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SPACE EXPLORATION SYMPOSIUM (A3)
Moon Exploration – Part 3 (2C)

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TWO-SEGMENT LUNAR FREE-RETURN TRAJECTORIES BASED ON THE PSEUDOSTATE THEORY

Abstract

In two-segment Earth-moon free-return profiles, the translunar injection is first made onto a free-return trajectory with a great perilune altitude, referred to as post-TLI outbound phase of free-return. Then the spacecraft feature a midcourse lunar targeting maneuver to target favorable conditions for lunar orbit insertion. The resulting lunar-orbiting phase is also designed as a free-return trajectory which terminates in the vicinity of the Earth, with no additional maneuvering. Such trajectories have a wider range of allowable lunar approach inclinations, and allow more freedom in the choice of translunar trip times and lunar arrival times, compared to single-flyby free-return trajectories. In contrast to hybrid non-free-return profiles, spacecraft using two-segment free returns have the additional advantage of safely returning a human crew to the Earth at any stage, without additional maneuvers. Accurate initial solutions for two-segment Earth-moon free-return trajectories, with midcourse transfer opportunities for favorable lunar targeting, are developed analytically by using the pseudostate theory. A constrained flight-path angle quasi-Lambert problem is formulated to determine the lunar-orbiting phase of the free-return trajectory. Gradient and direct-shooting algorithms are used to correct the initial estimates of certain two-body parameters. Numerical simulations with a high-fidelity model are undertaken to verify the accuracy of the pseudostate solutions and to illustrate the efficiency of the proposed algorithm. Perilune altitude errors for the pseudostate method are less than 10% of their corresponding values for the patched conic technique. The differences between the pseudostate and the high-fidelity solutions can be eliminated rapidly.