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OPTIMIZING SMALLSAT CONSTELLATION FOR ENHANCED STM IN LEO

Abstract

The escalating threat of space debris necessitates owner-operators' constant demand for precise ephemeris data to mitigate costs from false conjunction alarms. Space objects bigger than 10 cm are well catalogued, however, objects between 1-10 cm (approximately 900,000) can pose severe risks to the space environment. Moreover, land-based optical SSA provides limitations due to geographical and political boundaries, limited day operations, weather effects, and limited scanning/FOV capabilities. To mitigate this risk, minimize covariance, and analyze behaviour of objects, it is imperative to enhance the number of astrometric and photometric measurements from diverse locations. Space-based SSA using optical sensors not only overcomes land-based limitations but also enhances the scanning patterns, FOVs, and number of measurements. As a collaboration between Small Satellites (SSPG) and Space Safety and Sustainability (SSS) Project Groups at the Space Generation Advisory Council (SGAC), this project was conceived to devise a small satellite constellation solution in LEO to provide detection, tracking, and characterization services of objects between 1 cm and 10 cm. The satellites are equipped with COTS telescopes capable of detecting small space objects up to 1 cm or better. The essence of this endeavor lies in optimizing the orbit selection for constellation deployment, the number of satellites for constellation design, and the scanning pattern to ensure thorough coverage, along with enabling frequent follow-up measurements.

In terms of broad design characteristics, the satellites are electrically powered using solar arrays carrying chemical propulsion to maneuver for collision avoidance and stationkeeping. The interface to the

ground segment utilizes high bandwidth radio frequency connections with ground stations that communicate centrally with the Mission Control Center (MCS). The orbits for constellation deployment are optimized by considering the factors for assessing the obtained signal such as payload parameters, distance, size, albedo, sun phase angle, and integration time. The operations are based on a series of comprehensive scanning patterns to ensure coverage, sufficient integration time, and frequent revisits. The design strategy is to keep the aperture diameter small and achieve the required SNR and optical resolution by designing a constellation that focuses on denser orbital slots.

This study establishes a foundational framework for future research on constellation design and scanning patterns utilizing in-space optical sensors to tackle the escalating issue of space debris amidst the evolving space environment.