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BALLISTIC COEFFICIENT CHARACTERIZATION OF THE 3U CUBESAT IGNIS MISSION

Abstract

IGNIS (Infrared Geological Nano Imaging System) is an ongoing project led by a group of students at the University of Naples "Federico II." Its primary objective is to develop a 3U CubeSat by adapting a Commercial Off-The-Shelf (COTS) thermal camera for the space environment, integrating an educational program with an Earth observation experiment.

This study focuses on characterizing the spacecraft's ballistic coefficient, a key parameter for accurate orbital decay analysis. The ballistic coefficient is determined by defining the aerodynamic drag force, the cross-sectional area, and the drag coefficient. Since IGNIS operates in a free molecular flow regime, the Navier-Stokes equations are not applicable, necessitating the use of the Direct Simulation Monte Carlo (DSMC) method. The first step involved creating a detailed CAD model of the CubeSat, incorporating aerodynamic components such as antennas, solar panels, and sensors. The model was then converted into a mesh compatible with DS3V software, which was used to simulate the interaction between the atmospheric flow and the satellite's surface. These simulations enabled the calculation of the aerodynamic drag coefficient and the ballistic coefficient for different mesh configurations, confirming the convergence of results. Additionally, a mixed re-emission model was evaluated, introducing a 20% specular reflection component, which led to an increase in aerodynamic drag. A passive de-orbiting method, based on altering the satellite's attitude, was also analyzed. The results demonstrated that a 45 yaw maneuver relative to the flight direction significantly increases aerodynamic drag, thereby accelerating orbital decay. Furthermore, using the DS3V software, the net heat flux incident on the satellite at different altitudes was calculated, providing a comprehensive assessment of compliance with space debris regulations. The obtained values were compared with analytical and numerical methods related to atmospheric re-entry, ensuring robust validation of the thermal analysis.

The results of this study demonstrate that the methodology used to characterize the ballistic coefficient of IGNIS is a valid approach for analyzing the ballistic parameters of picosatellites.