Meeting MICROSCOPE's specific attitude-guidance requirements building upon MYRIADE satellite-family's inheritance

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Abstract

The objective and the philosophy of the MYRIADE bus family (150kg) has been to provide scientists opportunities to fly experiments for studying not-well known or defined science phenomena at reduced costs and development time, these constraints leading from a guidance point of view to a light AOCS configuration, limited slew and pointing performances.

MICROSCOPE - based on the generic MYRIADE ground and space segment - whose launch date is planned mid-2016, is a fundamental physics mission. Its main objective is testing the Equivalence Principle by measuring the differential acceleration induced by pure gravity on two test bodies of different mass and composition. However, MICROSCOPE exhibits several specificities which impact the attitude-guidance design and TC generator software requirements :

- An entirely new operational concept more complex than the one of generic CNES MYRIADE missions
- A new attitude-guidance reference frame (RNI) and new attitude laws with respect to MYRIADE ones
- A very low agility due to a satellite mass of twice MYRIADE's nominal one combined with a low-capability actuation system
- Limited resources of the cold-gas micro-propulsion system driving the maximum scientific mission's duration, unlike the other MYRIADE missions which are equipped with reaction wheels
- Absence of gyros hence a total intolerance to star-tracker glare

The interest of this paper is twofold:

- To present some of the specific and major attitude-guidance characteristics of MICROSCOPE.
- To present the design choices that were made by CNES to meet the original attitude guidance requirements of MICROSCOPE, on the basis of MYRIADE's recurring flight-dynamics software family product.

To this aim, the paper will go through:

- An introduction to the classical MYRIADE attitude-guidance design and TC generator software.
- A brief description of the MICROSCOPE mission and the basics of the operational concept to prepare the discussions on the specific MICROSCOPE attitude-guidance requirements and challenges:
    - The new ground operational concept for *automatic* routine-operations introduces *flexibility* in the weekly mission's programming compared to the classical MYRIADE scheme.
- The major challenges addressed :
    - The creation of a new quasi-inertial attitude-guidance reference frame specifically designed for the mission and its associated attitude laws :
        - The RNI (Inertial Nodal Frame) is a slowly rotating frame, at the mean rate of the helio-synchronous precession.
        - Its calculation is based on computing the rate of the mean orbital plane by a least-square fit of the predicted osculating plane's angular drift.
    - The design of the slew strategies between attitude-laws, including reference frame "switch" in the case of transitions between "Mission and Servitude" attitude-laws :
        - Based on the limited capacities and resources of the cold-gas actuation system
        - Minimizing "energy" cost of the slew
        - Keeping the algorithm complexity to its minimum
        - Fully compatible with the MYRIADE TC generator capabilities
    - The attitude-guidance strategy designed to cope with star-tracker glare during monthly moon-crossings:
        - Stops the scientific mission and switches *back* to a magnetically controlled satellite mode which requires a very specific attitude law - never done in any other MYRIADE missions - in order to save gas for the science mission.
        - Needs automatic programming of the required transition into this "servitude" mode and the transition back into "mission" mode at the end as part of the routine operations, due the frequency of the moon crossings.

- Retreats to “servitude” mode as late as possible in order to minimizing science mission unavailability.
- Returns to “mission” mode as fast as possible, under the constraints of very high satellite de-pointing due to the degraded magnetic control mode, with the risk of glare by both Earth and Moon
- Takes into account MYRIADE TC generator capabilities.

o The TC generator design upgrades required for the new flexible automatic routine programming scheme.

It is to be noted that to this date, the development of the TC generator software is complete and the product has been validated to an important extent, among others via full system tests on CNES MICROSCOPE‘s satellite simulator (validation bench). At the date of the ISSFD conference, the TC generator will be fully validated.