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REDSHIFT DISPOSAL MODULE FOR THE DESIGN OF END-OF-LIFE DISPOSAL
TRAJECTORIES FOR LEO TO GEO MISSIONS

Abstract

The ReDSHIFT project has developed a software tool for spacecraft operators, space agencies and research institutions to design the EOL of Earth-based missions and to study the interaction with the space debris environment. As part of this, the disposal module, presented in this paper in its structure and algorithm, computes the EOL disposal strategy for missions whose operational orbit is in the orbital region from LEO to GEO. Given the initial orbit, the available v on board and the spacecraft characteristics in terms of cross area and mass, the options for end-of-life disposal are given and compared; namely, end-of-life disposal via one or a sequence of impulsive manoeuvres, end-of-life disposal through the use of a solar/drag sail or end-of-life through a hybrid sail + manoeuvre. This module is based on a study of the natural orbit evolution of many initial conditions in the low to medium and geostationary regions to identify long-term stable and unstable orbits to be used as graveyard or natural re-entry trajectories. The manoeuvre to reach such conditions from the operational orbit is calculated and compared with the available v on board the spacecraft at the EOL. Moreover, the re-entry can be enhanced through a sail. Different strategies for sail attitude control are compared and selected. The simpler solution is to deploy a passively stabilised sail or a balloon so that the attitude of the sail is always constant with

respect to the Sun-Earth line. As a more advanced solution, in case control of the attitude of the sail can be ensured, a new modulating sail strategy is devised, that changes the attitude of the sail every six months, on average, to monotonically increase the orbit eccentricity and allow the use of solar sails also to higher altitude orbits in the MEO regime. In the case a sail is used, the disposal module also output the parameters for the technological design of the sail. Finally, a hybrid method is also proposed, where first a manoeuvre is given to move the spacecraft in a condition close to resonances, and then a sail is deployed. The disposal mapping module outputs the available solutions given the operational constraints for the spacecraft to be then passed to the other modules of the software that assess the effect of this disposal on the space debris environment, and the demisability of the re-entry trajectory. The tool is integrated in the openSF simulation framework.