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DYNAMICAL EVOLUTION ANALYSIS OF STANDARD GEOSTATIONARY TRANSFER ORBITS INJECTED BY CHINESE LAUNCHERS

Abstract

With the increase of satellite launches, the space around Earth has been becoming crowded with space debris of various sizes, from particles smaller than 1 mm to non-operational spacecraft and abandoned rocket bodies of several square meters. National and international efforts, such as U.S. Government Orbital Debris Mitigation Standard Practices, IADC Space Debris Mitigation Guidelines, and etc., have been made to ensure that the increase of space debris associated with current and future space activities are properly mitigated.

The dynamical evolution of geostationary transfer orbits (GTOs) is an important issue for the space debris mitigation. Upper stages in GTOs are potential sources for collisions and future debris in LEO region and GEO region. In this aspect, knowledge of the dynamical evolution under natural perturbations is urgent for predicting the distribution, decay, and lifetime of the space debris in GTOs. Due to its low perigee and high apogee, GTOs are subjected to multiple perturbations and their interactions. As a result, the orbital dynamics are complicated and extremely sensitive to the initial conditions and model parameters. Previous studies have shown that the high sensitivity of the dynamics can be attributed to the solar apsidal resonance, which is difficult to predict or manage. With the initial state, it is possible to predict the orbit evolution of GTO only before the resonance, but it is impossible to predict the orbital lifetime accurately.

The initial inclination and perigee height of GTOs are usually determined by launchers and launch sites: The inclination is close to the latitude of launch site, and the perigee height is determined by the launcher's capacity. Therefore, GTOs belonging to different countries have distinct orbital elements. Because of the complicated dynamics, GTOs with different inclinations and perigee heights will have quite different dynamical properties. In this paper, dynamical evolution of standard GTOs injected by Chinses launchers, including GTOs with an inclination of 28.5 degrees launched from Xichang Satellite Launch Center by Long March-3 (Chang Zheng-3) series launchers and GTOs with an inclination of 19.5 degrees launched from Wenchang Satellite Launch Center by Long March-5 (Chang Zheng-5) series launchers, will be investigated by numerical studies. Especially, the solar nodal resonance and solar apsidal resonance will be identified, and their effects will be analyzed. The dynamical properties of Chinese GTOs will be compared with the low-inclination European GTOs. The results will provide useful insights for the space debris mitigation in GTOs by Chinese launchers.