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INCREASING ADR EFFECTIVENESS VIA AN ALTITUDE-SHELL-DEPENDANT REMOVAL APPROACH

Abstract

Space debris guidelines will become increasingly relevant as tools to enable the stability and preservation of the whole space environment, even though they have yet to achieve real widespread adoption. For this reason, it is important to understand the benefits and limitations of current guidelines and to explore debris mitigation methods . Among these methods, Active Debris Removal (ADR) is a promising one, but it is still to be successfully proven in orbit. Moreover, its benefits are linked both to a priority removal list and to the randomness of the collisions in each simulation. The aim of this work is to investigate a new approach which can increase the ADR effectiveness regardless of the boundary conditions and population evolution. An evolutionary model of Low Earth Orbit (LEO) has been recently developed at Southampton University. This statistical model uses a source-sink approach whereby new objects are added by launches, explosions, and collisions, while the atmospheric drag, ADR and Post-Mission Disposal (PMD) are removal mechanisms. A proportional controller applied to parameters associated with ADR represents the main novelty of this model. It is capable of emulating different removal principles in each of the altitude shells in which the LEO region is divided. Through its application, several strategies for preventing (or limiting) the growth of the LEO population) are investigated and compared . This study presents results from 24 different scenarios performed with various PMD compliance level (0%, 30%, 60% and 90%) and control parameters. They demonstrate that a locally optimised removal rate (obtained via a multiple altitude-shell-dependant ADR approach) always performed better than a fixed proportional removal rate. Comparing these two strategies, the relative benefits of the first one are quantifiable in a reduction up to 8.3% in the total population (at the end of a 200-years simulation time-frame) and 8.8% in collisions. Moreover, the most crowded orbital regions of 900-1000 km and 1300-1500 km enjoy the major benefits, having a relative population reduction up to 16.1% and 16.8% respectively. The total number or removal was also always lower (except for a single case) up to 42% thanks to the use of a different removal profile both in space and time. The results demonstrate that the use of such multiple removal directives can improve the effectiveness of ADR while meeting external constraints on the maximum number of removals due, for example, to logistic constraints (e.g. launch availability) and economic factors.