MULTI-SENSORS BASED CONTROL SYSTEM FOR GENERIC AUTONOMOUS RVD

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HARVD (High Integrity Autonomous Rendezvous & Docking Control System) is an ESA-funded activity implementing a GNC/Autonomous Mission Management/FDIR on-board software for rendezvous and docking/capture around Mars, Earth or potentially other planets. Mars Sample Return and IBDM demonstration missions have been the scenarios chosen for verifying and validating the control system.

Navigation function relies on measurements coming from different absolute and relative sensors. The absolute sensors suite is classical and can be considered as consolidated (heritage from past planetary exploration missions). For MSR scenario, it foresees the utilization of star-tracker and gyros for attitude and attitude rate estimation, ground tracking and accelerometers for position and velocity estimation (in case of RVDM scenario, also GNSS measurements are available). The relative sensors selection is the result of a trade-off process, supported by performance analysis, driven by mission requirements and including criteria such as operational range, performances, robustness to failures and to scenario conditions (e.g. illumination conditions), adaptability to contingency scenarios (e.g. target acquisition failure or target loss), acquisition times, mass/power requirements or reliability. At long range, the hybridisation of RFS2 (Radio Frequency extension of the Proba3 RF System) and Narrow Angle Camera (NAC) has proved to be a potential optimum solution because of the complementarity of the two sensors (the former provides good range accuracies, while the latter provides good LoS accuracies, so both can be combined to obtain good performances). At short range, the LIDAR has been identified as the most suitable nominal sensor, mainly because of its performances and robustness to illumination conditions. Because of its omnidirectional coverage, the RFS2-S (Short Range mode) is ideal as independent collision risk warning system and as baseline sensor for relative navigation during collision avoidance manoeuvres (where LIDAR orientation towards the target is not ensured).

The development, validation and verification of HARVD Control System are being carried out at three different levels: algorithms design and verification in a High-Fidelity Functional Engineering Simulator, SW demonstrator to be verified in Real Time Avionics Test Bench and Dynamic Test Bench. The Real Time avionics Test Bench includes processor in the loop (PIL) and real hardware sensors electrically stimulated in the loop (HIL) in order to achieve the maximum HARVD system validation capabilities. The dynamic test bench is the last step on the on-ground validation and verification chain and provides real dynamic conditions reproduction that stimulates real HW sensors with real signals in order to achieve the maximum ground testing representativeness of the flight conditions.

This paper will introduce the HARVD Control System, focusing in particular on GNC-sensors interfaces and on sensors in the loop activities. Analysing HARVD architecture and the results obtained during the HARVD test campaign, the paper will contribute to provide recommendations about possible future improvements in sensors suite area.