Paper ID: 88001
student

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

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DRAG COUPLING OF ATTITUDE AND ORBITAL DYNAMICS FOR LEO SATELLITES.

Abstract

For unpowered satellites in Low Earth Orbit, accelerations due to atmospheric drag effects are predominant in determining the expected lifetime and mission return. The principle aim of this work is to reduce the uncertainty in the ballistic coefficient for space objects subject to atmospheric particle streams. The ballistic coefficient of a body is a measure of its ability to overcome air resistance in flight, which is a key parameter in determining the disturbances due to aerodynamic effects. As the spacecraft tumbles, the ballistic coefficient varies as a function of the cross sectional area with respect to the particle stream. A cross-section estimation algorithm is developed to determine the ballistic coefficient based on the instantaneous orientation of the satellite. This procedure is implemented in a mission analysis tool for STRATHcube, a 2U CubeSat with a primary payload to detect objects in Low Earth Orbit. STRATHcube is researched, developed and led by students at the University of Strathclyde.

A high fidelity model of the perturbed orbital dynamics is developed in CALYPSO, an in house orbit propagation tool developed at Strathclyde which formulates the variation of a set of averaged orbital elements undergoing perturbed motion. CALYPSO considers an exponential model of the atmospheric conditions and assumes the ballistic coefficient to be constant during the lifetime of the satellite. In operation however, the ballistic coefficient will change as it is dependent on the cross sectional area of the satellite. The aerodynamic perturbative accelerations in the model of the orbital dynamics are coupled to an osculating model of the attitude dynamics by determining the averaged ballistic coefficient over short intervals of flight and updating the orbit model during the propagation. This work demonstrates the degree to which the ballistic coefficient varies during flight and the effect of this variation on the overall lifespan for a LEO CubeSat.