NASA SBIR 2011 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 the universe beyond. SMD's future direction will be moving away from exploratory missions (orbiters and flybys) into more detailed/specific exploration missions that are at or near the surface (landers, rovers, and sample returns) or at more optimal observation points in space. These future destinations will require new vantage points, or would need to integrate or distribute capabilities across multiple assets. Future destinations will also be more challenging to get to, have more extreme environmental conditions and challenges once the spacecraft gets there, and may be a challenge to get a spacecraft or data back from. A major objective of the NASA science spacecraft and platform subsystems development efforts are to enable science measurement capabilities using smaller and lower cost spacecraft to meet multiple mission requirements thus making the best use of our limited resources. To accomplish this objective, NASA is seeking innovations to significantly improve spacecraft and platform subsystem capabilities while reducing the mass and cost, that would in turn enable increased scientific return for future NASA missions. A spacecraft bus is made up of many subsystems like: propulsion; thermal control; power and power distribution; attitude control; telemetry command and control; transmitters/antenna; computers/on-board processing/software; and structural elements. Science platforms of interest could include unmanned aerial vehicles, sounding rockets, or balloons that carry scientific instruments/payloads, to planetary ascent vehicles or Earth return vehicles that bring samples back to Earth for analysis. This topic area addresses the future needs in many of these sub-system areas, as well as their application to specific spacecraft and platform needs. Innovations for 2011 are sought in the areas of:

- Command and Data Handling, and Instrument Electronics
- Thermal Control Systems
- Power Generation and Conversion
- Propulsion Systems
- Power Electronics and Management, and Energy Storage
- Guidance, Navigation and Control
- Unmanned Aircraft and Sounding Rocket Technologies
- Terrestrial and Planetary Balloons

Significant changes to the S3 Topic for 2011 are:

- Merged the 2010 subtopics of S3.08 Planetary Ascent Vehicles and S3.10 Earth Entry Vehicles into a broader "Spacecraft Technology for Sample Return Missions" sub-topic under the S5 Topic.

- Moved power electronics/power processing unit content for electric propulsion systems from S3.04 Propulsion Systems to the revised sub-topic of S3.05 Power Electronics and Management, and Energy Storage.

The following references discuss some of NASA's science mission and technology needs:

- The Astrophysics Roadmap: http://nasascience.nasa.gov/about-us/science-strategy.

- Astrophysics Decadal Survey - "New Worlds, New Horizons: in Astronomy and Astrophysics": http://www.nap.edu/catalog.php?record_id=12951.

- The Earth Science Decadal Survey: http://books.nap.edu/catalog.php?record_id=11820.

- The Heliophysics roadmap: "The Solar and Space Physics of a New Era: Recommended Roadmap for Science and Technology 2009Â2030": http://sec.gsfc.nasa.gov/2009_Roadmap.pdf.

- The 2011 Planetary Science Decadal Survey was released March 2011. This decadal survey is considering technology needs. http://www.nap.edu/catalog.php?record_id=13117.

- The 2006 Solar System Exploration Roadmap: http://nasascience.nasa.gov/about-us/science-strategy.

- 2010 Science Plan: http://science.nasa.gov/about-us/science-strategy/.

Subtopics

S3.01 Command, Data Handling, and Electronics

Lead Center: GSFC

Participating Center(s): ARC, JPL, 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 command and data handling and instrument electronics are sought to support NASA's goals and several missions and projects under development.

The subtopic goals are to:

- Develop high-performance processors, memory architectures, and reliable electronic systems.

- Develop tools technologies that can enable rapid deployment of high-reliability, high-performance onboard processing applications and interface to external sensors on flight hardware. 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 NASA science missions.

Successful proposal concepts should significantly advance the state-of-the-art. Proposals should clearly:

- State what the product is.
- Identify the needs it addresses.
- Identify the improvements over the current state of the art.
- Outline the feasibility of the technical and programmatic approach.
- Present how it could be infused into a NASA program.

