Eumetsat study for Attitude Dynamics and Disturbances in LEO and GEO environment

Pessina S.(1)**, Gomes Paulino N.M.** (2)**, De Juana J.M.**(1)**, Righetti P.**(1)

(1) *EUMETSAT, Eumetsat Allee 1, Darmstadt, D-64295 Germany +49 61518077*
(2) *GMV, Isaac Newton 11 P.T.M., Tres Cantos, 28760 Madrid, Spain; Tel. +34 918072100*

Stefano.Pessina@eumetsat.int, npaulino@gmv.com,
Jose.DeJuana@eumetsat.int, Pierluigi.Righetti@eumetsat.int,

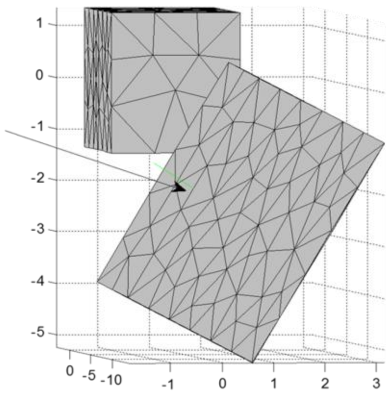
Keywords: *Attitude Dynamics, Environment Torques, Wheels off-loading, Star-trackers blinding*

ABSTRACT

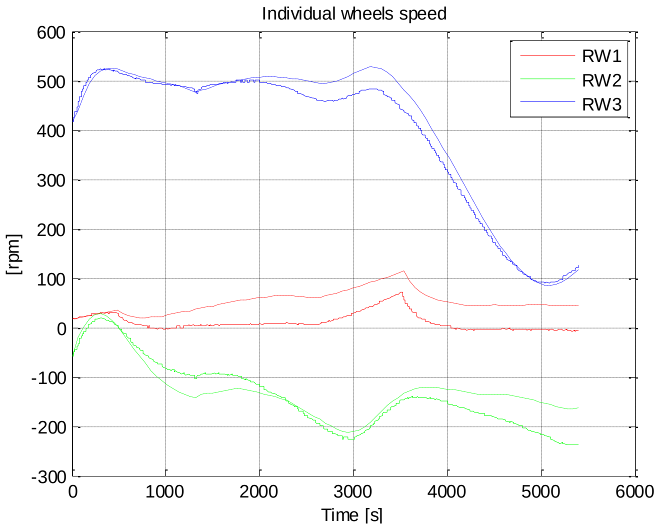
EUMETSAT is an independent intergovernmental organisation created in 1986 to establish, maintain and exploit European systems of operational meteorological satellites. It currently operates a system of meteorological satellites, monitoring the atmosphere and ocean and land surfaces which deliver weather and climate-related satellite data, images and products – 24 hours a day, 365 days a year. This includes the Meteosat Transition Programme (MTP) and the Meteosat Second Generation (MSG), operating in geosynchronous (GEO) orbit, and the EUMETSAT Polar System (EPS) and Jason-2, observing the Earth from Low-Earth-Orbit (LEO). The future programmes Meteosat Third Generation (MTG), EPS Second Generation (EPS-SG) and Jason Continuity of Services (Jason-CS) will provide continuity of observations. EUMETSAT will also operate the Sentinel-3 satellite, as part of the Copernicus initiative (formerly Global Monitoring for Environment and Security – GMES). For more detailed information about all EUMETSAT programmes: http://www.eumetsat.int.

To support both mission analyses within the space segment procurement of the future programmes and in-flight analyses for the currently flying satellites, EUMETSAT implemented a dedicated study with the following objectives:

- To model the dynamic loads induced by the space environment (according to ECSS Space Environment standards) for gravity gradient, radiation pressure, air drag and magnetic field, based on prescribed orbits and attitude laws, characteristic of current and future EUMETSAT satellites, both for LEO and GEO;
- Assuming multiple reaction wheels control for the spacecraft, to characterise the wheel off-loading frequency/needs, based on angular momentum accumulation;
- To predict and analyse the blinding/occultation of instruments (such as star-trackers), together with solar-array(s) illumination.



A specific tool has been developed by GMV for achieving the study objectives. To compute the space environment forces and torques, the spacecraft is modelled by limited set of satellite surfaces, shape and mass distribution (see figure aside), including the eventual rotation of external appendices (such as the solar arrays); simplified models for the spacecraft sensors and actuators are also implemented. The spacecraft pointing is defined by various sets of guidance profiles characteristic of the different mission of interest; the modelling doesn't involve spacecraft specific AOCS control algorithm impacting attitude accuracy and stability, but allows effective steady-state attitude representation with reduced computational load, suitable for long term multi-mission and multi-year predictions and mission analyses. Different off-loading schemes are also implemented, both for the off-loading strategy itself (maximum angular momentum, maximum angular speed for a single wheel, regular off-loading in time) and for the hardware used (pulsed thrusters mode, magnetorquers actuation, or a combined exercise of two systems).



Before the deployment of the tool for the EUMETSAT specific analyses, special care is given to its final validation: thanks to the modular design, all the components followed dedicated test campaign against various completely independent reference data or previously validated tools. The overall top level functionalities are tested also making use of flight data coming from Eumetsat flying satellites (see figure aside: telemetry wheels speed for the LEO satellite EPS versus predictions from the torque on-ground modelling).

As final step for the study, two dedicated study cases are run.

A first study case is for LEO environment based on the currently flying EPS satellite: it analyses various solar activity profiles and orbit altitude: this allowed both to characterise the seasonal and long term trends in the satellite observed dynamics, but also to have an internal evaluation of the torque load in view of the foreseen satellite end-of-life deorbiting.

A second study case is for GEO environment based on the future MTG satellite: it analyses various orbital inclinations, mission phases and year of operations, including regular 180 deg yaw-flip manoeuvres: this allowed characterising the variable need of thrusters' based off-loading of the reaction wheels during the mission and the subsequent impact on the orbit control for station keeping, due to thrusters misalignment and aging dependant plume impingement.

Author(s) statement for acceptance: this paper describes an effective approach to model attitude dynamics and disturbances suitable for long-term and multi-satellite mission analyses, also addressing the crucial validation of the selected implementation with operational flight-data. The results of the study, both related to in-flight dynamics characterisation and pre-launch mission analysis, are presented for current and future EUMETSAT missions. These results are of general interest for a wide range of satellites operating both in LEO and GEO environment, with special interest for wheels-controlled spacecraft.