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IMPACT OF THE BALLISTIC COEFFICIENT ESTIMATION ON ORBITAL LIFETIME PREDICTIONS OF ROCKET BODIES

Abstract

One of the essential aspects of space debris mitigation is the performance of Post-Mission Disposal (PMD) once the mission of a space vehicle has concluded. The main goal of the PMD is to avoid the creation of further space debris, especially mitigating the risk for on-orbit collisions or explosions that would cause a fragmentation and potentially contribute to the collisional cascading effect known as the Kessler syndrome. An integral part of the PMD is the clearance from the protected regions, as it is stated in the IADC space debris mitigation guidelines. For the Low Earth Orbit (LEO) protected region, this implies the re-entry in Earth's atmosphere within 25 years after the end of mission. In this context, orbital lifetime estimations are crucial to assess the compliance of new missions to be launched.

The decay of objects in LEO is mainly dominated by drag, caused by the residual atmosphere that is still existing in these lower altitudes. On the other hand, objects located in Highly Eccentric Orbits (HEO) experience various cross-coupled perturbations, mainly as third body gravity effects, that also have a strong influence on their decay behavior. In both cases, the modelling of the ballistic coefficient, which is the parameter determining how strong the influence of drag is on an object, will have a great impact on the orbital lifetime estimation.

RACER (Radiation and Atmospheric Drag Coefficient Estimation Routine) is a tool by the European Space Agency that estimates the ballistic coefficient of an object based on a set of Two-Line Elements (TLEs). This ballistic coefficient can be used to improve current orbital lifetime predictions. Furthermore, as different ballistic coefficients can be observed for different time windows, information about the attitude of the object and its changes within the lifetime can be inferred.

The analysis in this paper has two foci: first, a general procedure is found to improve the lifetime predictions of a dataset of almost 800 rocket bodies, divided in objects resident in the LEO region and objects in HEO orbits. Secondly, a more detailed analysis is performed on the stages corresponding to a specific rocket family, in order to identify patterns and provide a set of recommendations that can guide future predictions.