Paper ID: 10316
student

41st STUDENT CONFERENCE (E2)
Student Conference – Part 1 (1)

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PERTURBATION ANALYSIS AND DESIGN OF LONG-LIFETIME LOW LUNAR SATELLITE MISSION ORBITS

Abstract

Renewed activities of Lunar exploration needs new types of mission orbits. And one focus is on the long lifetime orbits, which are probably low altitude, near circular and inclined orbits with long term stability and can be applied for the scientific missions, manned vehicles and global coverage constellations.

The research on the design of long lifetime lunar satellite mission orbits usually concentrates on frozen orbits in the averaged model and periodic orbits in the un-averaged model, using analytical methods and systematic numerical methods respectively. However, most of the analytical methods just take one perturbation force into account.

Accordingly, this thesis conducts study into the long-term effects of both selenopotential and the gravity of Earth on low lunar satellite orbits. Assuming the eccentricity is small, as well as ignoring the inclination of Earth-Moon orbital plane with respect to the lunar equatorial plane by an angle of 6.8 deg, adopting the averaging method we obtain the secular change rates of orbital semi-equinoctial elements. Frozen orbits correspond to equilibriums of the averaged differential equations, while periodic orbits represents the periodic solutions.

Comparing the above analytical solutions with previous ones which only consider selenopotential, we found that the frozen eccentricities of them are nearly identical in near equatorial case, however, different in near polar case at the same initial conditions (semi-major axis a and orbital inclination i). With the LP165P model, we even come to a conclusion that there exists no frozen orbit for lunar polar spacecraft at the altitude of 100km. Besides, by integrating the differential equations, we find that periodic orbits are circulating around frozen orbits.

Considering the frozen conditions we obtained as well as the precession of line of nodes, two types of orbits with low altitude are designed: (1) near-polar, near-circular lunar frozen orbits for mapping missions; (2) near-equatorial, near Sun-synchronous, near-circular lunar frozen parking orbits for landing missions in low latitude areas.

Finally, with the above two initial orbit conditions, we carry on high precision numerical integration with JPL-DE405 ephemeris and RKF7(8) integrator. The simulation results verify the accuracy of the analytical model and its solutionsand indicate that the orbits have long term stability.