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EFFECTS OF PASSIVE DE-ORBITING THROUGH DRAG AND SOLAR SAILS AND ELECTRODYNAMIC TETHERS ON THE SPACE DEBRIS ENVIRONMENT

Abstract

Solar and drag sailing and electrodynamic tethers have been proposed as passive end-of-life deorbiting methods, and technological demonstrators are under development. In the drag dominated regime the required area-to-mass-ratio for deorbiting a sail spacecraft is primarily dependant on the semi-major axis, growing exponentially with increasing altitude. In the solar radiation pressure dominated regime, the required area-to-mass ratio strongly depends on both semi-major axis and inclination of the initial orbit.

The deorbiting phase, at least in the first phase, is achieved on an elliptical orbit, not a circular orbit like in the case of drag sail with inward deorbiting. Another technology for end-of-life satellite deorbiting is represented by electrodynamic tethers. In general, increasing the cable length as well as its cross section increases the deorbiting force. During deorbiting the satellite passes through the debris environment. The cumulative collision risk can be quantified as a function of the collisional cross-section present in orbit and the time of exposure of this cross-section to the flux of debris present in the environment. The objective of this study, funded by the European Space Agency, is to understand the net effect of using de-orbiting technologies like sails or tethers over the future debris population around the Earth. Indeed, the increased cross sectional area will decrease the deorbiting time, however they will increase the collision risk over the deorbiting phase with respect to a standard satellite. We aim at assessing the collisions risk of deorbiting satellites using these deorbiting techniques, and the consequence of such a collision in terms of global effects onto the whole debris population. To do that fragmentation models have been devised to define when a catastrophic collision will take place and to characterise the following fragments distribution. Long-term simulation of the whole space object population environment are used to evaluate the net effect of using these strategies by means of the definition of an environmental index. Finally, the effort in terms of collision avoidance manoeuvre by conventional spacecraft is assessed and methods for sails and tether to avoid small fragments with low-push manoeuvres or attitude control are investigated.