SPACE EXPLORATION SYMPOSIUM (A3)
Mars Exploration – Science, Instruments and Technologies (3B)

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VISION-BASED GUIDANCE, NAVIGATION AND CONTROL SYSTEM FOR PHOBOS SAMPLE RETURN MISSION

Abstract

Sample return missions are very complex and require advanced technologies. One of the enabling technologies is the Guidance, Navigation Control (GNC) system. The requirements on the GNC systems for a mission to land on Phobos are very demanding. Tight orbital and landing performance requirements have to be attained in the complex dynamics of the Mars-Phobos system. Furthermore, robustness is a fundamental concern because of the large uncertainties in the environment.

An autonomous GNC system for descent and landing (DL) on Phobos is being developed by GMV under several ESA contracts. The GNC system is based on advanced algorithms and European navigation sensors. Lessons learned from ROSETTA have been incorporated in the definition of the ground operations

and performances. In addition, previous results from hardware-in-the-loop (HIL) tests in robotic facilities for asteroid sample return mission has also been considered in the definition of the GNC strategy and descent profile.

The GNC system considers two different vision-based navigation strategies: pure relative navigation and enhanced relative navigation. Both strategies are based on the tracking of unknown features on the surface of the asteroid. The differences are mainly in the initialization procedures. Focus is placed on the design of a GNC strategy that can achieve the landing performances and reduce mission costs (space segment development and ground operations).

The image processing and relative navigation algorithms have been optimized for Phobos landing. They have been implemented in flight representative hardware in a tight and optimal implementation with HW/SW co-design methodology onto a FPGA plus processor device system. The system has been tested in real time testbench with simulated images. In addition, HIL tests with a mock-up of Phobos surface and a real camera have validated the performances of the core of the system in a representative environment.

For the rest of the GNC system, extensive tests will be performed in order to validate the selected approach including ground initialization. Monte Carlo tests and worst case analysis in a high-fidelity, closed-loop simulator with realistic images will validate the GNC system to TRL-4. Later on, tests in a real-time testbench are executed with flight-representative avionics for the complete GNC. The real world is simulated in a real time hardware (dSPACE board), and realistic images are generated in closed-loop. These tests will validate the complete GNC system to TRL-5.