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Orbit Determination and Propagation (9)

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OPTIMIZED RE-ENTRY TIME PREDICTION OF MOLNIYA ORBIT OBJECTS

Abstract

Space debris, a threat to the stable and safe space operations environment, at times endanger terrestrial life. The long-term stabilization of space debris population level is critical for future launch activities. One of the guidelines recommended by IADC is limiting the post-mission lifetime to 25 years [1]. With low perigee and high apogee, the orbital motion in highly elliptical orbits (HEO) is governed by extreme dynamical perturbations. HEO objects can either have longer lifetime due to raised perigee altitude or disintegrate at sharp re-entry angles due to the lowered perigee altitude [2].

Molniya orbit is a type of HEO for repeated swath coverage at high latitudinal regions. Molniya satellites with higher mass and large surface area have complex orbital dynamics which produces not a typical oscillation in the perigee altitude. The orbital evolution and re-entry time estimation are sensitive to the initial parameters. Higher accuracy in lifetime prediction can be achieved by having accurate initial conditions. Significantly uncertain orbital parameters from two line elements (TLE) are ballistic coefficient (B) and eccentricity (e). B depends on the drag model and area to mass ratio of the object, which captures the attitude dynamics.

By response surface methodology [3] and genetic algorithm [4], B and e were optimally estimated to predict the re-entry epoch of upper stages in geostationary transfer orbits [5–6]. In the present study, re-entry prediction of Molniya satellites is done as optimal estimation problem using traditional and regularized orbit propagators. Re-entry times of Molniya objects are predicted with relative error less than 5% when compared with TLE data.

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