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COMPARISON OF DISPOSAL OPTIONS FOR TUNDRA ORBITS IN TERMS OF DELTA-V COST AND LONG-TERM COLLISION RISK

Abstract

Tundra orbits are inclined, moderately eccentric orbits with a 24-hour period. The selection of eccentricity and argument of perigee enables a satellite to dwell over a region bounded by latitude and longitude. Compared to a traditional geosynchronous orbit (GEO), Tundra orbits offer the benefit of regional coverage at non-equatorial latitudes with higher elevation angles. Examples of actual missions that have used Tundra orbits are the Sirius satellite constellation and the Quasi-Zenith Satellite System. Previous studies by the authors considered disposal in an orbit near the Tundra orbit. High altitude, high inclination disposal orbits (above 2000 km altitude and 30 degrees inclination) can in general undergo large excursions in eccentricity due to luni-solar gravity perturbations. Results of the previous studies demonstrated that, for inclinations above 50 degrees, eccentricity can grow to a value that causes perigee to reach the Earth's atmosphere, resulting in vehicle reentry. Collision probability with background objects can be significantly reduced below that for traditional GEO disposal orbits due to the risk-dilution effect of orbital eccentricity. In the current study, a range of potential disposal options for Tundra orbits are compared. Two typical Tundra orbit cases are considered: a higher eccentricity and inclination orbit (0.268, 50 to 80 degrees) that has reentry options, and a lower eccentricity and inclination orbit (0.075, 40 degrees) that does not have reentry options. Disposal options considered include moving to a near-Tundra disposal orbit, lowering apogee just below GEO, raising perigee just above GEO, and moving to near-circular orbits below and above GEO. Comparison metrics include delta-V cost and long-term collision risk. Delta-V cost of controlled reentry and heliocentric escape are also included for comparison. Collision risk metrics include collision probability with all background objects and total cumulative time spent by a disposed Tundra satellite in the GEO altitude region. The Aerospace Debris Environment Projection Tool (ADEPT) software suite is used to determine collision risk with background objects. Results include the variation of the collision risk metrics with initial right ascension of ascending node (RAAN) and inclination. For the near-circular disposal orbits, variation with argument of perigee is also determined since this disposal orbit parameter can be targeted.