IAF ASTRODYNAMICS SYMPOSIUM (C1)
Attitude Dynamics (2) (9)

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RETRIEVAL STRATEGIES FOR TETHERED SATELLITES

Abstract

Space tethered systems are attracting a lot of attention from the scientific community since they have proved to be promising devices for a wide range of applications, such as the orbiting or the de-orbiting of satellites, the study of plasma physics, propulsion and electrical generation, rendezvous, and space elevators.

The two most critical phases of tethered systems are the deployment and the retrieval maneuvers of the tether. Even though similar, the deployment and the retrieval have difficulties inherent to each of them. In particular, the retrieval has to fulfill demanding stability issues and its control strategy has to provide adequate energy dissipation because, due to the conservation of the angular momentum, rewinding the tether makes the system dynamics unstable. Moreover, the retrieval must be able to avoid undesirable events, such as jamming or winding the tether around the mother spacecraft. As of today, TSS-1 is the only known mission where a partial tether retrieval was performed in orbit.

This paper aims to investigate the retrieval dynamics for small satellite tethered missions. A numerical simulator developed in MATLAB is introduced, presenting the model of a space tethered system that involves very complex phenomena such as: the three-dimensional flexible dynamics of the tether, swinging in-plane or out-of-plane vibrational motions of the whole system, and longitudinal and transverse vibrations. In addition, several environmental models, such as gravitational perturbation, solar pressure, atmospheric drag and thermal fluxes acting on the tether, are implemented.

In the simulator, control strategies for the retrieval maneuver are numerically implemented to stabilize the system dynamics and their performance is evaluated considering both ideal and non-ideal scenarios.

Furthermore, the final approach strategy (in the last couple of meters) will be tested on the SPARTANS hardware facility of the University of Padova, that consists of a reel-in mechanism mounted on a small satellite mock-up moving on a low-friction test table with dimensions of 2 m x 3 m.