END OF LIFE DISPOSAL OF SATELLITES IN THE GEO REGION, THE ISSUE OF HIGH INCLINATIONS

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Keywords: *orbit propagation, end of life disposal, GEO protected region, resonances*

ABSTRACT

In the frame of the French Space Act, whose objective is to ensure that the technical risks associated with space activities are properly mitigated, CNES provides the French government with technical expertise on space operations regulations. Space debris mitigation is one objective of the law, in line with IADC (Inter-Agency Space Debris Coordination Committee) recommendations, through the removal of non-operational objects from populated regions. CNES recommends Good Practices as well as a dedicated tool, STELA (Semi-Analytical Tool for End of Life Analysis), to address the compliance of disposal orbits with the law technical requirements.

After their end of mission, space objects within the GEO protected region have to be placed on disposal orbits that ensure the non-crossing of the protected region within the next 100 years. The choice of the disposal orbit is relatively simple for typical geostationary satellites due to the smooth and predictable perturbations that affect these orbits (in particular, no atmospheric drag). Using the so called “ISO formula” from ISO document 28672 (Space systems – Disposal of satellite operating at geosynchronous altitude), one can compute the minimum disposal orbit perigee altitude ΔH above the geostationary altitude that ensures compliancy:

$$\Delta H = 235 + \left(1000.Cr.\frac{A}{m}\right) \tag{1}$$

With ΔH expressed in km, Cr the reflectivity coefficient, A the spacecraft cross sectional area and m the spacecraft mass.

However, the disposal of space objects in geosynchronous orbits, meaning at the geostationary altitude but with non-zero inclinations, can be more tedious, especially in the case of high inclinations. Figure 1 shows the final eccentricity of a disposal orbit after 100 years of numerical propagation (or less in case of atmospheric re-entry), as a function of the initial inclination of the disposal orbit. Note that the disposal orbit is initially a GEO+200 km circular orbit:

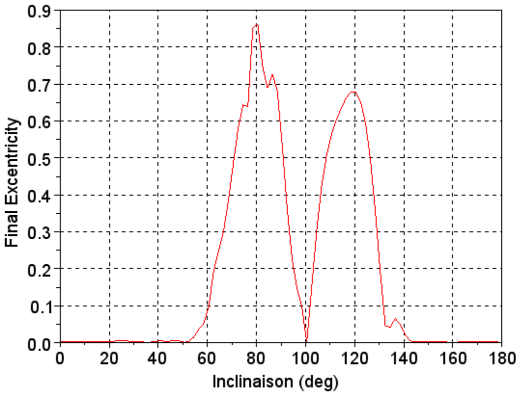

Figure 1: Final eccentricity as a function of initial inclination

One can see from Figure 1 the extreme eccentricity variations for high initial inclinations. First of all, the paper will explain the physical phenomena leading to those variations: the coupling between perturbations will be detailed and the resonance conditions will be analyzed to try and identify the critical orbit domains. Note that the spacecraft considered here has a typical area to mass ratio value (that is to say $0.01m^2/kg$); the issue of High Area to Mass Ratio being out of the scope of this paper. Then, the selection of an appropriate disposal orbit for space objects initially in such critical orbit domains will be discussed, considering the fact that the ISO formula is obviously non-applicable here. Finally, a methodology and a “minimum” dynamical model will be presented to check the compliance of such disposal orbits with the law technical requirement.