Assessing the effectiveness of resonant corridors in passive debris disposal

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ABSTRACT

In the framework of the EU H2020 Project ReDSHIFT a complete mapping of the Low Earth Orbit (LEO) space was performed, looking for “passive dynamical” disposal strategies exploiting natural perturbations to the orbits of the spacecraft. Some preferential de-orbiting routes, natural reentry corridors dubbed “deorbiting highways”, result from specific resonances populating the different orbital regimes involving gravitational and non-gravitational perturbations. In order to properly exploit the solar radiation pressure driven resonances, the use of area augmentation devices is also foreseen.

In this work, we show the results of a set of long term evolution simulations aimed at testing the effectiveness of the proposed dynamical disposal by means of the “de-orbiting highway” in limiting the accumulation of large objects in space after the end of the operational life. The simulations were performed evolving an ad-hoc launch traffic, expressly modified in order to highlight the possible benefits of the “de-orbiting highways” in facilitating the disposal of the spacecraft at the end-of-life. Therefore, to enhance the signal coming out of the simulations, a displacing of the launch traffic with respect to the historical one (e.g., moving many missions towards higher altitudes where the atmospheric drag perturbation is not effective or changing the orbit inclination towards the resonant ones) was adopted.

The results show how the resonance corridors can be very effective in removing the majority of objects within 25 years from the end of the operational life, thus contributing to the stabilization of the space debris environment. In higher LEO orbits, which might become more populated in the near future (e.g., with the possible advent of the large constellations), to reach the same level of compliance with a simple impulsive maneuver an increase in $\Delta V$ of about 1 order of magnitude would be required.

Whereas the displacing of the launch traffic in the simulations was arbitrary, it is worth pointing out that an accurate choice of the original mission parameters (e.g., inclination closer to resonance corridors) could sometime be taken into consideration, still preserving the original goals of the mission. These possible changes should be properly leveraged against the advantages encountered at the end of the operational life enabling a better compliance with the de-orbiting guidelines. This should represent a new paradigm in mission planning, where the whole life-cycle of the spacecraft, including disposal, has to be taken into account from the very beginning of the design.

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