Furthermore, proposals should indicate an understanding of the intended operating environment, including temperature and radiation. It should be noted that environmental requirements can vary significantly from mission to mission. For example, some low Earth orbit missions have a total ionizing dose (TID) radiation requirement of less than 10 krad(Si), while some planetary missions can have requirements well in excess of 1 Mrad(Si). For descriptions of radiation effects in electronics, the proposer may visit (http://radhome.gsfc.nasa.gov/radhome/overview.htm). If a Phase II proposal is awarded, the combined Phase I and Phase II developments should produce a prototype that can be characterized by NASA.

The technology priorities sought are listed below:

Novel, Ruggedized Packaging/Interconnect

- High-density packaging (enclosures, printed wiring boards) enabling miniaturization.
- Novel high density and low resistance cabling, including carbon nanotube (CNT) based wiring.

Discrete Components for C&DH Subsystems

- 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 (>40,000 MIPS at >1,000 MIPS/W for general purpose processing platforms, >20 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.

Tunable, Scalable, Reconfigurable, Adaptive Fault-Tolerant Onboard Processing Architectures

- Development system design tools that:
    - Take full advantage of rapid prototyping hardware-in-the-loop (HIL) environments for hybrid processing platforms.
    - Automate/accelerate the deployment of data processing and sensor interface design on flight hardware.

Technologies Enabling Custom Radiation-Hardened Component Development

- Radiation-Hardened-By-Design (RHBD) cell libraries.
- Radiation-hardened Programmable Logic Devices (PLDs) and structured ASIC devices (digital and/or mixed-signal).
- Intellectual Property (IP) cores allowing the implementation of highly reliable System-On-a-Chip (SOC) devices for spacecraft subsystems or instrument electronics. Functions of interest include processors, memory interfaces, and data bus interfaces.

Power Conversion and Distribution relevant to Command, Data Handling, and Electronics, will be covered in sub-topic S3.05 Power Management and Storage.

S3.02 Thermal Control Systems

Lead Center: GSFC

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

Future Spacecraft and instruments for NASA's Science Mission Directorate will require increasingly sophisticated thermal control technology. Innovative proposals for the crosscutting thermal control discipline are sought in the following areas:

- New generations of electronics used on numerous missions have higher power densities than in the past. High conductivity, vacuum-compatible interface materials that minimize losses across make/break interfaces are needed to reduce interface temperature gradients and facilitate heat removal.
- Sensitive instruments and electronics drive increased requirements for high electrical conductivity on spacecraft surfaces. This has increased the need for advanced thermal control coatings, particularly those with low absorptance, high emittance, and good electrical conductivity. Also, variable emittance surfaces to modulate heat rejection are needed.

- Exploration science missions beyond Earth orbit present engineering challenges requiring systems that can withstand extreme temperatures ranging from high temperatures on Venus to the cryogenic temperatures of the outer planets. High performance insulation systems, which are more easily fabricated than traditional multi-layer (MLI) systems, are required for both hot and cold environments. Potential applications include traditional vacuum environments, low-pressure carbon dioxide atmospheres on Mars, and high-pressure atmospheres found on Venus. Systems that incorporate Micro-meteorite and Orbital Debris protection (MMOD) are also of interest.

- Future high-powered missions, some possibly nuclear powered, may require active cooling systems to efficiently transport large amounts of heat. These include single and two-phase mechanically pumped fluid loop systems which accommodate multiple heat sources and sinks; and long life, lightweight pumps which are capable of generating a high pressure head. It also includes efficient, lightweight, oil-less, high lift vapor compression systems or novel new technologies for high performance cooling up to 2 KW.

- Phase change systems are needed for Mars, Venus, or Lunar applications. Reusable phase change systems are desired which can be employed to absorb transient heat dissipations during instrument operations. Technology is sought for phase change systems, typically near room temperature, which can then either store this energy or provide an exothermic process that would provide heat for instrument power-on after the dormant phase.

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

Note to Proposer: Subtopic X3.04 Thermal Control Systems for Human Spacecraft, under the Exploration Mission Directorate, also addresses thermal control technologies. Proposals more aligned with exploration mission requirements should be proposed in X3.04.

