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MAINTAINING THE RESONANCE MODE TO ENSURE ORBIT DEGRADATION FOR AN OBJECT BELONGING TO THE GLOBAL POSITIONING SYSTEM

Abstract

The paper considers the dynamics of motion of large passive objects in medium orbits belonging to the GPS system. In the full force model, a long-term forecast (300 years) of their motion is performed, on the basis of which one can conclude about the stability/unstability of the orbit.

Studies of C.-C. Chao show that under the action of gravitational perturbations from the Sun and the Moon, the eccentricity of the initially near-circular orbit can increase. However, the natural drift of the pericentre and the ascending node leads to the fact that the derivative de/dt can change its sign to negative, and the orbit starts to become circular again with the semi-major axis unchanged.

Estimates show that, if the resonance regime is maintained, the stretching elliptical orbit reaches the dense atmosphere in 75 years. This period can be significantly reduced if an initial value of eccentricity lying between 0 and 0.75 is generated using a transversal velocity impulse.

Analysis of the sum of five harmonics in the de/dt formula shows that the fourth term with the argument $2w+\Omega$ has the greatest influence. This allows us to formulate the requirements for the resonance to occur: $\sin(2w+\Omega) = -1$, $w = 225$ deg or 45 deg, $\Omega = 180$ deg. Bringing the orbit parameters to these values can be accomplished with a special propulsion module similar to that used in Northrop Grumman's promising MRV project. Due to the secular drifts of AoP and RAAN, it is necessary to keep the sum of $2w+\Omega$ in the vicinity of the value 270 deg. The paper shows that with a permitted deviation of 15 deg, several corrections will be required before the perigee of the orbit reaches the atmosphere.

The paper investigates two questions:

- what value of the initial eccentricity leads to acceptable costs for formation of the initial elliptical orbit at acceptable duration of reaching the atmosphere?
- which of the ways of bringing the parameters and of the initial circular orbit to the condition of resonance occurrence is more effective?

Analyzing the results for each of these two points allows us to evaluate the effectiveness of using a resonant orbit compared to the business-as-usual scenario, which consists in transferring the object to a disposal orbit 300-500 km above the operational altitude.