Paper ID: 47253
oral
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IAF SPACE EXPLORATION SYMPOSIUM (A3)
Interactive Presentations - IAF SPACE EXPLORATION SYMPOSIUM (IP)

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OPTIMAL MULTIPLE-IMPULSES TRANSFER TO AVOID THE SHADOW EFFECT ON A RELAY SATELLITE ON EARTH-MOON PERIODIC ORBITS

Abstract

Due to the unique dynamics characteristics, the periodic orbits of Earth-Moon libration point L2 are idealized mission orbits for a communication relay satellite, which is deployed to support the communication and data transmission for the lunar far-side exploration mission. However, the time-variant relative positions between Sun-Earth-Satellite and Sun-Moon-Satellite may cause the shadow effect on relay satellite, which has an influence on the relay mission. To reduce the shadow effect, the phasing transfer on the periodic orbit is needed during the mission.

Subjected to the relay mission, the phasing transfer for relay satellite is different from the transfer between different periodic orbits. The transfer time is required short and the trajectory should be as close as possible the original mission orbit. The transfers on the basis of invariant manifolds are not appropriate options. In this paper, the multiple impulses transfer on the same periodic orbit is investigated. Firstly, based on the restricted three-body problem, the phasing trajectories for periodic orbits is described as an optimization question with time constraint and terminal constraints. The parking time, transfer time and initial impulse are set as the optimal variables and the penalty function is constructed to constrain the terminal state. Then, the evolutionary algorithm is adopted to find the best two-impulse transfer trajectory with different phase differences. Several types of transfer trajectories are found with the same phase difference. Finally, the primer vector theory is applied to the best two-impulse transfer trajectory. The cost of transfer decreases by employing the coastal arcs. The interior impulses are added to further reduce total velocity increment and to satisfy the conditions for optimality.

The results show that optimal multiple-impulses transfer requires less cost than two-impulse transfer. The proposed method can provide the optimal phasing transfer with the time constraint. It also improves the convergence of solution compared with the conventional correction process. This study can be used to avoid the shadow effect and fast rendezvous trajectory design on Earth-Moon periodic orbit. It can also be extended to mission design in other planetary systems.