S3.03 Power Generation and Conversion

Lead Center: GRC

Participating Center(s): ARC, 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. Proposals are solicited to develop advanced power generation and conversion technologies to enable or enhance the capabilities of future science missions. Requirements for these missions are varied and include long life, high reliability, significantly lower mass and volume, higher mass specific power, and improved efficiency over the state of practice for components and systems. Other desired capabilities are high radiation tolerance and the ability to operate in extreme environments (high and low temperatures and over wide temperature ranges).

While power generation technology affects a wide range of NASA missions and operational environments, technologies that provide substantial benefits for key mission applications/capabilities are being sought in the following areas:

Radioisotope Power Conversion

Radioisotope technology enables a wide range of mission opportunities, both near and far from the Sun and hostile planetary environments including high energy radiation, both high and low temperature and diverse atmospheric chemistries. Technology innovations capable of advancing lifetimes, improving efficiency, highly tolerant to hostile environments are desired for all thermal to electric conversion technologies considered here. Specific systems of interest for this solicitation are listed below.

Stirling Power Conversion: advances in, but not limited to, the following

- System specific mass greater than 10 We/kg.
- Highly reliable autonomous control.
- Low EMI.
- High temperature, high performance materials, 850-1200 C.
- Radiation tolerant sensors, materials and electronics.

Thermoelectric Power Conversion: advances in, but not limited to, the following

- High temperature, high efficiency conversion greater than 10%.
- Long life, minimal degradation.
- Higher power density.

Photovoltaic Energy Conversion

Photovoltaic cell, blanket, and array technologies that lead to significant improvements in overall solar array performance (i.e., conversion efficiency >33%, array mass specific power >300watts/kilogram, 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) are solicited. Technologies specifically addressing the following mission needs are highly sought:

- Photovoltaic cell and blanket technologies capable of low intensity, low-temperature operation applicable to outer planetary (low solar intensity) missions.
- Photovoltaic cell, blanket and array technologies capable of enhancing solar array operation in a high intensity, high-temperature environment (i.e., inner planetary and solar probe-type missions).
- Lightweight solar array technologies applicable to solar electric propulsion missions. Current missions being studied require solar arrays that provide 1 to 20 kilowatts of power at 1 AU, are greater than 300 watts/kilogram specific power, can operate in the range of 0.7 to 3 AU, provide operational array voltages up to 300 volts and have a low stowed volume.

Thermophotovoltaic conversion is currently focused on follow-on technology for the International Lunar Network (ILN) and for the outer planets mission. Advances sought, but not limited to, include:

- Low-bandgap cells having high efficiency and high reliability.
- High temperature selective emitters.
- Low absorptance optical band-pass filters.
- Efficient multi-foil insulation.

Note to Proposer: Topic X8 under the Exploration Mission Directorate also addresses power technologies (X8.03 Space Nuclear Power Systems, and X8.04 Advanced Photovoltaic Systems). Proposals more aligned with exploration mission requirements should be proposed in X8.

S3.04 Propulsion Systems

Lead Center: GRC

Participating Center(s): JPL, MSFC

The Science Mission Directorate (SMD) needs spacecraft with more demanding propulsive performance and flexibility for more ambitious missions requiring high duty cycles, more challenging environmental conditions, and extended operation. Planetary spacecraft need the ability to rendezvous with, orbit, and conduct in situ exploration of planets, moons, and other small bodies in the solar system (http://www.nap.edu/catalog.php?record_id=10432). Future spacecraft and constellations of spacecraft will have high-precision propulsion requirements, usually in volume- and power-limited envelopes.

This subtopic seeks innovations to meet SMD propulsion requirements, which are reflected in the goals of NASA's In-Space Propulsion Technology program to reduce the travel time, mass, and cost of SMD spacecraft. Advancements in chemical and electric propulsion systems related to sample return missions to Mars, small bodies (like asteroids, comets, and Near-Earth Objects), outer planet moons, and Venus are desired. Additional electric propulsion technology innovations are also sought to enable low cost systems for Discovery class missions, and eventually to enable radioisotope electric propulsion (REP) type missions.

