Paper ID: 25843
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SPACE DEBRIS SYMPOSIUM (A6)
Poster Session (P)

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DEPLOYABLE DRAG DEVICE FOR LAUNCH VEHICLE UPPER STAGE DE-ORBIT

Abstract

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 unless mitigated. Spent launch vehicle upper stages represent a problematic category of orbital debris in highly utilized orbits. They can stay in orbit for well over 100 years if left to deorbit naturally, and they represent a significant fraction of large space debris in low-Earth orbit. It is estimated that removing a few large objects per year will mitigate the exponential growth of debris. To address the debris problem, this research is focused on accelerating the orbit degradation of upper stages by using a deployable drag device that can be launched as a secondary payload. Following the operation of the upper stage, the drag device will be deployed to decrease the orbit lifetime of the system. The design is targeted toward upper stages launched into orbital altitudes ranging from 650-850 km. Three categories of deployable drag devices are being investigated: drag sails, inflatable aerodynamic decelerators, and electrodynamic tethers. The device will be mounted to the upper stage using a standardized secondary payload launch interface, such as a CubeSat deployer device or the EELV Secondary Payload Adapter (ESPA). A trade study was conducted to compare the drag device configurations based on cost, risk, and deorbit time. The cost is estimated based upon parametric data and scaled by drag area. The risk is evaluated based upon four categories. The first risk category addresses the capability of the device to adhere to secondary payload requirements levied by the launch system. Next is the risk that the device will create new debris through collision with resident space objects, based upon the area-time product of the device-launch vehicle system. Risks associated with device deployment and sustained drag area during the orbit decay period are also considered. A maximum deorbit period of 25 years is a performance design requirement. Included in the trade study is the option of using residual propellant in the upper stage to perform a burn to initiate a deorbit trajectory. This is shown to be the lowest cost option, however the drag device is more mass efficient and has less of an impact to the payload capability of the launch vehicle. This paper describes the process for the selection of the deployable drag device architecture, and discusses the design and performance of the system.