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THRUST EXPENDITURE FEASIBILITY ANALYSIS FOR RENDEZVOUS OPERATIONS IN CIS-LUNAR SPACE

Abstract

In recent years, Moon exploration have become a primary objective within most space agencies worldwide. The Lunar Space Gateway program (or LOP-G) is an example of mission proposal for technology feasibility in terms of autonomous (and later manned) operations of a space station orbiting the L2 Earth – Moon Lagrangian point. Rendezvous and docking (berthing) are tasks that are envisioned to be performed fully autonomously. The focus of the paper falls in this category, whereby an active module called Lunar Ascender Element, returning from the lunar surface, (LAE) shall be able to operate an automatic rendezvous mission with the LOP-G station. The paper concentrates, in particular, with the feasibility analysis needed to assess the engines' thrust capabilities to provide appropriate propulsion for open loop and closed loop control during rendezvous. The capability of providing the desired amount of thrust is not only linked to the actual guidance commands, but also on the nature of the motors, and their models, as discussed later.

The rendezvous maneuver sequence, dynamics and hold points are first defined, and the thrust distribution and configuration detailed for the specific mission. The guidance logic are described, and the implementation of a passively safe trajectory outlined. Based on the dynamic model of the system, and the assumed actuator model, the main causes of unfeasibility are listed. The paper continues by analyzing the sensitivity of the thrust profile at each motor with respect to the control allocation algorithm, the duration of the maneuver, the duration of each impulse (assuming a two-impulse maneuver), and the location of the berthing port within a selected near rectilinear halo orbit around the Moon. The tests take into account how the parameters influence the Delta V required to perform the mission.

The authors wish to remark that this analysis is critical to the design of rendezvous and berthing (docking) operations, since feasibility is necessary for the success of the mission, and it provides a structured computation of a realistic parameter space in the relative motion in the presence of a third body perturbation.