The focus of this solicitation is for next generation propulsion systems and components, including high-pressure chemical rocket technologies and low cost/low mass electric propulsion technologies. Specific sample return propulsion technologies of interest include higher-pressure chemical propulsion system components, lightweight propulsion components, and Earth-return vehicle propulsion systems. Propulsion technologies related specifically to planetary ascent vehicles will be sought under S3.08 Planetary Ascent Vehicle. Propulsion technologies related specifically to Power Processing Units will be sought under S3.05 Power Management and Storage.

Chemical Propulsion Systems

Technology needs include:

- Pump or alternate pressurization technologies that provide for high-pressure operation (chamber pressures > 500 psia) of spacecraft primary propulsion systems (100- to 200-lbf class) using Earth storable or space storable bipropellants.
- Catalytic and non-catalytic ignition technologies that provide reliable ignition of high-performance (Isp > 240 sec), nontoxic monopropellants for power-limited spacecraft.

Electric Propulsion Systems

This subtopic also seeks proposals that explore uses of technologies that will provide superior performance for high specific impulse/low mass electric propulsion systems at low cost. These technologies include:

- Thrusters with efficiencies > 50% and up to 1 kW of input power that operate with a specific impulse between 1600 to 3500 seconds.
- An efficient (>60 %), dual mode thruster that is capable of operating in both high thrust (>60 mN/kW) and high specific impulse (>3000 sec) modes for a fixed power level.
- High power electric propulsion thrusters (up to 25 kW) and components including cathodes, ion optics, low sputtering materials with long life (>1x10^8 N-s), high temperature insulators with low secondary electron emission, and high temperature, low electrical resistivity wire.

Proposals should show an understanding of the state of the art, how their technology is superior, and of one or more relevant science needs. The proposals should provide a feasible plan to develop fully a technology and infuse it into a NASA program.

Note to Proposer: Topic X2 under the Exploration Mission Directorate also addresses advanced propulsion. Proposals more aligned with exploration mission requirements should be proposed in X2.

S3.05 Power Electronics and Management, and Energy Storage

Lead Center: GRC

Participating Center(s): ARC, JPL, JSC

Future NASA science objectives will include missions such as Earth Orbiting, Venus, Europa, Titan/Enceladus Flagship, Lunar Quest and Space Weather missions. Under this subtopic, proposals are solicited to develop energy storage and power electronics to enable or enhance the capabilities of future science missions. The unique requirements for the power systems for these missions can vary greatly, with advancements in components needed above the current State of the Art (SOA) for high energy density, high power density, long life, high reliability, low mass/volume, radiation tolerance, and wide temperature operation. Other subtopics that could potentially benefit from these technology developments include S5.05 - Extreme Environments Technology, and S5.01 - Planetary Entry, Descent and Landing Technology. Battery development could also be beneficial to X6.02 - Advanced Space-rated Batteries, which is investigating some similar technologies in the secondary battery area but with very different operational requirements. Power Management and Distribution could be beneficial to X8.05 - Advanced Power Conversion, Management and Distribution (PMAD) for High Power Space Exploration Applications, which is investigating some similar technologies but at a much higher power level. This subtopic is also directly tied to S3.04 - Propulsion Systems for the development of advanced Power Processing Units and associated components.

Power Electronics and Management

The 2009 Heliophysics roadmap (http://sec.gsfc.nasa.gov/2009_Roadmap.pdf), the 2010 SMD Science Plan (http://science.nasa.gov/about-us/science-strategy/), the 2010 Planetary Decadal Survey White Papers & Roadmap Inputs (http://sites.nationalacademies.org/SSB/CurrentProjects/ssb_052412), the 2011 PSD Relevant Technologies document, the 2006 Solar System Exploration (SSE) Roadmap (http://nasascience.nasa.gov/about-us/science-strategy), and the 2003 SSE Decadal Survey describe the need for lighter weight, lower power electronics along with radiation hardened, extreme environment electronics for planetary exploration. Radioisotope power systems (RPS) and Power Processing Units (PPUs) for Electric Propulsion (EP) are two programs of interest that would directly benefit from advancements in this technology area. Advances in electrical power technologies are required for the electrical components and systems for these future platforms to address program size, mass, efficiency, capacity, durability, and reliability requirements. In addition, the Outer Planet Assessment Group has called out high power density/high efficiency power electronics as needs for the Titan/Enceladus Flagship and planetary exploration missions. These types of missions, including Mars Sample Return using Hall thrusters and PPUs, require advancements in radiation hardened power electronics and systems beyond the state-of-the-art. Of importance are expected improvements in energy density, speed, efficiency, or wide-temperature operation (-125^{o}C to over 450^{o}C) with a number of thermal cycles. Advancements are sought for power electronic devices, components and packaging for programs with power ranges of a few watts for minimum missions to up to 20 kilowatts for large missions. In addition to electrical component development, RPS has a need for intelligent, fault-tolerant Power Management And Distribution (PMAD) technologies to efficiently manage the system power for these deep space missions.

