Paper ID: 39097
oral
student

15th IAA SYMPOSIUM ON SPACE DEBRIS (A6)
Space Debris Removal Issues (5)

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TAXONOMY AND ANALYSIS OF ISSUES FACING POST MISSION DISPOSAL CONCEPTS

Abstract

In order to ensure a sustainable space environment for future generations, a strategy for all spacefarers must be developed in order to mitigate the growth of the space debris population. To this end, this preliminary analysis is the first step towards the development of a cost-efficient but highly reliable PMD (Post Mission Disposal) module. This PMD module will be attached to the spacecraft on ground and will ensure the removal of the spacecraft at the end of the nominal operational lifetime or act as a removal back-up in the case of loss of control of the spacecraft. The PMD module will be scalable and flexible, enabling the PMD of any future spacecraft in an Earth orbit. Ultimately, the gap between the 90% PMD success rate required by ISO 24113:2011(E) and the current success rate of 50%-60% can be closed.

A survey of re-orbit techniques and concepts was carried out and a taxonomy of approximately 40 concepts, including 12 which do not appear in the literature, is presented. A qualitative analysis was carried out on the concepts identified in the taxonomy, and a comparison matrix was built including 12 different comparison metrics. The 5 most promising concepts for the PMD module were down-selected from this matrix. These concepts were: drag augmentation, solar sailing, electrodynamic tether, low thrust propulsion and high thrust propulsion. A further 3 additional concepts were also defined by considering combinations of the down-selected concepts.

A quantitative analysis of the down-selected concepts was performed using a purpose built analytical analysis tool. This tool was designed to rapidly predict re-entry epochs of space objects, given specific mission parameters. The analytical nature of this tool allowed for Monte Carlo analysis resulting in trade-off analysis within and between the different concepts for various mission parameters.

The output of the quantitative analysis provided preliminary mission parameters, systems sizing and trade-off data on each of the down-selected concepts and combination concepts. From this analysis it was concluded that each system had it advantages, and challenges, so recommendations were made on how each system could be used to its maximum potential and which systems were more effective than others in specific situations. The most prominent of these results were the need for the PMD to de-tumble the spacecraft prior to deployment of the removal system, and the fact that none of the down-selected concepts were recommended for use in long term missions.