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DYNAMICS AND CONTROL OF GYROSCOPIC STABILIZED TETHER SATELLITE SYSTEM IN LEO

Abstract

In this paper we present the results of a study done for a formation composed of a linear tether satellite system connecting two or more satellites and controlled using gyroscopic stabilization. This stabilization is obtained by spinning the system about a vector tracing a circumference on the radial along-track plane during the orbit. The rotational motion of the system causes a centrifugal force on the satellites, that provides the tension in tether needed to keep the formation in shape.

The behavior of this tethered system in low Earth orbit is analyzed introducing the dynamic equations of relative motion centered in an orbiting reference frame. The equations model the three-dimensional multibody dynamics of the system in this environment, considering all the most important external perturbations and the extensional and lateral dynamics of the tether, using accurate mathematical models taken from the literature.

This architecture is analyzed by extensive numerical simulations, which provided insight into the gyroscopic effects on the systems and the effectiveness of this stabilization. The effect of different rotational speeds has been analyzed, considering the possibility of tuning this speed to satisfy the requirements of different missions. The scalability of the system has also been considered, analyzing the performance varying the number of satellites and the tether length.

Finally, the effect of the gyroscopic stabilization on the current model has been compared with the behavior of a cross-track tethered system previously proposed and studied by the authors. That system consists in a configuration stabilized across-track using the aerodynamic force perturbing the system in the low earth orbit rarefied atmosphere.

The configuration analyzed in this paper is particularly convenient for Remote Sensing applications, guarantying a continuous oscillation in the cross-track direction that could be beneficial for application to MISAR (Motion-Inducted Radar Remote sensing).