SMD's In-space Propulsion Technology and Radioisotope Power Systems programs are direct customers of this subtopic, and the solicitation is coordinated with the 2 programs each year.

Overall technologies of interest include:

- High voltage, radiation hardened, high temperature components, such as capacitors and semiconductors, for EP PPU applications.
- High power density/high efficiency power electronics.
- High temperature devices and components/power converters (up to 450^{o}C).
- Intelligent, fault-tolerant electrical components and PMAD systems.

- Advanced electronic packaging for thermal control and electromagnetic shielding.

In addition, development is needed in the area of advanced High Voltage Transformer-Rectifier Technology Development for Advanced Cloud and Precipitation Radars, Interferometers, and other Advanced SARÂ applications where an integrated Transformer-Rectifier Assembly is needed to provide increased stability in the output voltages provided to the Cathode and Collector of a Vacuum Tube (EIK).Â This would result in increases inÂ the RF phase stability of the output RF Pulse or current approaches. The Transformer-Rectifier Assembly should address using innovative, single-integrated body regulator designs that regulate collector vs. cathode potential, and demonstrate increasing voltage stability over other approaches. The entire Transformer-Rectifier Assembly (Cathode-Collector-Body)Â should be optimized to achieve maximum energy efficiency and minimum size/mass of the system taking into account necessary high voltage insulation and potting for operation in a space environment (vacuum). Of interest are assemblies that demonstrate:

- Cathode voltages in excess of -12 kV, and Collector voltage in the -3 KV ranges with Beam currents in excess of 340 mA.
- Assemblies for which the primary winding of the transformer is driven through 60VDC (full load) switched at a nominal frequency of 40.5Â±1.5kHz, or higher.
- Duty cycles up to 16%.

Energy Storage

Future science missions will require advanced primary and secondary battery systems capable of operating at temperature extremes from -100^{o}C for Titan missions to 400^{o} to 500^{o}C for Venus missions, and a span of -230Â°C to +120Â°C for Lunar Quest. The Outer Planet Assessment Group and the 2011 PSD Relevant Technologies Document have specifically called out high energy density storage systems as a need for the Titan/Enceladus Flagship and planetary exploration missions. In addition, high energy-density rechargeable electrochemical battery systems that offer greater than 50,000 charge/discharge cycles (10 year operating life) for low-Earth-orbiting spacecraft, 20-year life for geosynchronous (GEO) spacecraft, are desired. Advancements to battery energy storage capabilities that address one or more of the above requirements for the stated missions combined with very high specific energy and energy density (>200 Wh/kg for secondary battery systems), along with radiation tolerance are of interest.

In addition to batteries, other advanced energy storage/load leveling technologies designed to the above mission requirements, such as flywheels, supercapacitors or magnetic energy storage, are of interest. These technologies have the potential to minimize the size and mass of future power systems.

Research should be conducted to demonstrate technical feasibility during Phase I and show a path toward a Phase II, and when possible, deliver a demonstration unit for NASA testing at the completion of the Phase II contract. Phase II emphasis should be placed on developing and demonstrating the technology under relevant test conditions. Additionally, a path should be outlined that shows how the technology could be commercialized or further developed into science-worthy systems.

Disclaimer: Technology Available (TAV) subtopics may include an offer to license NASA Intellectual

Property (NASA IP) on a non-exclusive, royalty-free basis, for research use under the SBIR award. When included in a TAV subtopic as an available technology, use of the available NASA IP is strictly voluntary. Whether or not a firm uses available NASA IP within their proposal effort will not in any way be a factor in the selection for award.

