Deployment Strategies for the Space Tow Solar Sail

Gunnar Tibert[†] and Andrew Lennon[*]

[†] *KTH Mechanics, Royal Institute of Technology, SE-100 44 Stockholm, Sweden.*
[*] *ABL Engineering Ltd, The Old Laundry, Marlfield, Clonmel, Tipperary, Ireland.*

Greschik[1] recently proposed a scalable solar sailing system, known as a *Space Tow*. This system is a series of small sails connected together in a train to obtain the required surface area. Design, manufacturing, and testing can be performed on the small sail, regardless of the final number of sails and overall sail area. The space tow opens the possibility of launching a solar sail in the near term but a number of areas remain to be investigated. One area of significant importance is deployment, as this structure is very flexible.

This study focuses on the deployment of a particular design of the space tow that has circular sail panels. This design has 2500 panels, a total sail area of 10,000 m^2 and total deployed length of 10 km. Each of the circular panels has a diameter of 2.26 m and a mass of 8.7 g. The total structural mass is 23 kg and together with a payload of 50 kg, the characteristic acceleration is 0.8 mm/s^2. The stowed height of all panels is only 1.0 m. The circular panel configuration provides a suitable basis for this study although it is not the optimal shape.[2]

Deployment dynamics is studied through various dynamics models of increasing complexity:

- A one-dimensional model with masses connected by no-compression springs can simulate the deployment of the full space-tow and provide useful insight into the deployment dynamics. However, this simple model cannot investigate the potentially detrimental effects of non-uniform panel illumination.
- A two-dimensional model of the deployment of the crucial first panels yields information about the effects of non-uniform illumination, required initial velocity and whether thrusters are needed to active and control the deployment.
- A three-dimensional model in LS-DYNA, developed for the simulation of very flexible space structures,[3] will be used to confirm the findings from the more simple analytical models.

A recent study on the deployment of highly-flexible structures[3] concludes that the key to a successful deployment is to let the forces that drive the deployment dominate any disturbing forces, e.g. torque from non-uniform illumination, other inertial forces and Coriolis forces. This rule will determine the chosen strategy for a reliable deployment of the space tow.

References

[1] G. Greschik. Solar sail scalability and the concept of a truly scalable architecture. In *Proc. 47th AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conf.*, New Port, RI, USA, 1–4 May 2006. AIAA-2006-1703.

[2] G. Greschik. Space tow solar sails — design study exploring performance and operational issues. Project review presentation at NASA Marshall Space Flight Center, Huntsville, USA, 14 February, 2007. 30 pages.

[3] G. Tibert and M. Gärdsback. Space Webs: Final Report. ESA/ACT, Adriana ID: 05/4109, September 2006. 85 pages.