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ORBITAL LIFETIME AND COLLISION RISK REDUCTION FOR INCLINED GEOSYNCHRONOUS DISPOSAL ORBITS

Abstract

A growing number of satellites are operating on inclined geosynchronous orbits (IGSOs), with inclination typically much higher than that of traditional geosynchronous orbits (GEOs). Several recent studies have considered the long-term evolution of disposal orbits close to IGSO-vehicle disposal orbits. Unlike traditional GEO-vehicle disposal orbits, IGSO-vehicle disposal orbits can undergo large excursions in eccentricity due to the effect of luni-solar gravity perturbations. For specific ranges of initial orbital elements, perigee can reach the Earth's atmosphere, resulting in vehicle reentry. A previously published study by the authors on Tundra orbits, a specific class of IGSO with critical inclination and moderate eccentricity, demonstrated that orbital lifetime can be reduced below 200 years (in some cases below 25 years) and that the corresponding collision probability with background objects can be significantly reduced below that for traditional GEO-vehicle disposal orbits. This paper presents a study of a broader range of IGSO-vehicle disposal orbits. Three classes of IGSO-vehicle disposal orbit were considered: (1) near circular orbits (motivated by the BeiDou and IRNSS constellations); (2) orbits with intermediate eccentricity (motivated by the QZS constellation); and (3) orbits with larger eccentricity (motivated by the Sirius Tundra constellation). For each orbit class, a large number of long-term propagations using the high-precision code TRACE were performed. Disposal orbit initial inclination and right ascension of ascending node (RAAN) were parametrically varied. The Aerospace Debris Environment Projection Tool (ADEPT) suite was used to determine collision probability with background objects. The effective time spent in protected regions (ETPR) by the disposed IGSO vehicle was also determined. The protected regions include the GEO protected region and the low Earth orbit (LEO) protected region defined in the Inter-Agency Space Debris Coordination Committee (IADC) debris mitigation guidelines. The study results demonstrate that orbital lifetime can be reduced below 200 years for all three IGSO-vehicle disposal orbit classes. The initial inclination required to reduce orbital lifetime below 200 years varies with initial RAAN. The paper will provide the quantitative orbital lifetime, collision probability, and ETPR results. These results can be used to assess the utility of these orbits for post-mission disposal with a goal of more effective long-term debris mitigation by reducing the overall risk of collisions.