Patent 6,461,944, Methods for growth of relatively large step-free SiC crystal surfaces Neudeck, et al. October 8, 2002

Summary: A method for growing arrays of large-area device-size films of step-free (i.e., atomically flat) SiC surfaces for semiconductor electronic device applications is disclosed. This method utilizes a lateral growth process that better overcomes the effect of extended defects in the seed crystal substrate that limited the obtainable step-free area achievable by prior art processes. The step-free SiC surface is particularly suited for the heteroepitaxial growth of 3C (cubic) SiC, AlN, and GaN films used for the fabrication of both surface-sensitive devices (i.e., surface channel field effect transistors such as HEMT's and MOSFET's) as well as high-electric field devices (pn diodes and other solid-state power switching devices) that are sensitive to extended crystal defects.

S3.06 Guidance, Navigation and Control

Lead Center: GSFC

Participating Center(s): ARC, JPL, JSC

Advances in the following areas of guidance, navigation and control are sought.

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.

Lightweight 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 bearings. 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.

S3.07 Terrestrial and Planetary Balloons

Lead Center: GSFC

Participating Center(s): JPL

NASA's Scientific Balloons provide practical and cost effective platforms for conducting discovery science, development and testing for future space instruments, as well as training opportunities for future scientists and engineers. Balloons can reach altitudes above 36 kilometers, with suspended masses up to 3600 kilograms, and can stay afloat for several weeks. Currently, the Balloon Program is on the verge of introducing an advanced balloon system that will enable 100-day missions at mid latitudes and thus resemble the performance of a small spacecraft at a fraction of the cost. In support of this development, NASA is seeking innovative technologies in three key areas to monitor and advance the performance of this new vehicle.

Power Storage

Devices or methods to store electrical energy onboard the balloon with lower mass than current techniques are needed.Â Long duration balloon flights at mid-latitudes will experience up to 12 hours of darkness, during which electrical power is needed for experiments and NASA support systems.Â Typically, solar panels are flown to generate power during the daylight hours, and excess power is readily available.Â This excess power needs to be stored for use during the night.Â Current power storage techniques consist of rechargeable batteries that range from lead-acid to lithium-ion chemistries.Â Innovative alternatives to these batteries, either advanced chemistries or alternate power storage techniques such as capacitors or flywheels, which result in overall mass savings are needed.Â Nominal voltage levels for balloon systems are 28 volts DC, and nominal power levels can vary from 100 watts to 1000 watts.Â Therefore, power storage requirements range from 1000 watt-hours to 12,000 watt-hours or more.Â Alternative power systems that do not rely on solar panels may also be proposed.Â These alternative systems may use energy storage techniques such as fuel cells or flywheels, which are prepared or charged on the ground prior to flight, and then would provide continuous power throughout the flight at the power levels specified above.

Balloon Instrumentation

Devices or methods are desired to accurately measure ambient air temperature, helium gas temperature, balloon film temperatures, film strain, and tendon load. These measurements are needed to accurately model the balloon performance during a typical flight at altitudes of approximately 36 kilometers. The measurements must compensate for the effects of direct solar radiation through shielding or calculation. Minimal mass and volume are highly desired.Â Remote sensing of the parameters and non-invasive and non-contact approaches are also desired.Â The non-invasive and non-contact approaches are highly desired for the thin polyethylene film measurements used as the balloon envelope, with film thickness ranging from 0.8 to 1.5 mil.Â Strain measurements of these thin films via in-flight photogrammetric techniques would be beneficial.Â Devices or methods to accurately measure axially loaded tendons on an array of ~50 or up to 300 separate tendons during flight are of interest.Â Tendons are typically captured at the end fittings via individual pins with loading levels ranging from ~20 N to ~8,000 N per tendon, and can be exposed to temperatures from room temperature to the troposphere temperatures of -90 degrees Celsius or colder.Â The measurement devices must be compatible with existing NASA balloon packaging, inflation, and launch methods. These instruments must also be able to interface with existing NASA balloon flight support systems or alternatively, a definition of a data acquisition solution be provided.Â Support telemetry systems are not part of the this initiative; however, data from any sensors (devices) that are selected from this initiative must be able to be stored on board and/or telemetered in-flight using single-channel (two-wire) interface into existing NASA balloon flight support systems.Â The devices of interest shall be easily integrated and shall have minimal impact on the overall mass of the balloon system.

