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A Scalable Drag Sail for the Deorbit of Small Satellites

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Abstract

It is predicted that over 2,600 nanosatellites and microsatellites will be launched into orbit over the next five years. In addition, plans for large commercial constellations consisting of thousands of small satellites in the 1,100–1,400 km orbit altitude regime are currently in development, driving the need for a scalable, reliable deorbit system. A drag device provides an efficient method for accelerating deorbit following the completion of a satellite's operational mission. The Passively Stable Pyramid Sail is a standardized, bolt-on deorbit system in the form of a thin-membrane drag sail. The sail geometry is established to provide passive aerodynamic stability in the upper atmosphere, allowing the system to trim to the maximum drag attitude. This scalable system is sized according to the satellite mass and orbit altitude in order to deorbit the host satellite within 25 years. Unlike propulsive deorbit systems that require operability of the host satellite, the drag sail approach can be implemented in a manner that ensures deployment and deorbit even if the host satellite is inoperative. The ESPA-class version of the design requires 10 m long booms to deorbit a 180 kg satellite from a circular orbit at an altitude of 1,110 km. A prototype version is in development for a CubeSat demonstration mission called the Aerodynamic Deorbit Experiment. This paper will provide an overview of the Passively Stable Pyramid Sail by describing the design of the ESPA-class system, followed by discussion of the prototype system for the Aerodynamic Deorbit Experiment.

1. Introduction

Orbital debris is a growing problem in low-Earth orbit; it has crossed a threshold of critical density where the number of debris objects will grow exponentially due to collisions unless actively mitigated (Levin et al., 2011; Kessler and Cour-Palais, 1978), especially in high value orbits. The recent trend toward CubeSats and small satellite missions has led to a proliferation of space objects. The most recent Nano/Microsatellite Market Forecast compiled by Spaceworks (Williams et al., 2018) states that there was a 205% increase in the number of satellites with masses of 1–50 kg launched in 2017 over 2016. They estimate 2,600 nanosatellites and microsatellites will be launched in the next five years (Williams et al., 2018). There is a need for a standardized system that

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