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ANALYSIS OF THE INFLUENCE OF AREA-TO-MASS RATIO ERROR ON THE ORBITAL MOTION OF A SOLAR POWER SATELLITE

Abstract

Recent years have witnessed the resurgence of space-based solar power research, and in particular the concept of a solar power satellite (SPS), due to its potential for continuously generating large amounts of electrical power. Many different SPS concepts and technologies have been proposed by NASA, JAXA, ESA and CAST, but a common requirement to achieve maximum efficiency is to ensure that the SPS is located in a stabilized orbit. SPS is expected to be operational for more than 30 years, and their long term orbital motion could be therefore significantly affected by perturbations. Quite uniquely from other satellites, SPS have a very high area-to-mass ratio (ATMR), which is a key parameter in determining the effects of the solar radiation pressure. In practice, structural deformation due to thermal effects, installation errors and deployment errors could result in large errors of the ATMR. This gives rise to challenging problems in the long-term orbit prediction for a SPS.

This paper focuses on analyzing the influence of ATMR error on the SPS orbital motion. The orbit dynamics of a high ATMR geostationary SPS is proposed in terms of the Milankovitch orbital elements. The major perturbations, including solar and lunar gravitational attraction, terrestrial harmonics, solar radiation pressure, and microwave beaming force, are then modeled and discussed. The influence of ATMR error in proposed dynamic model on SPS orbital parameters is then studied. Besides, three evaluation indexes, including power received efficiency, orbit applicability and security, are proposed to evaluate different SPS orbits. Numerical simulations are finally provided to illustrate the above analysis. The results will demonstrate that the ATMR error has a great influence on SPS orbital radius, such as 1% ATMR error could lead to 2-3 kilometers bias of orbital radius. Furthermore, the influence of ATMR on the Keplerian orbital elements appears to be approximately linear.