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DEPLOYMENT METHOD OF THE LUNAR GLOBAL POSITIONING SATELLITE CONSTELLATION ON DRO IN CISLUNAR SPACE

Abstract

Similar to Earth orbiting global positioning satellite constellations (such as GPS, Beidou, etc.), a lunar global positioning satellite constellation can provide real-time positioning and timing services for lunar surface users, significantly enhancing lunar surface operational capabilities to better support lunar exploration activities. Scholars have conducted a series of constellation design work for lunar global positioning satellite constellations.

For constructing lunar global positioning satellite constellations, near-lunar orbits offer the advantage of close communication with lunar surface targets, libration point Halo orbits can achieve lunar surface coverage with fewer satellites compared to near-lunar orbits, and a mixed orbit approach can provide coverage with different orbit characteristics. However, these orbits have their drawbacks: near-lunar orbits face challenges in achieving autonomous satellite orbit determination, libration point Halo orbits are unstable three-body orbits requiring multiple position maintenance pulses within a year. DRO, due to its unique dynamical properties, can overcome some of these drawbacks to a certain extent.

DRO is a stable periodic orbit in the three-body model. Spacecraft located on DRO theoretically can operate for 100 years and can stably remain parked for at least 30 years in the ephemeris model, utilizing gravitational asymmetry for autonomous orbit determination. Compared to other orbit types, DRO offers the advantage of reducing the frequency of position maintenance pulses to every few years and enabling autonomous orbit determination.

This paper outlines the current research status of the lunar global positioning satellite constellation, with in-depth research on the Distant Retrograde Orbit (DRO)-based lunar constellation. Initially, starting with a planar DRO in the circular restricted three-body model, the initial phase angle, orbital mean period, and z-direction motion amplitude of the three-dimensional DRO are described as parameters to calculate a stable DRO in the double circular restricted four-body model over 3 years. Subsequently, a lunar constellation design method based on DRO benchmark orbit and equiphase difference deployment is presented. The effectiveness of this DRO lunar constellation design method is validated for a total of 16 satellites in the DRO lunar constellation. Finally, a method for deploying and transferring phase differences in different phase orbits on a single benchmark orbit is proposed, achieving low-energy orbit deployment of the constellation through a four satellites launched in one rocket approach.