to play an expanding role in planning NASA's future Solar System Exploration Program. Balloons and airships are expected to carry scientific payloads on Mars, Venus, and Titan in order to investigate their atmospheres in situ and their surfaces from close proximity. Their envelopes will be subject to extreme environments and must support missions with a range of durations. Proposals are sought in the following areas:

Metal Balloons for High Temperature Venus Exploration

Balloons made of metals are a potential solution to the problem of enabling long duration flight in the hot lower atmosphere of Venus. Proposals are sought for metal balloon concepts and prototypes that provide 1-5 m^3 of fully inflated volume, areal densities of 1 kg/m^2 or less, sulfuric acid compatibility at 85% concentration, and operation at 460 Â°C for a period of up to 1 year. (http://newfrontiers.nasa.gov/program_plan.html)

Cryogenic Testing of Titan Aerobots (http://www.nap.edu/catalog.php?record_id=10432)

Aerobots at Titan must operate at cryogenic temperatures in the range of 85 to 95 K. There is a need for inexpensive test facilities to conduct experiments on sub-scale and full scale prototype balloons ranging in size from 1 to 15 m in their largest dimension. Proposals are sought for the development and validation of innovative, low cost test facilities that can be used to conduct light gas and Montgolfiere balloon experiments with time scales ranging from hours to weeks.

Gas Management Systems for Titan Aerobots

Hydrogen-filled aerobots at Titan must contend with the problem of gas leakage over long duration (1 year or more) flights. Proposals are sought for the development and testing of two kinds of prototype devices that can be carried on the aerobot to compensate for these gas leakage problems: one device is to produce make-up hydrogen gas from atmospheric methane; the other device is to remove atmospheric gas (mostly nitrogen) that leaks from the ballonets into the hydrogen-filled blimp. Both kinds of devices will need to operate on no more than 15 W of electrical power each while compensating for a leakage rate of at least 40 g/week of hydrogen or 500 g/week of nitrogen.

Ground-launched Mars Balloons

NASA is interested in small balloons with very light payloads (< 1 kg) that can be autonomously launched on the Martian surface from a lander or large rover. Proposals are sought for balloon designs and systems concepts to enable this. It is important that proposals directly address the difficult problem of not damaging the balloon despite proximity to landed equipment and surface rocks. Preference will be given to proposals that include proof-of-concept experiments addressing key feasibility questions for the proposed approach.

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.