Paper ID: 73442
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20th IAA SYMPOSIUM ON SPACE DEBRIS (A6)
Post Mission Disposal and Space Debris Removal 1 - SEM (5)

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ANALYSIS OF POST-MISSION DISPOSAL STRATEGIES FOR ROCKET BODIES

Abstract

One of the essential aspects of space debris mitigation is the performance of Post-Mission Disposal (PMD) once the mission of a space vehicle has concluded. The main goal of the PMD is to avoid the creation of further space debris, especially mitigating the risk for on-orbit collisions or explosions that would cause a fragmentation and potentially contribute to a collisional cascading effect known as the Kessler syndrome. In order to do so, PMD strategies in Low Earth Orbit (LEO) typically focus on reducing the orbital lifetime of the objects residing in this region after their mission has been completed. However, as the spatial density varies across altitudes and inclinations, the orbit with the lowest orbital lifetime is not necessarily the one with the lowest cumulative collision probability. Consequently, a deeper analysis of the disposal orbit can be beneficial to further reduce the risk posed in the environment by the disposed object.

Rocket stages incorporate large propulsion systems, which can be easily used to perform a de-orbit manoeuvre if enough propellant is available (with some exceptions, such as systems which are not designed to be re-ignitable). However, many rocket stages still do not perform disposal manoeuvres at the end of their mission. It can be assumed that the main limitations come from mission and system constraints to add more propellant on board, which highlights the importance of optimizing the manoeuvres being performed.

In this paper, starting from different initial orbits, candidate disposal orbits are studied in terms of remaining orbital lifetime, cumulative collision probability for the remaining lifetime, and v required to perform the manoeuvre. The results allow to derive the disposal orbits leading to the largest reduction of the cumulative collision probability for a determined initial orbit and with specific v constraints, and to compare to the traditional approach to only reduce the orbital lifetime. Moreover, the impact of the shape and attitude of the rocket stage is analysed, as it influences both the orbital lifetime and the collision probability, and the impact on the preferred disposal orbits is shown.

Finally, the PMD manoeuvres performed by rocket bodies during the past 5 years are analysed and compared to the results obtained, aiming to show how current practices can be improved even without a significant increase on the amount of propellant used.