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ESCAPE, DISPOSAL AND RE-ENTRY TRAJECTORIES FROM LUNAR NON-KEPLERIAN ORBITS

Abstract

The exploitation of cislunar space for future exploration missions has recently gathered significant attention, in particular for the benefits non-Keplerian orbits offer as staging locations. An exploration outpost, manned or robotic, can be placed and maintained in such environment with small amounts of Delta-V; furthermore, favourable Sun illumination conditions and Earth visibility make such orbits appealing and beneficial for system design as well. Among the many possibilities, Halo orbits in the vicinity of Earth-Moon L2 point have been successfully used by recent lunar exploration missions, and Near Rectilinear Halo Orbits (NRHO) have been proposed as location for a future international lunar gateway . For vehicles located in such environment a disposal strategy shall be settled. Different options are possible: heliocentric escape, collision on the surface of the Moon, Earth atmospheric re-entry, disposal in a graveyard orbit, etc., although some of them might be limited by mission constraints. Graveyard orbits, in particular, seem more difficult to achieve in such dynamical environment, as they need a high energy increase to be achieved in order to be stable. The paper analyses ballistic, one impulse trajectories, that enable a spacecraft to leave the cislunar environment towards the Moon, the Earth or an heliocentric orbit. Starting from some recent results, the effect of manoeuvre magnitude and direction is investigated, in order to find optimal trajectories to achieve spacecraft disposal; the sensitivity to manoeuvre epoch and to un-modelled perturbations is studied as well. A case study is presented, assuming a spacecraft in a EML2 orbits, and analysing the possible disposal options that might be employed at end-of-life. The results are validated with a Monte-Carlo approach, were errors in manoeuvre magnitude and direction are added, guaranteeing a given confidence level to the results discussed in the paper.