In-flight assessment of star tracker performances: from Picard, through Prisma, to Microscope

Pascal Prieur, Florence Genin,
Centre National d'Etudes Spatiales (CNES) - pascal.prieur@cnes.fr
18, Avenue Edouard Belin - 31401 Toulouse CEDEX9 (France)

Abstract

Microscope is a CNES-ESA-ONERA-OCA-DLR mission whose main objective is to progress in fundamental physics by testing the Equivalence Principle (EP) with an accuracy of 10^{-15}. The scientific instrument is a differential electrostatic accelerometer developed by ONERA. The 300Kg drag-free satellite will be launched in April 2016 into a 700Km dawn-dusk sun-synchronous orbit for a 2 year-mission.
The Drag Free and Attitude Control System (DFACS) uses the scientific instrument as a sensor for linear and angular accelerations. In mission mode, the only other sensor is a star tracker with two camera heads, and the set of 8 cold gas GAIA-like thrusters is used as 6-axis actuators. The propulsion subsystem continuously overcomes the non-gravitational forces and torques (air drag, solar pressure, etc.) in such a way that the satellite follows the test masses in their pure gravitational motion.
The paper will begin with a quick presentation of the mission, followed by a description of the main DFACS challenges and general architecture. The attitude stability at low frequency is one of the most stringent requirements; an original hybridization between the accelerometers and the star tracker will provide the very fine attitude estimation in the scientific bandwidth of interest.
The performance of this filter nevertheless relies on hypothesis about star tracker performance at low frequency (field of view errors…) which had to be assessed. While the classical STR performances (NEA, RA) are quite easily available, the low frequency errors are very difficult to evaluate by test on ground and there was no in-flight experience with similar attitude guidance. The opportunity to perform such measurements on Picard and Prisma (same orbit, same star-tracker) was very interesting.
Several campaigns of in-flight experiments were performed on Picard and Prisma between 2010 and 2013. Picard is representative in quasi-initial pointing while the agility of Prisma was exploited to simulate rotating and oscillating modes. Picard was recently used again to validate an enhanced version of STR software optimized for Microscope.
Basically, mimicking Microscope attitude for hours and taking benefit of multiple accurate attitude sensors we could draw credible models depending on the attitude motion and on the quality of the star pattern. The interpretation was facilitated by massive download of images from the camera heads. The paper will explain the different experiments, the most effective methods to characterize the performance and some examples of results.
The paper will show how in-flight tests can be effective to prepare the next missions by improving our physical comprehension and assessing the numerical models.
The 25th ISSFD will take place 6 months before Microscope launch, the presentation will provide a status of the satellite AIV and ongoing activities.