NASA SBIR 2010 Phase I Solicitation

S3.07 Terrestrial and Planetary Balloons

Lead Center: GSFC

Participating Center(s): JPL

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.

Terrestrial Scientific Balloons

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.

(1) Power Storage: Devices or methods to store electrical energy onboard the balloon with lower mass than current techniques are needed. 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. Typically, solar panels are flown to generate power during the daylight hours, and excess power is readily available. This excess power needs to be stored for use during the night. Current power storage techniques consist of rechargeable batteries which range from lead-acid to lithium-ion chemistries. 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. Nominal voltage levels for balloon systems are 28 volts DC, and nominal power levels can vary from 100 watts to 1000 watts. Therefore, power storage requirements range from 1000 watt-hours to 12,000-watt hours or more. Alternative power systems, which do not rely on solar panels, may also be proposed. 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. Spacecraft power storage requirements are found under subtopic S3.05 Power Management and Storage.

(2) Balloon Instrumentation: Devices or methods are desired to accurately measure ambient air temperature, helium gas temperature, balloon film temperatures, film strain, and tendon load are desired. 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. Remote sensing of the parameters and non-invasive and non-contact approaches are also desired. 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. Strain measurements of these thin films via in-flight photogrammetric techniques would be beneficial. 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. 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. 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. 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. The devices of interest shall be easily integrated and shall have minimal impact on the overall mass of the balloon system.

(3) 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) 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. Spacecraft thermal control requirements are found under subtopic S3.02 Thermal Control Systems.

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 maintain the condenser section warm. It is desirable to develop a cost-effective method of conducting the heat in this manner and allowing the flow to be reduced/eliminated when conditions warrant. Therefore, innovative thermal control techniques and devices developed must be inexpensive to implement. They must function reliably at balloon altitudes of 30-40km and temperature ranges from -90C to +40C. 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 Balloons

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 and airships 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:

(1) Titan Montgolfiere Balloons: Recent NASA mission studies have recommended the use of radioisotope-heated Montgolfiere balloons for future in situ Titan exploration. Proposals are sought for the design, fabrication and Earth atmosphere flight testing of prototypes that can support an eventual Titan Montgolfiere balloon mission. Particular importance is attached to the acquisition of test data that can help validate thermodynamic and fluid mechanic models that will ultimately be used to design the Titan flight balloon. The size of balloon required for Titan will be approximately 10 m in diameter and will require 2 kW of thermal energy to float the balloon at an expected Titan temperature of 85 to 95 K. Any proposed Earth-test prototype will require an alternate heat source that nevertheless adequately mimics the effects of using radioisotope energy at Titan.

(2) 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.

(3) 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 m³ of fully inflated volume, areal densities of 1 kg/m² or less, sulfuric acid compatibility at 85% concentration, and operation at 460 °C for a period of up to 1 year.