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LOW-COST MISSION TO DE-ORBIT A SPENT STAGE OF A ROCKET USING 250-KG SPACECRAFT PLATFORM

Abstract

The count of Resident Space Objects greater than 10 cm in size orbiting the earth has exceeded 36500, this fact coupled with the exponentially increasing rate of new satellite launches, poses a threat of triggering a Kessler's Syndrome. This jeopardizes humanity's plans for long-term, sustainable use of space. Space debris is therefore acknowledged by space community as the single most important problem requiring an immediate solution. The challenge of debris mitigation can be addressed efficiently by limiting the probability of collisions through the removal of large, defunct debris. An Active Debris Removal (ADR) mission necessitates development of a "chaser" satellite capable of rendezvousing with the debris to capture and de-orbit it. The existing ADR solutions being developed either consist of heavy-budget, ton-class chasers focused on removing large debris or low-cost 100-kg class chasers that target smaller debris like MicroSats and CubeSats since they lack the propulsive capability to deorbit larger debris. Bellatrix Aerospace, an in-space propulsion company, has identified this existing lack of low-cost solutions for mitigation of debris weighing between 200 kg-1200 kgs and is developing a 250 kg class Orbital platform, Pushpak^{TM} with the required propulsive capability to bridge this gap.

The focus of this paper is on design of a technology demonstration mission planned by Bellatrix to de-orbit a spent stage of a rocket, a target that was chosen for having the most challenging mass-inertia properties. The paper presents the mission design and concept of operations including major phases like Rendezvous and Proximity Operation (RPO), target capture, stabilization, and de-orbiting. It also briefly outlines platform subsystem design. The paper further identifies all the critical technologies involved. This includes propulsion, Robotic arm for debris capture (both being developed at Bellatrix), sensors and algorithms for autonomous relative navigation.

Bellatrix has attained TRL 6-7 for in-house developed Electric and Green propulsion systems. Leveraging this development, Pushpak^{TM} is equipped with a hybrid propulsion system wherein the electric propulsion provides the required delta-V to the spent stage to de-orbit it through low-thrust maneuvers, whereas chemical propulsion facilitates agile maneuvers during RPO.

The paper also elaborates on the Robotic arm being designed to handle the mass-inertia of the large spent stage and a thruster pointing mechanism being developed to enable thrust vectoring despite large variations in center of gravity post capture.

The mission is optimized for cost and propellant consumption.