Paper ID: 39885
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15th IAA SYMPOSIUM ON SPACE DEBRIS (A6)
Space Debris Removal Concepts (6)

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CUBESATS FOR ACTIVE ORBITAL DEBRIS REMOVAL

Abstract

The number of space debris has increased in recent years due to intentional and accidental explosion or collision of orbital objects. This has led to a higher number of near-miss events between orbital objects, and more frequent collision avoidance maneuvers by operational satellites. As a result, the problem of space debris has become a major concern in the space community. The safety of space assets is becoming progressively more dependent on the active elimination of orbital debris. Space agencies in many countries are conducting studies of methods to remove space debris, and some agencies have already announced plans to perform technology demonstration missions in Earth orbit in near future.

In this paper, an alternative method for active removal of Earth-orbiting debris is presented. The method is based on the utilization of a class of miniaturized satellites that is known as CubeSat, which is equipped with commercial off-the-shelf components, attitude sensors and actuators, and low-thrust propulsion system to navigate between orbits. The deorbiter CubeSat is delivered to a target debris aboard a mothership. After separation from the mothership and latching on to the target debris, the deorbiter CubeSat cancels the residual tumbling motion of the debris, and subsequently transfers it to a lower orbit where atmospheric drag is much higher. The conceptual design of the deorbiter CubeSat is presented, and the key components are identified and described. An overview of the dynamics and kinematics of the system is provided, and the detumbling mechanism and control algorithm are explained. Deorbiting trajectories are designed using the Gauss variational formulation. The mass and power budgets are evaluated and presented. The Monte Carlo simulation is used to model the deumbling and deorbiting maneuvers. In light of the simulation outcome, the technical feasibility of the deorbiter CubeSat removal concept is investigated. The physical characteristics of orbital debris, i.e., mass and shape, are retrieved from the DISCOS database that is provided by the European Space Agency's Space Operations Centre, and their orbital states are propagated from their latest two-line element data.