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Evaluation of aerodynamic and radiation pressure force models using accelerometer data

Eelco Doornbos (1), Marek Ziebart (2), and Georg Koppenwallner (3)

(1) Aerospace Engineering, Delft University of Technology, Delft, The Netherlands (e.n.doornbos@tudelft.nl), (2) Department of Civil, Environmental and Geomatic Engineering, University College London, London, UK (marek@cege.ucl.ac.uk), (3) Hypersonic Technology Göttingen, Katlenburg-Lindau, Germany (G.Koppenwallner@htg-hst.de)

Models of the aerodynamic and radiation pressure forces acting on satellites are applied in the precise orbit determination of many geodetic and other Earth observation satellite missions. These models generally consist of three related parts: models of the space environment (density, wind, radiation flux), models of the satellite (surface geometry and materials), and models of the interaction of the gas particles or photons with these surfaces (absorption, reflection, energy accommodation). Traditionally, variations of these models and submodels have been evaluated indirectly, in terms of their effect on tracking data residuals and consistency of overlapping orbits and derived geodetic products. However, the availability of precise accelerometer data from satellites such as CHAMP, GRACE and GOCE enables direct comparisons of modelled and measured forces.

There are several complicating factors in this type of comparison: only the sum of all non-gravitational forces is measured by the accelerometer, there are uncertainties in the calibration of the accelerometer data, and there are acceleration artefacts in the data due to thruster firings and other on-board events which are often difficult to model and remove. Our data processing and selection strategy is optimised to limit the influence of these complicating factors, so that many components of the aerodynamic and radiation pressure force models could be individually evaluated.

Highlights among the conclusions that can be drawn from these comparisons are (1) the possibility of considerable residual geometry errors for certain satellite shapes, when creating models from technical drawings, (2) good general agreement between radiation pressure models and observations, (3) large possible errors in the solar radiation pressure force related to eclipse transitions and (4) large biases in traditional empirical thermosphere density models, especially at solar minimum.