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LONG-TERM EVOLUTION SAFETY ANALYSIS AND DISPOSAL ORBIT DESIGN METHOD OF BDS MEO SATELLITE ORBITS

Abstract

Purpose:

The constructing of BeiDou Navigation Satellite System-3 (BDS-3) means that more and more Medium Earth Orbit (MEO) satellites will be launched into orbits. Meanwhile, the step by step to life of BDS-2 MEO satellites means that more satellites will become space debris. The research on the long-term evolution safety analysis and disposal orbit design has significant impact on the sustainable developments of BDS.

Approach

Firstly, the distribution status of the space objects in Global Navigation Satellite Systems (GNSS) region has been counted based on the up to date observation data. Secondly, the long-term perturbation analytical model is established, which considers the non-spherical perturbation, the luni-solar perturbations and the solar radiation pressure perturbations, the proposed model can support the long-term evolution over one hundred years with high precision. Thirdly, based on the worst initial semi-major axis, eccentricity and inclination, the orbit intersection time of BDS with GLONASS, GPS and Galileo are analyzed. Finally, two kinds of disposal orbit design strategies are proposed, one is to keep the disposal orbit stable as long as possible, the other is to change the eccentricity and make the disposed satellite decay within 200 years. The first case is simulated in this paper, and a hybrid particle swarm optimization (PSO) - sequential quadratic programming (SQP) algorithm is proposed to optimize the disposal orbital parameters, such as semi-major axis, eccentricity, and inclination.

Practical implications

One aim of this research is to provide theoretical basis for the disposal of the end-of-life BDS-2 satellite and the spent upper stages, the other is to provide references for the compatibility and interoperability of the orbital constellations of BDS with other GNSS.

Results

The eccentricity value is the most important factor which influences the long-term evolution safety analysis of BDS MEO satellite orbits; under the worst initial conditions, the orbits of BDS MEO satellites will intersect with other GNSS orbits about one hundred years; by optimizing the semi-major axis, eccentricity, and inclination, the stable disposal orbit can be design.