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ASSESSMENT OF PASSIVE AND ACTIVE SOLAR SAILING STRATEGIES FOR END-OF-LIFE RE-ENTRY

Abstract

The increase of space debris in the past decades has boosted the need of end-of-life disposal devices for future and orbiting spacecraft. Among the passive deorbiting methods, solar and drag sailing have been analysed and technology demonstrator are under development.

This study focuses on the disposal using a solar sail or a deployable reflective surface to increase the Area-to-Mass (AtM) of the spacecraft and enhance the effects of solar radiation pressure and atmospheric drag. While the effect of drag can be enhanced by maximising the cross area to the velocity vector, the effect of solar radiation pressure can be exploited in two different ways. Conventional active solar sailing for deorbiting aims at maximising the cross area of the sail perpendicular to the spacecraft-Sun direction when the spacecraft is moving towards the Sun, while the sail area is minimised when the spacecraft is flying away from the Sun. In this way the semi-major axis and thus the energy of the orbit is decreased. A second strategy, proposed by Lücking et al., keeps the reflective surface always oriented towards the Sun and control it though passive stabilisation. Deorbit in this case is achieved by increasing the eccentricity of the orbit, at a quasi-constant semi-major axis.

In this work the passive and active solar sailing techniques are compared to determine the most efficient deorbiting strategy under a maximum deorbiting time constraint. An optimization algorithm is implemented to find the best deorbiting parameters required (i.e. Area-to-Mass and time to deorbit). Maps of the best deorbiting parameters for active/passive solar sailing are obtained from LEO to GTO orbit, and inclination up to 90. An extension to elliptical orbit is also carried out.

The passive deorbiting process is found to be the fastest deorbiting technique. For every orbital inclination, it offers a deorbiting possibility within 5 years, and a sail parameter of less than 6 m2/kg, down to 0.75 m2/kg (42 inclination). Therefore it extends the range of solar sailing deorbiting up to 7000 km altitude (for low inclination), down to 500 km (for 42 inclination). The active solar sailing technique remains interesting for longer deorbiting time, enabling smaller Area-to-Mass ratio of the sail. Deorbit from an elliptical orbit reduces the AtM and time required to deorbit, and favours more one of the two sailing technique, depending on the initial orbit configuration. The efficiency of the passive method paves the way to a semi-passive sailing technique.