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Overview of the Lunar Transit Trajectory Performed by the Power and Propulsion Element of NASA's Gateway

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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 is 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 combined the first two elements of the Gateway, the Power and Propulsion Element (PPE) and NASA's Habitation and Logistics Outpost (HALO), onto a single commercial launch vehicle (CLV). When launched together, the PPE and HALO make up the first two elements of NASA's Gateway and exceed the performance capacity of commercially available launch vehicles to deliver directly to the moon. The delivery of the Gateway is enabled by and takes advantage of the high efficiency of the PPE's high-power Solar Electric Propulsion (SEP) system 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 SEP 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 brings the capability to the assembled Gateway for transfer between orbits in cislunar space. This paper captures the preliminary low thrust lunar transfer reference trajectory to be flown by the PPE it delivers itself and HALO via a spiral trajectory 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. Once in its final NRHO, the Gateway is being designed to enable long duration human and robotic exploration of the lunar south pole as a precursor to Mars. The Gateway's low thrust lunar transit trajectory is envisioned to prove out the application of and flight of a high-power SEP system as a demonstration of technologies applicable to the enabling of future human space exploration.

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