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END-OF-LIFE DISPOSAL DESIGN FOR SPACECRAFT AT LIBRATION POINTS ORBITS AND AN INTERPRETATION OF THEIR PROBABILITY OF EARTH RETURN

Abstract

Since space activity started, the number of spacecraft completing their missions continue to rise, increasing the amount of debris which could collide with operative spacecrafts or re-enter to Earth. No guidelines currently exist for spacecraft orbiting around Libration Points, and since those orbits are increasingly used, it is important to dispose them in a safe way. This goal is sometimes achieved performing a non-optimal single disposal manoeuvre directed along the Sun-Earth line direction. This paper will prove that it is instead better to optimise such a manoeuvre dividing it in, at least, two burns, even if the total available Δv is low. The energetic approach, firstly introduced for the circular restricted three body problem by Olikara et al. is used, which consists in giving one v to let the spacecraft enter the unstable manifold and a second one to decrease its energy to the close the Zero Velocity Curves. More recent work also showed how the required v manoeuvre changes as a function of the position of Earth-Moon Barycentre (EMB) around the Sun, at the time when the disposal is initiated, since its orbit is elliptical. In this work we will analyse the optimal disposal manoeuvre design using the Elliptical Restricted Three Body Problem (ER3BP) and the energetic approach. The dynamics is propagated for 100 years and the parameters to describe the disposal manoeuvre, namely the direction and the magnitude of the first Δv and the time after which the second manoeuvre shall be given, are optimised via a genetic algorithm. The disposal design is performed for the GAIA and Lisa Pathfinder missions for different initial conditions over one year. Since in the ER3BP the ZVCs have a pulsation behaviour and there is no analytical representation of them, an approximation of the ZVCs is used. Moreover, a sensitivity analysis of the solution to the magnitude of the available Δv is performed and it is shown how the solution passes from a two body problem-like trajectory to a low-energy trajectory. Finally, an interpretation of the results of a long term simulation of the disposal orbit in the n-body problem is given, by analysing the probability of return to Earth against the date when the disposal manoeuvre is given. In particular a link with the position of the minimum orbit interception distance between the Earth-Moon system and the s/c trajectory and the phasing angle between the EMB and the s/c is found.