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DESIGN OF A LOW THRUST, LOW ENERGY LUNAR TRANSFER TRAJECTORY FOR A MICROSATELLITE USING GREEN PROPULSION.

Abstract

NASA's Artemis Program is aimed at establishing a human outpost on the Moon and paving way for human missions to Mars and beyond. Gateway, the international space station slated to be built in the cis-lunar space, will serve as a staging platform for lunar and deep space missions. This has seeded the lunar space economy with a plethora of opportunities for developing innovative mission ideas and effective transportation solutions to deliver them. Bellatrix Aerospace Private Limited proposes a low thrust, efficient and sustainable lunar transportation solution for microsatellites, leveraging their proprietary Green Propulsion Technology. This paper particularly focuses on the trajectory design for a low energy transfer from Geo-Stationary Transfer Orbit (GTO) to the Near Rectilinear Halo Orbit (NRHO) which also happens to be the planned orbit for the Gateway.

NASA's CAPSTONE mission was a pathfinder for the Gateway. The mission took a Ballistic Approach for transfer to NRHO, wherein, effect of Earth, Sun, Moon gravity was utilized to reduce the ΔV requirement for its conventional chemical propulsion. For this mission, the Trans Lunar Injection (TLI) was achieved using Launch Vehicle upper stage, and the Ballistic Lunar Trajectory (BLT) optimized the ΔV requirement (70-150 m/s) for further transfer to NRHO.

This paper considers a novel mission design approach that reduces the requirement on Launch Vehicle upper stage by enabling the Spacecraft to perform the TLI using onboard Green propulsion after having launched in GTO. For the subsequent TLI to NRHO segment, a Ballistic Lunar Trajectory is employed.

This work elicits the trajectory design for both mission phases Viz. low-thrust transfer from GTO to TLI and Ballistic Lunar Transfer from TLI to NRHO. The first phase trajectory design shall minimize the ΔV requirement for desired TLI. The second phase trajectory design is divided in two stages, first stage entails calculating the necessary change in inclination for perigee raising, using the gravitational influence of the sun to reach Moon's orbit while the second stage involves achieving the NRHO with a gravity assist around the Moon. Bellatrix Aerospace is also developing a 27U microsatellite to accomplish such a mission efficiently. As opposed to the conventional high thrust solutions, this satellite equipped with Green propulsion system, offers a cost-effective transportation solution to Gateway. This presents a unique opportunity to deliver small scientific payloads to be hosted on Gateway. The scope of the paper also briefly touches upon, the configuration of Bellatrix's 27U microsatellite.