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3U CUBESAT AERODYNAMIC DESIGN AIMED TO INCREASE ATTITUDE STABILITY AND ORBITAL LIFETIME

Abstract

Small satellites, such as Cubesats, are widely used in space flight missions. As of the beginning of 2020, more than 1200 satellites of this type have been launched. Almost half of them are 3U Cubesats. The vast majority of all Cubesats launched are in low-Earth orbits. In these orbits, the atmosphere strongly influences both the orbit parameters and the attitude motion of the satellite. For some types of missions, it is important that the satellite stay in orbit as long as possible. On the other hand, it is often necessary that a slender Cubesat is oriented along its orbital velocity vector. Both problems can be solved by modifying the shape of the satellite using deployable or retractable panels. It worth noting that the attitude stability can be also increased by adjusting the position of the center of mass. The purpose of this study is to increase the orbital lifetime and attitude stability of a standard 3U Cubesat in a rarefied atmosphere by modification of its shape and adjusting the position of the center of mass.

The attitude motion of the satellite under consideration is mainly influenced by gravitational and aerodynamic torques. The former tends to align the satellite along the local vertical, the latter – along the local horizontal. At high altitudes, the gravitational torque prevails, and the desired satellite position along the orbital velocity vector becomes unstable. In this case, the oscillations of the elastic panels can cause chaotic attitude motion of the satellite. Therefore, the use of deployable panels does not provide guaranteed stabilization at all possible altitudes and should be complemented by a modification of the satellite nose section. This modification should exclude instability and at the same time reduce air drag on the satellite, increasing its orbital lifetime. For the detailed analysis of the described problem, a mathematical model of the attitude motion of the satellite was created, which takes into account the influence of gravitational and aerodynamic torques and the oscillations of the deployable panels.

As a result of the study, a combination of the shape of the considered 3U Cubesat nose section, panel sizes and deployment angles, as well as the position of the center of mass, was chosen. These measures will significantly increase the upper limit of the operational altitude range of the satellite. The results of the study can be used for planning future missions involving Cubesats.