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SEMI-ANALYTICAL APPROACH TO FASTEN COMPLEX AND FLEXIBLE POINTING STRATEGIES DEFINITION FOR NANOSATELLITE CLUSTERS: THE HERMES MISSION CASE FROM DESIGN TO FLIGHT

Abstract

HERMES is a scientific mission project which aims validating on orbit a new approach to Gamma Ray Bursts (GRBs) detection and localisation. The novelty stays in both the data to recover, led by the multi-messenger astrophysics concept, and the new, miniaturized payload to be host on board. University of Cagliari and INAF, retain the science and the payload concept and realization paternity, respectively. To monitor the whole sky for the random GRBs occurrence, a distributed space asset has been preferred which led to the nanosatellite class to contain the cost. The triangularization needed to precisely localise the detected GRBs and perform science, in addition to the constraints imposed by the active component of the payload itself, gives rise to many restrictive operational requirements on the fleet, the compliance of which asked for a careful coordination between the fleet orbits and attitude history design. A further complexity is on the scene, due to the performance limitation the current COTS, space qualified technology offers in the nanosatellite market. The program financing has two sources: a national MIUR funding strongly supported by the Italian Space Agency (HERMES-TP), and the 2018 Space program H2020 from EC (HERMES-SP).

The paper discusses the HERMES-TP service module attitude subsystem, from the scientific requirements declination into the fleet attitude dynamics analysis and control, up to the determination, guidance and control algorithms design and the sensors/actuators suite selection, to the SIL and HIL activities for characterisation and verification. The different attitude modes the nanosatellite can nicely transit into

are presented, highlighting the fundamental role the implemented combination of SW/HW plays in the space asset advanced agility.

The new semi-analytical algorithm, specifically developed to rapidly design and optimize slewing maneuvers according to a flexible set of operational constraints (e.g. forbidden pointing directions, maximum angular velocities, maximum Sun Aspect Angle, etc.), is presented. A quaternion shaping and a fully analytical dynamics recovery is adopted and the attitude profiles are compressed into guidance coecients to be uploaded and commanded on-board: this approach represents a fast and computationally ecient ight dynamics tool to adopt for fast, but still precise, pointing transition history definition in medium and short planning during mission operations, whenever significant flexibility and manoeuvrability is required as in like HERMES-TP. Results of the whole verification campaign, from the SIL testing with high fidelity orbital-attitude GNC simulator in the loop, to the Engineering Model HIL results are extensively discussed.