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COMPLEX ORBIT DYNAMICS OF DECOMMISSIONED GEOSTATIONARY SATELLITES

Abstract

This work investigates the long-term orbit evolution of decommissioned geostationary satellites, under the assumption that the final disposal maneuver does not occur and orbital motion evolves with no control. The dynamical model accounts for all the meaningful harmonics of the terrestrial gravity field at the typical altitude of geostationary orbits, as well as solar radiation pressure and the third-body perturbations caused by the Moon and the Sun. Orbit propagations are performed using two distinct equation sets and numerical integration methods: (i) the Gauss equations for nonsingular equinoctial elements, in conjunction with an embedded Matlab routine, and (ii) Cartesian coordinates (in an Earth-fixed frame), together with a Runge-Kutta-Verner 8/9 integration scheme. For methodology (ii), the parameters of the propagator are tuned to the desired positional accuracy, and so is the maximum degree and order of the geopotential. Additionally, the spherical harmonics are expressed through Helmholtz polynomials in Cartesian Earth-fixed coordinates. The numerical results exhibit some well-known phenomena, in particular the longitudinal drift due to the resonance between the orbital motion and Earth's rotation. This effect is associated with triaxiality of the Earth and is specifically related to harmonic J22. In addition, the third body perturbation due to Sun and Moon is proven to be responsible for two major effects: (a) precession of the orbital plane, and (b) complex longitudinal dynamics. This work proposes an analytical approach for prediction of the overall precession motion, pointing out its agreement with the (more accurate) orbit evolution obtained numerically. Moreover, orbit propagations demonstrate the existence of a long-term complex longitudinal dynamics, over time scales of several decades. In fact, repeated and unpredictable migrations toward different longitudinal regions are proven to occur, in contrast with the known effects due to the only perturbative action of J22.