Lessons from Structural Design of a Highly-Flexible Space Structure: the Space-Tow Solar Sail

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Solar sails are an example of Hedgepeth's [1] assertion that large space structures must be *"designed to deal with phenomena as primary criteria which have been considered as only secondary in the past"*. Solar sails are particularly problematic because they combine two large spatial dimensions with a small film thickness forming the third dimension. Solar sail design falls outside the boundaries for which experience, intuition and judgement are readily available.

Greschik [2] has proposed a scalable solar sailing system, known as a *space-tow*. This system is a series of small sails connected together in a train. The advantage of this system is its scalability as the desired surface area can be achieved by joining a number of small sails. Design, manufacture, and testing can be performed on the small sail, regardless of the final number of sails and total sail-area.

The objective of this paper is to present lessons learned in the structural design of a space tow solar sail. The design set the following limitations: currently available materials, stowed dimensions that fit in the payload bay of available launch vehicles, sufficiently large deployed sail area to act as a useful technology demonstration. The preliminary design has a total sail area of 10 000 m^2 divided into 2500 circular panels, each with a diameter of 2.26 m. The total deployed length of the train is 10 km and its stowed height is 1.0 m. The estimated total structural mass is 23 kg. This configuration has sufficiently small stowed dimensions to fit as a secondary payload on a launch vehicle.

Structural design raised a number of issues relevant to the design of highly flexible structures. Examples of these issues are the configuration for the tension truss connecting the panels, the design of a supporting rim for the individual sail panels, and the deployment strategy for a long highly-flexible structure [3]. This project identifies some of the issues likely to be encountered by other designers of highly flexible structures that meet Hedgepeth's description.

References

1 Hedgepeth, J.M., *Critical requirements for the design of large space structures*, CR-3484, NASA, 1981.

2 Greschik, G., "Solar sail scalability and the concept of a truly scalable architecture," *47th AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conf.*, AIAA, New Port – RI, USA, May 2006.

3 Tibert, G. and Lennon, A., "Deployment Strategies for the Space Tow Solar Sail", *1st International Symposium on Solar Sailing*, Herrsching, Germany, June 2007.