

Poincaré Map-Based Station-Keeping for Lunar Gateway NRHOs

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A specific 9:2 resonant member of the L2 halo orbit family in the Earth-Moon system—known as a Near Rectilinear Halo Orbit (NRHO)—has been selected as the operational orbit for NASA’s upcoming Lunar Gateway. The current baseline station-keeping strategy, PACCMAN (Phase Augmented Crossing Control Maneuver), relies on an iterative differential corrector to compute orbit maintenance maneuvers (OMMs) that track a long-term reference trajectory. In this work, we propose a faster alternative based on a linearized Poincaré map at the perilune crossing, which significantly reduces computational cost while preserving maneuver quality. The reference trajectory is computed in a high-fidelity, ephemeris-based model using a hierarchical multiple-shooting scheme tailored to the projected 2028 launch window. Monte Carlo simulations incorporating expected navigation uncertainties assess the performance of both strategies. The analysis, initially developed in the Circular Restricted Three-Body Problem (CRTBP), is transitioned to the ephemeris model to confirm robustness. This new framework opens perspectives for improved efficiency and broader applicability to other parking orbits in multi-body dynamical models.

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