Albuja, Antonella A. (Ph.D., Aerospace Engineering Sciences)

Rotational Dynamics of Inactive Satellites as a Result of the YORP Effect

Thesis directed by Dr. Daniel J. Scheeres

Observations of inactive satellites in Earth orbit show that these objects are generally rotating, some with very fast rotation rates. In addition, observations indicate that the rotation rate at which defunct satellites spin tends to evolve over time. However, the cause for this behavior is unknown. The observed secular change in the spin rate and spin axis orientation of asteroids is known to be caused by the Yarkovsky-O'Keefe-Radzievskii-Paddack (YORP) effect, which results in a torque that is created from reflected thermal energy and sunlight from the surface of an asteroid. This thesis explores the effect of YORP on defunct satellites in Earth orbit and offers this as a potential cause for the observed rotation states of inactive satellites. In this work, several different satellite models are developed to represent inactive satellites in Geostationary Earth Orbit (GEO). The evolution of the spin rate and obliquity for each satellite is then explored using Euler's equations of motion as well as spin and year averaged dynamics. This results in the dynamics being analyzed to understand the secular changes that occur, as well as the variations that result from short period terms over the course of a year. Some of the model satellites have asymmetric geometries, leading to the classical YORP effect as originally formulated for asteroids. One model satellite is geometrically symmetric, but relies on mass distribution asymmetry to generate the YORP effect. Because the YORP effect is directly dependent on geometric, optical and thermal properties of the satellite, varying these parameters can lead to different long-term rotational behavior. A sensitivity study is done by varying these parameters and analyzing its effect on the long-term dynamics of a satellite. Additionally, available observation data of inactive GEO satellites are used to estimate the YORP torque acting on those bodies. A comparison between this torque and the expected torque on a defunct satellite shows that the two are of the same order of magnitude, demonstrating that YORP could be a cause for the observed behavior.