Model Predictive Control real time performance in a rendezvous&capture scenario for Mars Sample&Return

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The Mars Sample&Return (MSR) mission, belonging to European Space Exploration Programme "AURORA", has the main objective in bringing back to the Earth a sample of Martian soil. To achieve this, a rendezvous and capture system shall be implemented, which would be able to detect, approach and capture the sample previously put in a predefined orbit by the Mars Ascent Vehicle (MAV). Fundamental parts of this system are the Guidance, Navigation and Control algorithms (GNC), that have to cope with poorly cooperative target and operational constraints.

The ESA study "On-line Reconfiguration Control System and Avionics Architecture" (ORCSAT) addressed the application of optimization-based control strategies such as Model Predictive Control (MPC) to the rendezvous scenario. Indeed, the capability to include performance goals, optimal path planning and dynamic safety margin in an optimization problem in addition to the feedback stabilization has been considered extremely attractive for this kind of mission.

The MPC algorithms developed in the frame of the study have been widely tested in a MonteCarlo simulation campaign, showing great robustness against different dynamic conditions and performance improvements with respect to classical GNC solution both in terms of propellant consumption but also in terms of optimal trajectory planning. The design phase have also identified that a distributed architecture for the Central Data Management Unit (CDMU), which considers a processor plus a coprocessor, is necessary to cope with high computational capability required by optimization algorithms embedded in MPC.

The final objective of the ORCSAT study was to evaluate by a real-time demonstrator of the Avionics Architecture the performances of the rendezvous and capture phases in MSR scenario, embedding MPC control system into a space representative avionic platform. A demonstrator has been set up mainly composed by following elements:

- the Real-time Simulation environment (RTS) which is in charge to simulate the dynamics/kinematics and the onboard equipments
- The Flight segment, which embed the CDMU, the GNC (MPC) algorithms and the Data Handling Software (DHS);
- The Ground segment, devoted to CCSDS telemetry acquisition and telecommands preparation and dispatching.

The paper will present the ORCSAT final real-time simulation results and the demonstrator setup, with particular focus on the flight segment architecture, including GNC partitioning, implementation and testing.

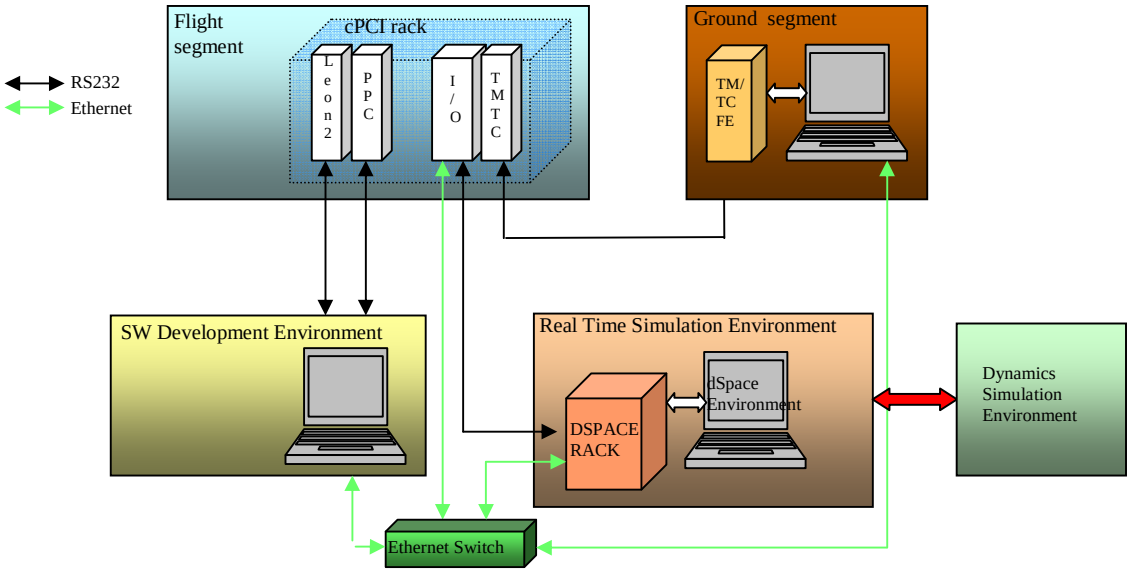

Figure 1 – ORCSAT demonstrator scheme