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OPTIMAL DESIGN OF SATELLITE CONSTELLATION IN LOW-LUNAR CIRCULAR/ELLIPTICAL ORBITS FOR LUNAR SOUTH POLE EXPLORATION

Abstract

Lunar exploration, which decades ago started as a space war for technology supremacy, is now fueled by a quest to quench scientific curiosity. Added to this, the existence of ice and other minerals and large periods of illumination of the south pole act as conducive conditions for the setup of a possible outpost for future interplanetary missions. Hence, lunar exploration, especially the south pole, is deemed to be a potential stepping stone for sustainable deep space exploration. However, Apollo-era mission landings were restricted to form equatorial to mid-latitudes on the lunar nearside, due to constrained line-of-sight communications with Earth. Within the last decade, it has become evident that independent spacecrafts or missions will not be able to answer the growing questions regarding our natural satellite. To overcome this, a dedicated and shared telecommunications and navigation service around the Moon has been proposed in the recent times. Such constellations would allow missions to land whenever and wherever, aiding in future operations on the lunar surface and other deep-space missions. This could also reduce the design complexity of future individual missions and make them lighter, freeing space for more scientific instruments. In the per-view of constellations, Walker and Draim have made major contributions to the optimal constellation designs of satellites in Low-Earth Circular and Elliptical Orbits respectively, for continuous global coverage. In Draim's strategy, the number of satellites 2N+2 in low-earth elliptical orbits fixes the multiplicity of the coverage to N for continuous global coverage. This means, 4 satellites ensure single coverage, 6 satellites ensure double coverage and so on. But higher multiplicity of the coverage may not always be the mission requirement. In this study, a new approach which overcomes the limitations of Walker's and Draim's strategies has been presented for optimal design of Lunar constellations. Acting as a compelling spot for future exploration missions and a suitable candidate for a lunar outpost, it becomes indispensable to first deploy Lunar Navigation and Telecommunication services over the South Pole (70S to 90S) and then later, extend to the entire lunar surface. This paper presents optimal constellation designs of Low-Lunar Elliptical/Circular Orbits for continuous South Pole and also complete Lunar surface coverage of user-defined multiplicity. The approach can also consider orbital parameters, like Argument of Perigee and Mean Anomaly of each satellite, as unknowns for irregular phasing between satellites in the same and adjacent orbits respectively.