IAF ASTRODYNAMICS SYMPOSIUM (C1)
Interactive Presentations - IAF ASTRODYNAMICS SYMPOSIUM (IPB)

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CUBESAT ATTITUDE DYNAMICS DURING FLEXIBLE PANELS DEPLOYMENT

Abstract

One of the most promising and popular applications of CubeSats is Earth observation from low and very low Earth orbits (LEO and VLEO). For most applications, it is important to control the angular orientation of LEO and VLEO satellites. In these orbits, where the influence of the atmosphere is significant, the simplest way is to use passive aerodynamic stabilization, since it does not require any power supply. This type of stabilization is realized for several environmental nanosatellites currently orbiting the Earth. Aerodynamic stabilization on CubeSats is usually realized by means of deployable tail panels. Initially lying against the sides of the satellite, the panels rotate during the deployment in order to reach their operational position. These additional aerodynamic surfaces are inevitably flexible and, while the satellite oscillates under the action of the environmental torques, the deployed panels oscillate as well at frequencies different from that of the satellite. The dynamics of flexible satellites has received considerable attention in the literature. Namely, it was shown that if the satellite has unstable equilibrium positions, even small disturbances, e.g., elastic oscillations of the panels, can cause chaos in the attitude motion. However, the attitude motion of the satellite during the panels deployment itself has not been studied sufficiently. The purpose of this work is to study the satellite attitude dynamics during tail panels deployment taking into account their flexibility. The attitude motion of the satellite under consideration is mainly influenced by gravitational and aerodynamic torques. The restoring and damping aerodynamic torque coefficients are calculated using the Schaaf and Chambre's approach assuming that the flow is free molecular. The tail panels are modeled as cantilever beams. The equations of motion of the system are derived using the Langrangian approach, taking into account the change of the satellite inertia matrix during the deployment.

As a result of the study, recommendations for the panels deployment phase are formulated and control laws for the panels deployment angle are proposed. Their focus is to maintain the attitude stability of the satellite in presence of disturbances, such as elastic oscillations of the panels themselves, or possible uneven deployment of the individual panels. The proposed measures will significantly decrease the risk of the chaotic rotation of the satellite after the panels deployment. The results of the study can be used for planning future LEO and VLEO missions involving aerodynamically stabilized Cubesats.