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A CISLUNAR IN-ORBIT INFRASTRUCTURE USING CYCLER TRAJECTORIES IN THE EARTH AND MOON SYSTEM

Abstract

Motivated by the increased interests in lunar exploration and development, lunar sample return missions will become more frequent in future decades. In particular, by the requirements from the lunar laboratory and base, large numbers of data or images, and people or materials need to be transmitted from the Moon to the Earth, or reverse. Therefore, a scheduled but low-cost flight in the cislunar space is preferable.

In this paper, a new concept known as the cislunar scheduled "bus" is proposed to contribute to the telecommunications, navigation, spacecraft servicing and astronaut rescue in the cislunar space. An infrastructure is allocated on some natural cycler trajectories in the celestial gravities, which keep synchronously cycling between Earth and Moon with very little propellant usage to maintain the trajectory. Most of necessities, like the fuels for braking maneuvers during powered descent trajectories on Earth or Moon's surfaces, or the food and oxygen supporting the crews' lives, are expected to be stored extensively in this bus module.

In the first investigation, the circular restricted three body problem (abbr. CR3BP) is employed to yield two families of periodic cycler orbits from the following methodologies: the first type of p-q resonant orbit iterated from differential correction and continuation, and the second type of homoclinic orbit achieved by Poincare mapping between the unstable and stable manifolds inheriting from LL1 or LL2 points. However, the eccentricity of the Moon's orbit and gravitational forces from other celestial bodies (like the Sun and the Jupiter) will make CR3BP different from the real dynamics and geometries, even these cyclers cannot keep stationary due to this perturbations. Therefore, quasi-periodic cycler trajectories are refined numerically by a multiple shooting corrector in the full ephemeris model with the help of periodic cyclers created by CR3BP acting as an initial iteration to accelerate the convergence, and then are targeted in Satellite Tool Kit (STK) using Astrogator tool.

The real cyclers encounters the Earth and the Moon on a regular basis, which impose transferring windows for Earth-targeted and Moon-targeted modules. Hence, the detailed investigations on these windows are implemented with a consideration of equatorial inclinations with respect to the Earth-Moon orbital plane, and also the Metonic cycle of 19 years. Moreover, cost analysis on stationkeeping and launching for both Earth-targeted and Moon-targeted modules is presented for this constellation in detail.