Paper ID: 48069
oral
student

21st IAA SYMPOSIUM ON HUMAN EXPLORATION OF THE SOLAR SYSTEM (A5)
Interactive Presentations - 21st IAA SYMPOSIUM ON HUMAN EXPLORATION OF THE SOLAR SYSTEM (IP)

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RENDEZVOUS IN LUNAR NEAR RECTILINEAR HALO ORBITS

Abstract

Near Rectilinear Halo Orbits (NRHO) have been recently identified as suitable location for a cislunar space station, to orbit in the Earth Moon vicinity and offer long term infrastructural services to manned and unmanned missions to the Moon and further. Indeed, to reliably perform rendezvous and docking/undocking phases between space vehicles orbiting on highly non-Keplerian orbits, such as NRHOs, represents a fundamental key technology. RVD is well-known for Earth centred missions, while no mission ever performed it on non-Keplerian orbits. The paper critically discusses the adopted approach and the obtained results in modelling the non-Keplerian relative dynamics and in synthetizing the guidance, to safely rendezvous and dock on NRHOs. The entire study is strongly driven by engineering constraints and mission requirements which lead the practical implementation. The dynamics intrinsic non-linearity - which makes the trajectories highly sensitive to small deviations - is here exploited to benefit both rendezvous operations and safety. The paper shows the relative trajectories, designed in a way that both NRHO central and unstable manifolds are used: the former to ensure the chaser relative orbit to be periodic with respect to the target, the latter to answer the passive safety philosophy here preferred. In fact, chaser deviation from target is naturally obtained, whenever on an unstable direction. Along the approaching trajectory, three holding points are assumed: on the central manifold the farthest, at about 100 km from the target, to prepare for the final approach; if a no-go is commanded, the spacecraft hovers on the central manifold, waiting for the next approach opportunity. The intermediate and the closest holding points are designed to lay on the unstable manifold direction, to privilege risk mitigation through passive safety, since if no active control occurs, the chaser - now just meters away from the target - naturally drifts away. The rationale behind the relative trajectory and approach strategy design, risen by the guidance and mission operations definition in nominal and non-nominal scenarios, is explained in the paper: the sensitivity analysis – with respect to the non-Keplerian natural dynamics parameters – which led to the approach corridor shape, Keep-Out Zones (KOZ) radius and Collision Avoidance Manoeuvres (CAM) settling is here exposed. The practical case of the cislunar space gateway servicing is here exploited to present the proposed rendezvous and approach techniques for non-Keplerian scenarios and to highlight the tool flexibility for general application in the n-body framework.