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TRANSFERS BETWEEN NEAR-RECTILINEAR HALO ORBITS AND THE MOON

Abstract

Near-rectilinear halo orbits (NRHOs) are periodic orbits that belong to the families of halo orbits around the L1 and L2 points in a three-body system and have low pericenter distances to the secondary primary body. NRHOs possess good dynamical and geometrical properties and are now considered as potential locations for future crewed deep space stations. An amount of work has been done in studying Earth-NRHO transfer options, NRHO station-keeping and shadow avoidance strategies, navigational and radio visibility capabilities.

At the same time, low lunar orbits (LLO) may serve as a platform for transport communication between the lunar surface and the working NRHO. In the current work, we analyze transfers between NRHOs and LLOs and between NRHOs and the Moon's surface. First, we calculate lunar orbit parameters resulting from the scenario of one-impulse descent from a given NRHO. A wide range of polar and near-polar orbits with different perilune distances proved to be available. Second, lunar regions attainable after one-impulse NRHO departure maneuvers are identified. Horizontal and vertical components of the lander velocity in a descending trajectory are estimated at given altitudes.

Several working NRHOs are considered in this investigation: the 4:1 and 9:2 resonant L2 northern halo orbits, and the 11:3 resonant L1 northern halo orbit. In general, resonant orbits are of special interest because of simpler state and operations predictability due to the periodically repeating configuration of the Earth, the Moon, and the Sun. The northern halo orbits are selected since their perilunes are above the south pole of the Moon. The resonances 4:1, 9:2, and 11:3 make it possible to obtain sufficiently low perilune (1500-3000 km above the lunar surface) and compact, nearly-periodic nominal motion.

All calculations are performed in a high-fidelity model of motion that includes the ephemeris model of the Solar system (JPL DE430) and solar radiation pressure. The lunar gravitational field is modeled by the GRAIL spherical harmonic model of order 8.