SPACE DEBRIS SYMPOSIUM (A6)
Mitigation and Standards (4)

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PROPELLANT-EFFICIENT METHOD FOR CONTROLLED DEORBIT OF LEO SATELLITES

Abstract

The end-of-life spacecraft mission phase has received increasing attention over the past years, due to the growing risk of collisions through space debris. This paper discusses a ΔV efficient controlled deorbit strategy that exploits atmospheric drag to reduce the propellant consumption in comparison to a classic Hohmann-type manoeuvre.

Guidelines issued by the inter-agency space debris coordination committee (IADC) demand low Earth orbit (LEO) satellites to deorbit within 25 years after the end of operations. For the majority of (larger) satellites a controlled re-entry strategy is needed, that ensures an impact in a specified target landing zone. However, active deorbiting means an increase in mass, reliability requirements, and overall costs. The typical approach is to make one large manoeuvre that inserts the satellite into an elliptical orbit with a sufficiently steep atmospheric re-entry angle. In this paper, an alternative strategy is proposed, which reduces the required ΔV by approximately 50%, using the normal propulsion system for orbit maintenance. The strategy is developed in detail and applied to a specific example scenario. The presented approach is general and can be applied to any LEO mission with ΔV capability.

The proposed strategy consists of an active phase to lower the perigee, a passive phase to further lower the orbit through atmospheric drag and a final active phase to initiate re-entry. The required ΔV for the first active phase is driven by the allowed maximum time until re-entry. This time is restricted because the satellite bus is required to be operational to initiate the controlled deorbit. In the final active phase a manoeuvre is performed that guarantees re-entry into the atmosphere with a certain minimum entry angle. A Pareto-front is constructed that facilitates a trade-off between ΔV and atmospheric entry angle. Each point on the curve corresponds to a re-entry trajectory.

A sensitivity analysis has been carried out for a set of optimum trajectories, to assess the effect of uncertainties in manoeuvre execution, atmospheric drag and lift-to-drag ratio on the impact location. The result expresses the uncertainty of the landing location as a function of the entry angle. This is used to support the selection of the minimum ΔV manoeuvre from the Pareto curve.

Using this active-passive-active strategy for controlled deorbit allows significant propellant savings compared to the usual single manoeuvre strategy, while limiting the total time to deorbit, engaging the existing propulsion system, and guaranteeing an impact in the target landing area.