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TRAJECTORY OPTIMIZATION IN THE THREE-BODY PROBLEM FOR A LUNAR TRANSPORTATION SYSTEM

Abstract

Lunar missions and their design are in the agenda of most main space agencies around the world. With the goal of regular lunar missions, many of them manned, both time and fuel efficiency are currently being considered as key aspects of space mission design. With this in mind, new and more sophisticated methods of transportation to the Moon are to be designed as alternatives for the ones used by NASA during the Apollo era to improve sustainability. One of the most logical steps to take towards this goal is ISRU (In-Situ Resource Utilisation), which would allow for a mission in which a single ship is refueled with propellant produced on the Moon. This single fact leads to a wide range of possible missions even beyond the Moon, potentially spanning other celestial bodies like Mars.

This project from DLR in collaboration with ISAE-SUPAERO consists of two ships which have to carry cargo from a Low Earth Orbit (LEO) to the lunar surface, while obtaining propellant from the regions near the lunar poles, in order to have an efficient transportation system that can benefit from lunar resources. The two ships exchange both fuel and cargo while in a Libration Point Orbit (LPO): Halo, Distant Retrograde Orbit (DRO), etc.

The aim of this work is to optimize the trajectories to and from the LPO in terms of ΔV and time of flight, taking into consideration the various constraints that this type of mission requires. These constraints include, for instance, an in-orbit time limit due to propellant boil-off (cryogenic LOx/LH2) or a minimum time in orbit to perform rendez-vous. This optimization is computed over the entire duration of a mission, which extends from the departure of the payload from a LEO until its arrival in Low Lunar Orbit (LLO). Flexibility is allowed in terms of the inclination of the LLO, which is subject to change depending on the focus of the mission or the nature of the payload. While current estimations are available for both time and ΔV, this optimization is aimed at narrowing down those quantities to more precise, reliable results.