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THE FARSIDE EXPLORER: MISSION ANALYSIS - DESIGN AND COMPUTATION OF A QUASI BALLISTIC TRANSFER TRAJECTORY TO THE FAR SIDE OF THE MOON

Abstract

In the framework of the **4-body problem**, this project aims to perform the mission analysis for a whole transfer trajectory to the far side of the **Moon**. In particular, the objective of the **Farside Explorer** mission is to place two robotic landers on the farside hemisphere of the Moon and to put an instrumented relay satellite into a **Halo Orbit** around the Earth-Moon **Lagrangian point L2**. During the course of its 4-year nominal mission, Farside Explorer would conduct three broad scientific investigations (radioastronomy, thermal and impacts aspects). Thus, in order to allow the spacecraft to take advantage, the most conveniently, of the available launcher's payload capacity, the idea of a **Quasi-Ballistic** transfer is followed. Although the time required for the whole transfer is roughly forty times longer than a conventional transfer to the Moon, the advantage of this trajectory is particularly interesting for **non-human** missions. Thus, the computation of the trajectory and of the required $\mathbf{\Delta V}$ is done following the mathematical approximations behind the **3-body** and **3-body patched** problems, considering the chosen Lagrangian points, **LL2** for the Earth-Moon system and **EL1/EL2** for the Sun-Earth one. The entire computation is performed with **MATLAB®** and its outputs (e.g. complete trajectory) are being collected and described in the final paper.
Designing the trajectory, it is necessary to compute the Halo Orbits and their associated **Invariant Manifolds** (in the frame of the spatial 3-body patched problem). Within this, the spacecraft's found transfer trajectory follows different steps. Firstly, starting from a **GTO orbit**, an insertion into the stable manifold associated to the halo orbit around LL2 is performed. This maneuver requires an amount of $\mathbf{\Delta V}$, named as $\mathbf{\Delta V1}$. Once finished the transfer, an insertion into the chosen halo orbit around LL2 is performed. This maneuver requires a further amount of $\mathbf{\Delta V}$, named as $\mathbf{\Delta V2}$. The total amount of $\mathbf{\Delta V}$ needed for the transfer ($\mathbf{\Delta V} = \mathbf{\Delta V1} + \mathbf{\Delta V2}$) is the only amount required for the whole trajectory (not-considering a few m/s for rejecting long-time perturbations). As result, the authors obtained $\approx$**50-60%** of $\mathbf{\Delta V}$ saving w.r.t. a conventional transfer (as expected) and several insertion occasions per synodic month (as desired). Furthermore, the authors are accomplishing the **validation** of the complete computation according to **JPL's ephemerides** (Multiple Shooting Method).