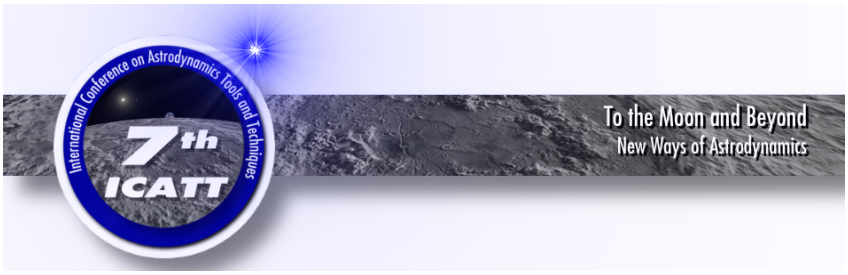

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Near Rectilinear Orbits around the Moon as Operational Orbit for the Future Deep Space Gateway

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A renewed vision to send humans beyond Low Earth Orbit (LEO) has given rise to a whole range of studies proposing different destinations and operational orbits for a new crew-tended space station; referred here as Deep Space Gateway (DSG). Near Rectilinear Halo Orbits (NRHO) have been identified as one of the most promising destinations for a DSG, due to the combination of both dynamical properties and accessibility to potentially water-rich regions in the Moon.

The aim of this paper is then to revise the suitability of NRHOs as long-term destinations for this new space station. The NRHO family indeed appears as a continuation of the classical Halo orbits, and, as such, also allows continuous line of sight with the Earth. The paper revises the formal definition and identification of NRHOs, as in the CR3BP model. Dynamical substitutes of the NRHOs are also refined in the Bi-Circular Model (BCM) by means of a multiple shooting method. key features such as lunar south-pole coverage, station keeping requirements and accessibility of the orbit are then analysed.

In particular, nine different station keeping strategies were identified and implemented. These strategies correspond to variations of three different underlying schemes; the cancellation of unstable dynamical modes, the use of the multiple shooting method and, finally, a weighted single-criteria numerical optimization.

The accessibility to and from the NRHO is discussed by computing direct and invariant manifold lead transfers. Due to the dynamical characteristics of the L2 NRHO family, the optimal strategy to transfer from LEO orbit is to target an auxiliary halo orbit first, for a posterior sub-transfer to a member of the NRHO family. A minimum LEO-to-NHRO transfer cost of 3.68 km/s is achieved following the aforementioned transfer strategy. An annual station keeping budget of only 1 m/s would be expected considering 1 km and 1 cm/s 3σ navigation errors, as computed in a BCM framework.

Summary

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