05/4104 Space Webs

Type of activity: Medium Study (4 months, 25 KEUR)

Background:

The deployment and stabilization of a net in space (space web) is a complex phenomenon that has only recently been given some attention triggered by a possible application to deploy very large antennas as for example needed for Solar Power Satellite (SPS), i.e. satellites producing electric power and beaming it back to Earth.

In a first attempt, a Japanese sounding rocket[4] will launch a mother satellite and three daughter satellites that will span up a triangular net under microgravity conditions. The launch is foreseen to take place by the end of 2005. Once the net is deployed, small robots[3] will try to move on the net from the mother satellite to the daughter satellites.

Such a net provides a credible alternative to formation flying and, at smaller scale, to inflatable structures for the deployment of large structures in space. The net, either spinning or active tension stabilized, has the additional advantages of a safety structure in case of temporary loss of control, the ability to reconfigure antenna elements by moving them on the net and in principle the possibility of reduced need for active shape and position control measures.

Because a space web may be regarded as a "two dimensional tether" some inspiration on their modelling may be drawn from the large number of publications available on tethers. If a net could be deployed and stabilized in space a number of possible applications other than the SPS, would be enabled. On a stable net robots (spiders) could be moving freely and reconfiguring themselves as to achieve, for example, any of the optimal configurations found by Golay[1] or Cornwell[2] for two dimensional antenna arrays.

Study Objectives

The study intends to understand the dynamics of the deployment and stabilization of a net in a space environment, including both, the rotational as well as the active tension control case.
Based on state-of-the-art mathematical models and taking into account the current trends in one-dimensional tether research, the study should develop a mathematical model able to describe the deployment and stabilization dynamics of a net in microgravity conditions. Once the model will be developed some simulations should be performed in order to identify and test its validity. Material, properties and shape of the net will be provided and intend to reflect as closely as possible the net used in the Japanese Furoshiki experiment.

The study should also provide the amount of perturbations due to orbital dynamics induced on such a net in e.g. GEO orbit and determine, based on required fuel consumption, its principal ability to serve as a structure for virtual aperture microwave frequency range antennas.

References

1. Golay, M., “Point arrays having compact non-redundant autocorrelations, Journal of Optical Society of America, Vol. 61, pg. 272, 1971.

2. Cornwell, T.J., “A Novel Principle for Optimization of the Instantaneous Fourier Plane Coverage of Correlation Arrays,” IEEE Trans. On Antennas and Propagation, Vol. 36, No. 8, pp. 1165-1167.

3. Kaya N., Iwashita, M.; Nakasuka, S.; Summerer, L.; Mankins, J. “Crawling Robots on Large Web in Rocket Experiment on Furoshiki Deployment”, IAC-04-R3, Vancouver, 2004

4. Kaya, N.; Nakasuka, Sh.; Summerer, L.; Mankins, J. “International Rocket Experiment on a Huge Phased Array Antenna Constructed by Furoshiki Satellite with Robots”. *ISTS’04* Miyazaki, Japan, 2004