NASA SBIR/STTR
Small Business Innovation Research / Small Business Technology Transfer

NASA SBIR 2011 Phase I Solicitation

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.