NASA SBIR 2016 Phase I Solicitation

H5.01 Large Deployable Structures for Smallsats

Lead Center: LaRC

Participating Center(s): GRC, MSFC

This subtopic seeks deployable structures innovations in two areas for proposed lunar and deep-space missions:

- Large solar sails with at least 85 m^2 of deployed surface area for 6U cubesats.
- Large solar arrays with at least 200 W of power for 6U-12U cubesats or 600 W for 50-100 kg microsats.

Design solutions must demonstrate high deployment reliability and predictability with minimum mass and launch volume and maximum strength, stiffness, stability, and durability.

Innovations are sought in the following areas for both capabilities (deployable solar sails and deployable solar arrays):

- Novel design, packaging, and deployment concepts.
- Lightweight, compact components including booms, substrates, and mechanisms.
- Validated modeling, analysis, and simulation techniques.
- Ground and in-space test methods.
- Load reduction, damping, and stiffening techniques.
- High-fidelity, functioning laboratory models.

Capability #1: Deployable Solar Sails

Solar sails provide propellant less in-space propulsion using reflected sunlight. Indefinite continuous thrust allows a wide range of advanced maneuvers including non-Keplerian orbits, efficient orbit changes, and extreme ultimate velocities. A near-term application of this technology is NASA's NEA Scout 6U cubesat missions. Larger and more capable solar sail systems are envisioned for future missions.

Square solar sails typically consist of four reflective triangular membranes supported by lightweight deployable booms, as well as mechanical sail actuation to assist attitude control. Specific innovations sought for 6U cubesat solar sails in this solicitation are: improved deployable boom technologies, novel sail designs and packaging concepts, and simpler or more-effective mechanical attitude control systems. Proposed improvements to the booms used on the LightSail mission (metallic Triangular Rollable and Collapsible (TRAC) booms) are of special interest.

Nominal solar sail requirements for 6U cubesats are:

- Deployed reflective surface area > 85 m^2 (>100 m^2 preferred).
- Stowed membrane volume < 10 cm x 10 cm x 20 cm.
- Sail membrane stress > 70 kPa.
- Minimum system deployed natural frequency > 0.1 Hz.
- Mission life > 3 years in deep space (< 2 AU from the Sun) including lunar vicinity.
- Deployed sail surface as flat as possible considering all thermal and mechanical loads and residual stresses.

Improvements to the deployable TRAC booms proposed for the NEA Scout solar sail should meet the following additional requirements:

- Deployed boom length: > 8 m (up to 10 m preferred).
- Stowed volume for all booms and deployment mechanisms < 5 cm x 10 cm x 20 cm.
- Boom buckling load > 3N.
- Mass of each boom < 0.25 kg (< 0.15 kg preferred).

Capability #2: Deployable Solar Arrays

Smallsats promise cost-effective solutions for diverse human spaceflight precursor missions using fuel-efficient solar electric propulsion (SEP). SEP thrust increases with electrical power, so larger solar arrays can shorten travel times and allow higher-power science and communications equipment. This subtopic seeks structures innovations for the next generation of smallsat solar arrays with at least 5x larger area than basic body-mounted solar cells or hinged pop-out panels. Scaling up electrical power for smallsats by > 5x will require game changing innovations. In particular, novel flexible-substrate solar array designs are sought that minimize structural mass and packaging volume while maximizing deployment reliability and deployed area, stiffness, strength, and longevity.

Nominal solar array requirements are:

- Beginning-of-life (BOL) power at 1 AU > 200 W for cubesats or > 600 W for microsats.
- Packaging efficiency > 50 kW/m^3 BOL.
- Recurring cost < $500/W.
- Deployment reliability > 0.999.
- Deployed stiffness > 0.5 Hz.
- Deployed strength > 0.05 g (all directions).
- Lifetime > 2 yrs.

Proposals should emphasize structural design innovations, not materials or photovoltaic innovations. Solar array designs that can be rapidly commercialized are of special interest.

For both capabilities, contractors should prove the feasibility of proposed innovations with suitable analyses and tests in Phase I. Significant hardware or software capabilities should be developed and demonstrated in Phase II. A Technology Readiness Level (TRL) at the end of Phase II of 3-4 or higher is desired.

References:

- (http://www.nasa.gov/sites/default/files/files/Small_Spacecraft_Technology_State_of_the_Art_2014.pdf).
- (http://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20140012882.pdf).
- (http://www.planetary.org/blogs/jason-davis/2014/20140610-lightsail-update-boom.html).