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OVERVIEW OF THE LOW THRUST LUNAR TRANSIT SPIRAL TRAJECTORY AND CISLUNAR TRANSFERS USING THE POWER AND PROPULSION ELEMENT OF NASA'S GATEWAY

Abstract

NASA has committed to returning to the moon, landing the first woman and the next man on its surface. To support a sustained lunar presence, NASA is designing an orbital platform to be assembled in an orbit near the moon called the Near Rectilinear Halo Orbit (NRHO). This platform is known as the Gateway and its purpose it to support missions primarily to the lunar south pole. As NASA continues to study ways to reduce the cost of lunar exploration, a simplification implemented in 2020 was combining the first two elements of the Gateway together onto a single commercial launch vehicle (CLV). When launched together, the Power and Propulsion Element (PPE) and NASA's Habitation and Logistics Outpost (HALO) make up the Co-Manifested Vehicle (CMV). The CMV will take advantage of the high efficiency of the PPEs high-power Solar Electric Propulsion (SEP) to transfer a significant starting mass from an initial Earth orbit to final insertion into the NRHO. The PPE is a 50-kW class high power solar electric propulsion stage comprised of two different types of electric thruster strings. The use of the highly efficient low thrust system allows for the delivery of more mass than any currently launching commercial vehicle would be capable of delivering directly to the moon. The EP system is operated in two different modes, a high thrust and high Isp (specific impulse), to both maximize the final delivered mass and attempt to minimize the time spent in the Van Allen Belts early in the transit trajectory. Additionally, this SEP system can transfer the assembled Gateway between orbits in cislunar space. This paper captures the preliminary low thrust lunar transfer reference trajectory to be flown by the CMV as they spiral from launch vehicle insertion to insertion into the NRHO as well as a preliminary reference round trip transfer of the Gateway from the NRHO to a Distant Retrograde Orbit (DRO) using the PPE. No restrictions are placed on the net thrust direction or the rate of change of the net thrust direction. The thrust is free to point in any direction to satisfy the mission constraints and maximize the objective. This translates to a continuously time varying thrust direction over the set of thrusting arcs. Further, it is assumed that thrust is delivered through the spacecraft center of gravity and the solar arrays can be pointed to provide adequate power for any thrust direction.