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HIL TESTING OF GNC/IP FOR APPROACH AND HOVERING OF IRREGULAR SMALL BODIES

Abstract

The threat from Near-Earth Objects (NEOs) to the future of our civilization is measurable and scientifically well-founded. The European industry is therefore focusing efforts on establishing mission baselines and maturing technologies for mitigation actions against this threat. A critical technology is the Guidance, Navigation and Control with embedded Image Processing (GNC/IP) for Reconnaissance & Monitoring of NEOs.

This paper addresses the design and hardware in-the-loop (HIL) testing of the GNC/IP in the context of the reconnaissance spacecraft technology branch of the H2020 NEOShield-2 project, inserted in the kinetic impactor reference mission. The aim was raising the maturity of GNC technology to TRL 5-6 with tailored ECSS standards. The requirements, performance evaluation and ultimately TRL certification was administered by experts of Airbus Defence and Space.

To achieve it, and in general for missions to minor bodies and moons, an autonomous GNC/IP is deemed necessary in three mission phases:

- Close Approach: starting 3 days before arrival (ground loop delays become relevant);
- Inertial Hovering: ensuring a safe arrival and maintenance for a few hours, before mission control centre and navigation solutions are established and transferred to ground control;
- Body-Fixed Hovering: starting at later time of the mission, activated by ground, and enabling surface characterisation and/or preparation of landing operations.

The design is focused on the critical set of GNC/AOCS modes and space qualified equipment, underlying two architectures that include:

- IP SW modules: centre-of-brightness and features detection & tracking (BRISK) running on LEON3 and PowerPC, respectively, and using real HIL camera images.
- Navigation SW modules: square-root information filters (SRIF), processing two different sets of measurements/observables, running on LEON3.
- Guidance & Control SW modules: sun direction targeting guidance and proportional-derivative controllers, running on LEON3.
- GNC and ADCS Executive SW: state machines and attitude guidance, running on LEON3.

The HIL validation is based on closed-loop realtime testing of the GNC/IP SW modes in the three mission phases against its functional and software requirements. It was performed at the optical laboratory at GMV that includes a representative camera HW, acquiring asteroid images (with noise and calibration residuals), and DEIMOS realtime elements. The paper includes substantive technical and programmatic contents of the incremental testing/integration, results in several scenarios (including emulation of radiation effects on camera) and conclusions on the achievement of TRL 5 and steps towards TRL 6.

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