ENVIROMENTAL TORQUES AND THE SOLAR ASPECT ANGLE

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ABSTRACT

The aim of this paper is to study the influence of the environmental torques in the angle between the spin axis and the Sun direction (solar aspect angle) for spin stabilized satellite. The theory uses a cylindrical satellite which is in an illumined orbit. Mathematical model for the gravity gradient, aerodynamic, solar radiation, residual magnetic and eddy current torques are shown.

The gravity gradient torque is created by the difference of the Earth gravity force direction and intensity acting on each satellite mass element and is inversely proportional to the cube of the satellite geocentric distance.

The aerodynamic torque is created by the interactions of rarefied air particles with the satellite surface and is predominant in satellites with low altitude, because it depends on the quantity of air molecules in the Earth atmosphere.

The solar radiation pressure is created by the continuous photons collisions with the satellite surface, which can be able to absorb or reflect on this flow. The total change of the momentum of all the incident photons on the satellite surface originates from the solar radiation force and it can be produce a torque.

Magnetic disturbance torques result from the interaction between the spacecraft's residual magnetic field and the Earth´s magnetic field. The residual magnetic torque results from the interaction between the spacecraft's residual magnetic moment and the Earth magnetic field and its main effect is to produce a spin axis orientation drift. The torque induced by eddy currents is caused by the spacecraft spinning motion and produces a reduction in the satellite spin rate with time.

The dynamic equations are represented in a reference system fixed on the satellite (body system) and described by spin velocity and the right ascension angle and declination of the spin axis. These equations depend on the torques components in the body system. The averages of these components of each torque are determined over on orbital period and are substituted in the equations of motion. Due to the cylindrical form of the satellite and others simplifications, only the gravity gradient and eddy currents torques have a non null z-components.

An analytical solution is gotten for the spin velocity and the attitude angles. The spin velocity has an exponential variation due to the eddy current torque and a linear variation due to the gravity gradient torque. The combinations of the others torques contribute for a precession and drift on the spin axis, due to the temporal variation on the right ascension and declination angles respectively.

These analytical solutions are used to study the behavior of the solar aspect angle is gotten by the dot product of the Sun direction and the spin axis, and depend on de declination and the right ascension angles and the longitude and latitude of the Sun direction.

The theory was applied for the real data of the Brazilian Satellite of Data Collection - SCD1 and SCD2 and two approaches were presented. In the first one the attitude and orbital data are daily updated with real attitude data supplied by INPE. In the second approach the attitude and orbital data are not updated.

Results have shown the agreement between the analytical solution and the real satellite behavior for specific time simulation. Then the theory has consistency and can be applied to predict the behavior of the solar aspect angle.