Paper ID: 67749
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IAF ASTRODYNAMICS SYMPOSIUM (C1)
Interactive Presentations - IAF ASTRODYNAMICS SYMPOSIUM (IPB)

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DIRECT PHASING MANEUVER IN CIS-LUNAR SPACE: SENSITIVITY AND ROBUSTNESS ANALYSIS

Abstract

The interest in returning to the Moon arose in recent years, this is proved by the fact that a new space station, called Lunar Orbital Platform Gateway - LOPG, will be placed on a L2-Near Rectilinear Halo Orbit around the Moon. The LOPG will be crewed, and multiple autonomous cargo missions will be required to maintain the operativity of the station: cargo vehicles will need to depart from Earth and dock/berth with the LOPG. Under the point of view of the mission design, all the cargo missions can be divided into four main steps: launch, Earth-Moon transfer, phasing and rendezvous/docking. The presented work is focused on the phasing and aims to assess the sensitivity and robustness of a guidance to perform a direct phasing maneuver, where the phasing maneuver is defined as the trajectory that brings the cargo spacecraft from the end of the Earth-Moon transfer to the beginning of the proximity operations, and the guidance is the sequence of operations that are required to successfully perform the phasing maneuver. The work describes a direct phasing guidance strategy, and it shows its sensitivity and robustness, in the limits of the validity of the Circular Restricted Three Body Problem with perturbations. The guidance to perform the phasing is described and evaluated in terms of: V and total transfer time. The guidance exploits the stable/unstable invariant manifolds and cr3bp-Lambert transfers to recover the lack of phase between the active cargo vehicle and the passive target on a NRHO. Then, the work shows how the performances of the proposed direct phasing guidance are affected when the initial conditions are perturbed (sensitivity analysis) and when the most significative perturbations are introduced (robustness analysis): the Sun, Solar Radiation Pressure and Moon's gravity perturbation. In both analyses the idea is to disturb the nominal trajectory 5 hours prior the end of the phasing, propagate until the end to evaluate the errors due to the perturbation of the initial condition and the perturbation of the model. The purpose is to evaluate where the disturbances can compromise the success of the phasing maneuver and how much V would be necessary to correct the errors. Everything is implemented in SEMpy, a Python library developed by ISAE-SUPAERO. To conclude, the aim of the work is to provide an innovative contribution in the evaluation of the CR3BP with and without perturbations, as simplified model to design guidance to perform the phasing.