Avionics Verification and Validation on the NEOShield-2 Project

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It is a proven fact that near-Earth objects (NEOs) will hit the Earth at irregular intervals in the future, with the potential for catastrophic damage to life and property. The objective of the H2020 Neoshield-2 project is the design and maturation of the critical techniques required in NEO missions, including those aimed to analyse in detail potentially dangerous NEOs and to deflect them from their established orbit. The Guidance, Navigation and Control techniques with embedded Image Processing (GNC/IP) in close vicinity of asteroids and comets (as part of NEO reconnaissance missions) has been identified as one of the critical areas where further scientific research and technical development work is necessary in order to reduce the risk of a NEO deflection attempt failing.

Within the scope of the H2020 NEOShield-2 project Elecnor Deimos has designed and developed several GNC algorithms for a reconnaissance S/C mission, achieving technology readiness level TRL5/6 at the end of the project, demonstrating the functional performances of the algorithms on MIL tests and validating these performances on PIL and HIL test benches (i.e. with space representative processor boards and camera in the loop), in which the real time performances have been also demonstrated.

The GNC/IP algorithms have been developed in a Matlab/Simulink® environment, following an internal modelling guideline designed to streamline the subsequent autocoding and validation procedures. In a first step, the GNC/IP algorithms have been tested in a Model-In-the-Loop test bench, through 300 Monte Carlo shots (each algorithm) where they were subject to non-ideal conditions and dispersions. The following step has been to port the GNC/IP algorithms to a real-time validation test bench with the following architecture:

- A space representative On-Board computer based on LEON3/RTEMS, which executes the GNC/IP SW. The mathematical algorithms have been generated through autocoding, while the basic services, such as communications or Real-Time Operating System management, have been manually coded.
- A dedicated unit for Image Processing based on a space representative PowerPC 750 board, needed for those GNC modes where the IP requirements are too demanding for the LEON performance.
- A PC running the Surrender space image simulator (courtesy of Airbus), in charge of the simulation of a camera and the target body images, which provides images of the asteroid according with the current states of the asteroid, the Sun and our spacecraft, and applying to them the effects of the selected Wide and Narrow angle cameras.
- A dSpace unit, which simulates the Dynamics, Kinematics and Environment. The SW running on this element has been generated from the Simulink environment by means of autocoding techniques.

A set of validation tests have been executed in this test-bed, with the objective of verifying the functional and non-functional performances of the algorithms, and to evaluate potential modifications required on the algorithms, when exercised in realistic conditions. The identified algorithms modifications are then fed-back to the Model in the Loop test bench, where Monte-Carlo runs are executed again.

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