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ANALYSIS ON THE STAGED DEPLOYMENT OF MULTI-SPACECRAFT CISLUNAR SPACE DOMAIN AWARENESS SYSTEMS

Abstract

Cislunar Space Domain Awareness (SDA) is gaining importance with the growing investments by government and commercial players in the Cislunar space, including the lunar surface. The primary purpose of Cislunar SDA is to establish the ability to detect, observe, and comprehend any activities in Cislunar space for its sustainable development. While established sensing systems exist for the Earth-orbit region, such as the Low-Earth Orbit (LEO), Medium Earth Orbit (MEO), and Geosynchronous/Geostationary Earth Orbit (GSO/GEO), extending their capability to Cislunar space is not straightforward, mainly due to the extensive coverage and the lunar exclusion.

Recently, many studies have investigated spacecraft-based Cislunar SDA systems. Although spacecraft are exposed to the Earth-Moon system's chaotic dynamics, several well-behaved families of orbits are capable of keeping observer spacecraft at affordable fuel consumption. Such orbital families include but are not limited to the Lyapunov, halo, and distant retrograde orbit (DRO) families. Due to the varying solar incident angle and the distance for the arbitrary combination of the target and observer trajectories, the SDA capability can be maximized by realizing sufficient geometric diversity between multiple observer spacecraft in different orbital families.

Although we are gaining knowledge about the SDA performance for different system architectures, such as the number and trajectories of observer spacecraft, their optimal deployment strategies have yet to be discussed extensively. Given the budget constraint and the uncertainty in the future demand and technical capabilities, the Cislunar SDA systems should be constructed in a staged manner.

This study aims to provide potential solutions for the staged deployment of the multi-spacecraft Cislunar SDA systems. We define the transition cost of the system and the demand growth model with reasonable model assumptions that allow large-scale analyses. The transition cost between different sensor trajectories has a trade-off between fuel and time consumption. The expected analysis includes the sensitivity study for the demand growth and the affordable fuel cost over time, by which we aim to provide an informative analysis for the coming Cislunar development.