Low-Cost Variable Conductance Heat Pipes for Balloon Payloads

With the ever-increasing complexity of both scientific instruments and NASA mission support equipment, advanced thermal control techniques are needed. The type of advanced thermal control techniques desired are similar to those utilized on large-budget orbital and deep space payloads (variable conductance heat pipes, diode heat pipes, loop heat pipes, capillary pumped loops, heat switches, louvers), but these techniques are far more expensive to implement on balloon payloads that their limited budgets can afford. Innovative solutions are sought that would allow these more advanced thermal control measures to be utilized with reduced expense.

Though not considered "cutting-edge technology", commercial quality, constant conductance, copper-methanol heat pipes have begun to be utilized on balloon payloads to effectively move heat significant distances. The problem with these devices is that the conductance cannot effectively be reduced under cold operating or cold survival environment conditions without expending significant energy in an active heater to keep the condenser section warm. It is desirable to develop a cost-effective method of conducting the heat in this manner while allowing the flow to be reduced/eliminated when conditions warrant. Innovative thermal control techniques and devices developed must be inexpensive to implement. They must function reliably at balloon altitudes of 30-40 km and temperature ranges from -90Â°C to +40Â°C. They should require little or no energy consumption and provide the capability of moderating heat flow autonomously or by remote control under certain thermal conditions.

Planetary Balloon Technologies

Innovations in materials, structures, and systems concepts have enabled buoyant vehicles to play an expanding role in planning NASA's future Solar System Exploration Program. Balloons are expected to carry scientific payloads at Titan and Venus that will perform in situ investigations of their atmospheres and near surface environments. Both Titan and Venus feature extreme environments that significantly impact the design of balloons for those two worlds. Proposals are sought in the following areas:

Steerable Antenna for Titan and Venus Telecommunications

Many concepts for Titan and Venus balloons require high gain antennas mounted on the balloon gondola to transmit data directly back to Earth. This approach requires that the antenna remain pointed at the Earth despite the motions experienced during balloon flight. A beacon signal from the Earth will be available to facilitate pointing. Innovative concepts are sought for such an antenna and pointing system with the following characteristics: antenna diameter of 0.8 m, total mass of antenna and pointing system of = 10 kg, power consumption for the steering system = 5 W (avg.), pointing accuracy = 0.5 deg (continuous), hemispheric pointing coverage (2 pi steradians), azimuthal and rotational slew rates (30 deg/sec. It is expected that a Phase I effort will involve a proof-of-concept experiment leading to a plan for full scale prototype fabrication and testing in Phase II. Phase II testing will need to include an Earth atmosphere balloon flight in the troposphere to evaluate the proposed design under real flight conditions.

Long-Life Ballonets for Titan Aerobots

Maintenance of a pressurized balloon shape during large altitude changes requires an internal bladder, or ballonet, that can fill and discharge atmospheric gas and thereby maintain the total gas-filled volume. Ballonets are commonplace in terrestrial blimps and airships; however, the cryogenic 85 K temperature at Titan reduces the flexibility of polymer materials and greatly increases the likelihood of pinhole defect formation over time. Innovative concepts are sought for materials and system designs of a ballonet that can function pinhole-free at 85 K for a minimum of 6 months at Titan while executing repeated altitude excursions from 100 m to 10,000 m. The proposed ballonet design should be scalable across the range of 1 to 50 m^3 in volume. Preference will be given to projects that do some cryogenic experimentation in Phase I that builds confidence in the viability of the proposed approach.

S3.08 Unmanned Aircraft and Sounding Rocket Technologies

Lead Center: GSFC

Participating Center(s): AFRC, ARC, GRC, JPL, KSC, LaRC

All 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.

