9th SYMPOSIUM ON VISIONS AND STRATEGIES FOR FAR FUTURES (D4)
Space Elevators and Tethers (4)

Author: Dr. Marco Sabatini
Sapienza University of Rome, Italy

Dr. Leonard Felicetti
Sapienza University of Rome, Italy
Prof. Giovanni B. Palmerini
Sapienza University of Rome, Italy

COORDINATED ATTITUDE CONTROL FOR ENHANCED SHAPE STABILITY OF A SPACE WEB

Abstract

Large, reconfigurable and light orbiting structures are necessary to accomplish a number of tasks, such as the ones related to astronomy and fundamental physics missions, where very large telescope or other sensor arrays are needed. Given the technical limits imposed to the mass at launch, a mostly studied solution can be found in the formation of many satellites controlled in such a way that they can be considered as a virtual structure. This is possible only if synchronized and very accurate control is accomplished. The present paper focuses on the alternative solution represented by the space webs, intended as a set of small corner satellites connected by tethers: along the ropes of the web small robotic systems can move like spiders to position and re-locate, at will, pieces of hardware devoted to specific missions. In this sense, this work is the natural prosecution of previous studies of the same authors, where the advantages, drawbacks and possible solutions have been analyzed.

In fact, the presence of rigid links would add the advantage of a simpler control strategy to the typical benefits of formation flying. Unfortunately, there is no stable configuration for an orbiting two dimensional web made by light, flexible tethers, since it cannot support compression forces caused by the gravity gradient. However, if the net is initially rotating (at a sufficiently high velocity) in the orbital plane, the centrifugal force counteracting the gravity gradient compression leads to a stable motion. Residual shape deformations are still present: in order to increase the desired shape stability of the web, the possibility of a coordinated and robust attitude control of the corner satellites by means of reaction wheels is now studied. In particular, two approaches are followed: in the first one, the tethers (modelled with a finite element approach) are considered as axial springs with no compression resistance; in the second one, also a low shear strength of the tethers is included. The proposed algorithms therefore are able to describe the corner satellites relative motion dynamics, that is coupled to the attitude dynamics because of the tethers interactions, leading to an enhanced performance of the space web designed.