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Space Debris in the Geostationary region as a Dynamical System

Daniel Casanova[1,2]

Satellites play an important role in daily life and provide essential information on a vast number of areas such as Earth observation, telecommunications or navigation. Nowadays, more than 7,437 satellites have been launched into an Earth orbit since Sputnik I in October 1957.

The location of new satellites in the Geostationary region is a difficult task since a large quantity of active satellites are placed in this area. In addition, this region contains large quantities of space debris, which increases the cost of the satellites to protect them from the small pieces of debris.

Consequently, time evolution of space debris has recently become a trending topic to predict safer regions and graveyard locations in space. In particular, a piece of space debris can be considered as a dynamical system whose equations are:

$$\dot{\mathbf{r}} = \mathbf{v},$$
$$\dot{\mathbf{v}} = \mathbf{a}_{kepl} + \mathbf{a}_{J_2} + \mathbf{a}_{SRP} + \mathbf{a}_{3BS} + \mathbf{a}_{3BM}.$$

where $\mathbf{r}$ and $\mathbf{v}$ represent the position and velocity vectors respectively, $\mathbf{a}_{kepl}$ accounts for the attraction of the Earth as a central body, $\mathbf{a}_{J_2}$ accounts for the Earth oblateness, $\mathbf{a}_{SRP}$ represents the Solar Radiation Pressure (SRP) acceleration, and finally $\mathbf{a}_{3BS}$ and $\mathbf{a}_{3BM}$ include the perturbation due to the Sun and Moon as third bodies.

In this work, an analytical way to propagate space debris in the Geostationary region (cf. [1]) is presented. The analytical evolution is compared with a numerical integrator to prove its efficiency. Furthermore, it is shown the evolution of space debris depending on its area to mass ratio (A/m). Finally, potential applications of this analytical tool will be presented.

References

[1] D. Casanova, A. Petit, and A. Lemaitre, Long-term evolution of space debris under the J_2 effect, the solar radiation pressure and the solar and lunar perturbations, *Celestial Mechanics and Dynamical Astronomy* **123(2)** (2015), 223–238.

[1] Área de Matemáticas, Estadística e Investigación Operativa. Centro Universitario de la Defensa, Carretera de Huesca s/n. 50090 Zaragoza (Spain).
casanov@unizar.es

[2] GME-IUMA, University of Zaragoza, Pedro Cerbuna, 12. 50009 Zaragoza (Spain)