Unmanned Aircraft Systems

Unmanned Aircraft Systems (UAS) offer significant potential for Suborbital Scientific Earth Exploration Missions over a very large range of payload complexities, mission durations, altitudes, and extreme environmental conditions. To more fully realize the potential improvement in capabilities for atmospheric sampling and remote sensing, new technologies are needed. Scientific observation and documentation of environmental phenomena on both global and localized scales that will advance climate research and monitoring; e.g., U.S. Global Change Research Program as well as Arctic and Antarctic research activities (Ice Bridge, etc.).

NASA is increasing scientific participation to understand impacts associated with worldwide environmental changes. Capability for suborbital unmanned flight operations in either the North or South Polar Regions are limited because of technology gaps for remote telemetry capabilities and precision flight path control requirements. It is also highly desirable to have UAS ability to perform atmospheric and surface sampling.

Telemetry, Tracking and Control

Low cost over-the-horizon global communications and networks are needed. Efficient and cost effective systems that enable unmanned collaborative multi-platform Earth observation missions are desired.

Avionics and Flight Control

Precise/repeatable flight path control capabilities are needed to enable repeat path observations for Earth monitoring on seasonal and multi-year cycles. In addition, long endurance atmospheric sampling in extreme conditions (hurricanes, volcanic plumes) can provide needed observations that are otherwise not possible at this time:

- Precision flight path control solutions in smooth atmospheric conditions.
- Attitude and navigation control in highly turbulent atmospheric conditions.
- Low cost, high precision inertial navigation systems (

UA Integrated Vehicle Health Management

- Fuel Heat/Anti-freezing.
- Unmanned platform icing detection and minimization.

Guided Dropsondes

NASA Earth Science Research activities can benefit from more capable dropsondes than are currently available. Specifically, dropsondes that can effectively be guided through atmospheric regions of interest such as volcanic plumes could enable unprecedented observations of important phenomena. Capabilities of interest include:

- Compatibility with existing dropsonde dispensing systems on NASA/NOAA P-3's, the NASA Global Hawk, and other unmanned aircraft.
- Guidance schemes, autonomous or active control.
- Cross-range performance and flight path accuracy.
- Operational considerations including airspace utilization and de-confliction.

Sounding Rockets:

The NASA Sounding Rocket Program (NSRP) provides low-cost, sub-orbital access to space in support of space and Earth sciences research and technology development sponsored by NASA and other users by providing payload development, launch vehicles, and mission support services. NASA utilizes a variety of vehicle systems comprised of military surplus and commercially available rocket motors, capable of lofting scientific payloads, up to 1300lbs, to altitudes from 100km to 1500km.

NASA launches sounding rocket vehicles worldwide, from both land-based and water-based ranges, based on the science needs to study phenomenon in specific locations.

NASA is seeking innovations to enhance capabilities and operations in the following areas:

- Autonomous vehicle environmental diagnostics system capable of monitoring flight loading (thermal, acceleration, stress/strain) for solid rocket vehicle systems.

- Location determination systems to provide over-the-horizon position of buoyant payloads to facilitate expedient location and retrieval from the ocean.

- Flotation systems, ranging from tethered flotation devices to self-encapsulation systems, for augmenting buoyancy of sealed payload systems launched from water-based launch ranges.

- High-glide parachute designs capable of deploying at altitudes above 25,000 ft to facilitate mid-air retrieval and/or fly-back/fly-to-point precision landing.

Disclaimer: Technology Available (TAV) subtopics may include an offer to license NASA Intellectual Property (NASA IP) on a non-exclusive, royalty-free basis, for research use under the SBIR award. When included in a TAV subtopic as an available technology, use of the available NASA IP is strictly voluntary. Whether or not a firm uses available NASA IP within their proposal effort will not in any way be a factor in the selection for award.

Patent 7,431,243 Guidance and Control for an Autonomous Soaring UAV, Allen, Michael J., October 7, 2008

Summary: The invention provides a practical method for UAVs to take advantage of thermals in a manner similar to piloted aircrafts and soaring birds.Â In general, the invention is a method for a UAV to autonomously locate a thermal and be guided to the thermal to greatly improve range and endurance of the aircraft.