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DESIGN AND ANALYSIS FOR EFFICIENT MOON-BASED COMMUNICATION SATELLITE CONSTELLATION

Abstract

Lunar exploration is making a strong comeback with new missions driven by space agencies and private companies. Investigating the Moon's surface is essential for advancing scientific knowledge, supporting future space exploration, utilizing lunar resources, and for commercial opportunities on the moon. It also provides insights into planetary evolution and serves as a gateway for deep-space missions. The lunar satellite constellation is one of the core infrastructures to explore the Moon, it plays a vital role in providing reliable Earth-moon communication, especially with the lunar far side which is essential for advanced missions and long-term lunar development. Most of the upcoming lunar missions are focused on both the equatorial region and the South Pole, in addition, the dark side of the moon is also considered one of the most targeted exploration destinations.

This paper presents a comprehensive design for a next-generation lunar satellite constellation that can communicate with both lunar equatorial facilities and the South Pole region with access values reaching 45% and 94% of the entire scenario time period respectively. It shall show the coverage and access analysis for the proposed satellite constellation. In addition, a detailed mission analysis is provided including an in-depth investigation of possible orbital transfer, lunar injection, trajectory options into the proposed orbits, in-station keeping and correction maneuvers as well as the possible launcher systems and launch windows. By enabling seamless communication between Earth, lunar orbiters, landers, and surface assets, this can pave the way to create the foundation for a sustainable lunar exploration and presence.

Keywords: Lunar Communications, orbital design, mission analysis