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Orbital Safety and Optimal Operations in an Increasingly Congested Environment (Joint Astrodynamics/Space Debris Session) (10-C1.7)

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RAPID MODELING OF ELECTROSTATIC FORCES AND TORQUES CONSIDERING DIELECTRICS

Abstract

Spacecraft can charge naturally up to tens of kV in GEO, and this charge can affect the orbits of uncontrolled debris objects by interacting with the earth's electric and magnetic field. Additionally, many concepts use electrostatic forces and torques as a method of touchless actuation. These forces and torques can be used for a variety of novel touchless actuation concepts, such as towing space debris out of the geosynchronous orbit regime (GEO), and de-spinning uncontrolled spacecraft before servicing or docking. Modeling electrostatic forces and torques is vital to designing stable control laws to guarantee performance and avoid collision in a close formation flying context. Previous work for faster-than-realtime methods assumed the spacecraft was continuously conducting. In this paper, modeling electrostatic forces and torques on spacecraft with electrically isolated dielectric regions are investigated by modifying the Multi-Sphere Method (MSM).

Two principal research questions are, "under what circumstances must dielectrics be considered?" and "How can MSM be modified to account for dielectrics when they are significant?" To answer the first question template spacecraft with more or less dielectric area, and more or less charge contained in the dielectric will be considered. Preliminary work for modifying MSM has explored adding point charges to the model and using a mutual elastance matrix to find their effect on the charge on the conducting spheres. Early work using this approach has revealed a dimensionless scalar quantity called the charge shielding ratio which shows how much of the dielectric charge is canceled out by the conductor being excited to a certain voltage. This charge shielding ratio likely will inform regimes for when dielectrics must be accounted for.

Future work will explore how many conducting spheres and dielectric points are needed to effectively model the electrostatic force and torque on a satellite composed of both conducting and dielectric surfaces. This will be done for different spacecraft designs and different dielectric charge and conductor voltage levels. This work is done using both analytic and numerical methods.