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ADR MISSION DESIGN AND DE-ORBITING STRATEGIES APPLIED TO HEAVY TARGETS

Abstract

The steady increase in the number of debris in LEO, is a matter of great interest and concern by the scientific community. If up to now, the number of collisions, resulting in fragmentation, has been rather limited, a space debris' rate of growth equal to the current will inevitably lead to an exponential increase of such collisions. Recent studies confirm that the simple strategy of post-mission disposal may not be enough. In order to ensure that the rate of growth of debris in LEO tends to zero or possibly becomes negative, it will be necessary to implement specific missions for active debris removal.

The idea behind the study is to exploit the effect of Earth's non-sphericity perturbation and optimize the V associated to the rendez-vous manoeuvre, by compensating for the and , present between the orbital transfer vehicle (chaser) and the debris to be captured (target). Obviously, the perturbation will lead to favorable variations of the orbital parameters only for some combinations of and , related to chaser and target. However, the presence of a population of debris with a random distribution of and , makes this application particularly suited to the problem.

The optimization problem has been addressed by implementing a hybrid evolutionary algorithm, which adopts, in parallel, three different strategies, namely, Genetic Algorithm, Differential Evolution and Particle Swarm Optimization. The orbital transfer to which the optimization algorithm has been applied is a 4-impulses time-fixed rendez-vous, in which the solution was expressed by a 6D vector, defining the manoeuvre. Moreover, by suitably selecting the target from a population of debris detected by NORAD in LEO, it was possible to achieve a substantial saving on V, associated with the transfer. This is due to the fact that J2 effect contributes to compensate and differences between chaser and target, that on expiry of the time of flight, will find themselves aligned.

The next step in the study was to insert a database containing the orbital parameters of some debris present in LEO, in the optimization program. At this point, the 7D solution vector that is produced by the optimizer, also contains the information linked to the specific target selected from the database. In this way, by carrying out various simulations in succession, it was possible to produce an optimal sequence of capture, with single depth, according to the nearest neighbour algorithm.