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GOCE Aerodynamic Torque Modeling

T. Visser¹, E.N. Doornbos¹, C.C. de Visser¹, P.N.A.M. Visser¹, and B. Fritsche²

¹ Faculty of Aerospace Engineering, Delft University of Technology, Delft, The Netherlands;
² Hyperschall Technologie Göttingen GmbH, Katlenburg-Lindau, Germany

In recent studies thermospheric densities and cross-winds have been derived from linear acceleration measurements of the gradiometer on board the GOCE satellite. Our current work is aimed at analyzing also the angular accelerations, in order to improve the thermosphere density and wind data by allowing for the estimation of mass-unbalanced parameters. On this paper an overview is provided of the modeling approaches involved in isolating the aerodynamic torque. The intermediate result is a comparison of modeled and measured torques.

Each box contains a plot of the torque from a specific source, compared to the measured torque, on October 16th, 2013. A short description of the model for each torque is also provided.

Total of modeled torques

Aerodynamics

Magnetic torques

Estimated payload dipole

Spacecraft bus dipole

Solar radiation pressure

Gravity gradient

Thrust misalignment

The authors would like to thank B. Frommknecht for his dedication to providing all requested GOCE data. For more information, contact the corresponding author (T. Visser) through email at t.visser-1@tudelft.nl.

* "Analysis of Non-Gravitational Accelerations due to Radiation and Aerodynamics", Hyperschall Technologie Göttingen GmbH

The spacecraft bus contains many elements apart from the torquers that generate a magnetic dipole. These dipoles again cause a magnetic torque acting on the Earth’s magnetic field direction. The results of a test last performed on GOCE during development, a hard magnetic dipole, as well as several soft-magnetic dipoles, are modeled. On top of that the magnet of the ion thruster causes a significant dipole (shown separately in the plot).

The measured dipoles are especially prominent in the roll and pitch axes.

The ion thruster is aligned such that the thrust vector acts exactly between the beginning- and ending centers of mass. This means that most of the thrust will have a slight offset from the center of mass, causing a torque. As the center of mass only shifts slightly, the torque level is equal to that of the thrust force.

The pointing error is largest in the body y-direction, causing a yaw torque. From a sensitivity analysis it was found that this torque is very sensitive to thrust pointing errors. It may be necessary in the future to estimate this pointing error as well.

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