NASA SBIR 2020 Phase I Solicitation

Z8.06 DragSails for Spacecraft Deorbit

Lead Center: MSFC

Participating Center(s): ARC

Technology Area: TA2 In-Space Propulsion Technologies

Scope Description

DragSails are a generic family of drag devices that can:

- Provide coarse, non-propulsive de-orbit capability which can aid in the disposal of end-of-life spacecraft through burnup upon reentry.
- Provide an accurate means of de-orbiting by modulating the ballistic coefficient to guide the system to a desired point at the Von Karman altitude for precision reentry targeting.

Small, lightweight, deployable membranes have been tested and deployed in Earth for both solar sail and drag sail applications. NASA's 10 square meter NanoSail-D2 solar sail and The University of Surrey's InflateSail drag sail are two examples. These systems demonstrated the technical viability of developing a deployable drag device to accelerate the deorbit of satellites to comply with end-of-life regulations and to mitigate the growth of orbital debris. Given the underlining technology similarities between solar sail and drag sail systems there are opportunities for adaptation or cross-use of some system elements. Further, there is also opportunity for cross-use into other fields such as PowerSails, thin-film surface power generation, and thin-film thermal control systems.

In terms of controlled, targeted de-orbit, the NASA Exo-Brake development effort has yielded promising though nascent results with the development of controllable tension structures. Tension structures don't have the 'beam buckling' issue associated with the more common drag sails at the higher dynamic pressures at atmospheric entry interface. This approach, while not as applicable to larger disposal efforts, can allow for more targeted reentry with potential additional uses in inexpensive Entry, Descent, and Landing (EDL) test-beds or sample return concepts.

Developing systems to actively provide a de-orbit disposal, or targeted de-orbit/re-entry capability, is the next logical step toward such systems becoming widely available for spacecraft manufacturers, NASA and other government agencies as an alternative to conventional propulsion systems. Specific technology development areas of interest include:

- Restowable concepts which can deploy, operate, then re-stow multiple times. This may include new boom and materials concepts, but must include a restowable/redeployable deployment architecture capable of meeting the de-orbit requirements below.
- Phase I proof of concept and preliminary design efforts that will lead to, or can be integrated into, environmental qualification and/or flight demonstration prototypes in a Phase II effort are of interest.

- Desired system-level capabilities include the de-orbit of CubeSats (3U to 12U or larger) and small spacecraft in the 50kg - 200kg mass range (frontal areas on the order of 2000 to 2700 cubic cm) from altitudes between approximately 700km and 2,000km in 25 years or less. Spacecraft flying below 700km will generally meet the 25-year-or-less requirement without augmentation.

References

Alhorn, Dean, Joseph Casas, Elwood Agasid, Charles Adams, Greg Laue, Christopher Kitts, and Sue O'Brien. "Nanosail-d: The small satellite that could!" (2011), Utah State University Small Satellite Conference, https://digitalcommons.usu.edu/smallsat/2011/all2011/37/

Andrew Viquerat, Mark Schenk, Vaios Lappas, and Berry Sanders. "Functional and Qualification Testing of the InflateSail Technology Demonstrator", 2nd AIAA Spacecraft Structures Conference, AIAA SciTech Forum, (AIAA 2015-1627), https://doi.org/10.2514/6.2015-1627

Expected TRL or TRL range at completion of the project: 3 to 6

Desired Deliverables of Phase II

Prototype, Analysis, and Hardware

Desired Deliverables Description

Ideal Phase II deliverable would be DragSail subsystems tested in a relevant environment

State of the Art and Critical Gaps

State of the Art is currently being defined by the solar sail propulsion community whose interest is deploying similar large-area, lightweight sails to reflect photons and derive thrust. Technologies which support solar sail development are inherently similar to those that would be required to develop and implement DragSails. Thin-film membranes capable of being stored in a folded state for several years or decades, lightweight deployable and potentially retractable booms, and combinations thereof that can survive in Earth orbit environment (UV, atomic oxygen, ionizing radiation, etc.) that can deploy, augment a spacecraft's aerodynamic drag, and restow are of interest. Flight control systems for DragSails have yet to be demonstrated or tested and will be essential for DragSail systems that provide deorbit independently of other, proven, deorbit systems.

Relevance / Science Traceability

Any spacecraft in Earth orbit must demonstrate how it will be either de-orbited or moved to an orbit that poses no risk to other spacecraft within a set period after its useful life. Therefore, any spacecraft launched by government, universities or industry are potential customers for a DragSail deorbit system. Further, the concepts developed as a part of the DragSail are applicable to large area solar sails, power sails, thin-film surface power, and the like.