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A STABLE HELIOCENTRIC DISPOSAL STRATEGY FOR LPO MISSIONS, INSPIRED BY THE NATURAL CO-ORBITAL MOTION OF SATURN'S MOONS

Abstract

We will present a disposal strategy for Sun-Earth LPO missions, based on stable heliocentric graveyard trajectories that do not approach the Earth-Moon system in the long term. Previous studies analyzed the possibility of reentering to the Earth, impacting on the Moon or move to a heliocentric graveyard orbit. As regards the third option, that is actually the only one implemented so far, the idea is to move the spacecraft beyond the zero-velocity curves (ZVC), interior to L_1 or exterior to L_2 depending on the operational orbit, and eventually apply an impulsive maneuver to close the ZVC to prevent the spacecraft from returning to the Earth's neighborhood. In this case, Monte Carlo simulations are usually required to evaluate the risk of an Earth's return in the long term, by considering a full dynamics that accounts for the main orbital perturbations. Another possibility is to take advantage of the natural third-body perturbation due to the Earth to increase continuously the Minimum Orbit Intersection Distance. The novelty of our work is that we take advantage of the mutual configuration observed in nature between Janus and Epimetheus, two moons of Saturn, to design a heliocentric graveyard strategy that is stable by definition and does not require additional operations to stay away from the Earth. Rather than lowering the energy of the spacecraft (or increasing the Jacobi constant) to close the ZVC, the configuration needs an energy increase to reach a quasi-periodic orbit stemming from L_3. Taking advantage of the theory developed to explain the motion of Janus and Epimetheus, we design quasi-periodic horseshoe orbits, associated with L_3, that satisfy the conditions required to be stable under the dominant orbital perturbations. The stability of these disposal orbits is verified considering a n-body problem with solar radiation pressure. The transfer required to move from a given L_2 LPO mission to such orbits is designed first via a Lambert procedure and then refined onto a more sophisticated dynamical model.

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