Beyond the Aurora Architecture for the new challenging applications.
The Enhanced Avionics Architecture for the Exploration Missions

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Different ESA studies are currently on-going in the frame of the Aurora initiative and are aimed at pawing the way to the future exploration missions. The main goal is to investigate, develop and test enabling technology supporting the new challenging requirements for these missions.

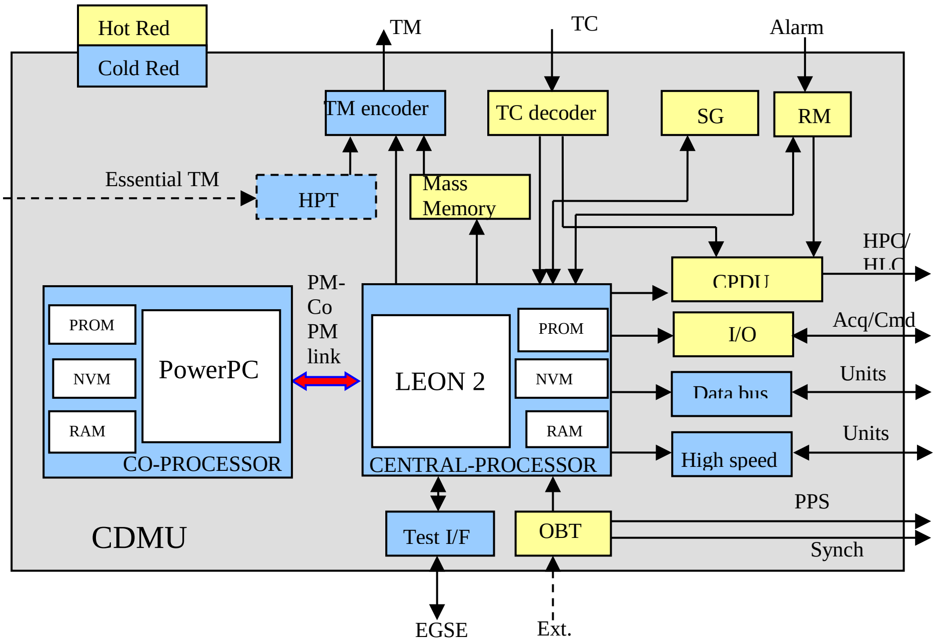
ThalesAleniaSpace Italia is leading some of these key studies where specific functionalities as "precision", "optimization", "scalability", etc are new additional demanding features required to be implemented on-board, running on the Avionic Architecture. The starting point for these studies has been the reference Aurora avionic architecture for the space exploration mission and this is the architecture that TAS-I has been improving for coping with the needs of specific applications. The two main reference scenarios that triggered such needs are the Mars Sample Return mission - in which Rendezvous&Capture and EDL functionalities must be implemented - and the MoonNext mission - in which the Visual Navigation is mandatory to drive an accurate descent and landing phase.

One driving factor in the exploration mission is the propellant saving. New guidance techniques based on Model Predictive Controllers (MPC) have been studied for the RVD&Capture phases requiring high computational capability.
The EDL scenario requests as well high computational capability together with new and very accurate sensor (LIDAR , Radar Altimeter, Navigation cameras) for a precise determination of the landing site avoiding hazards that could nullify the mission objective. Vision based navigation techniques are needed for both the absolute and relative position estimation as well as the hazard detection and avoidance and such algorithms have high computational burden.
The image storage and its transmission to ground - to review and analyze the crucial phases of the exploration mission (sample capture and final landing) - requests large memory storage capability and lossless compression algorithms. FLASH memories and dedicated FPGA hosting compression algorithms can be considered the more promising components of the future avionic architecture.

An additional aspect to be considered is the communication link between the central processor, the GNC and system sensors/actuators. Different needs have to be taken into account: mass and power saving, reliability, robustness and high communication speed. For instance the navigation camera can generate 1024x1024 images at 10Hz frequency requiring bus capability of about 100Mbs; similar capability is applicable to LIDAR which data generation frequency can reach 20 Hz.

These requested Data Handling performances can not be guaranteed with the mono-processor configuration based on current space qualified microprocessor and using the traditional serial communication links.

Starting from the Exomars project TAS-I is investigating in several ESA studies (ORSAT, SAGE, VISNAV) and in its internal researches new common DH architecture in which the central processor (LEON2 FT based) is associated to a more powerful co-processor.
The co-processor can be either a PowerPC750FX working at higher frequency and giving performance in the order of thousand of MIPS or a FPGA in which specific algorithms are embedded (MPC or Image Processing). A third more complex co-processor configuration could consist in a PowerPC750FX interfacing with FPGA.



Communication between main computer and coprocessor is based on a dedicated parallel bus (up to 1Gbps) which guarantees good interprocessor link performances.
The main computer is in charge of the data handling tasks interfacing with sensor, actuators and other subsystems (Electrical, Thermal, Radio Frequency) via several serial links, the coprocessor is in charge of GNC and other computationally demanding tasks.

In addition to traditional point to point communication (RS422, RS485) or serial bus linking several remote terminals with the bus controller (MIL1553) TAS-I is studying, in the frame of the EXOMARS project, the CAN bus protocol with the objective to reduce power consumption, improve reliability and build up European components ITAR free. Communication between the central processor, Cameras and Lidar is based on SpaceWire routers which provide a very fast and suitable serial link (up to 200Mbps). Instead of point to point acquisition of system sensor data from other subsystems TAS-I has also studied digital sensor network (I2C bus) which is very attractive from the mass and power saving point of view.

The deep investigation of this avionic architecture is being carried out by TAS-I in dedicated Avionic Test Benches based on improved RASTA systems (used as HW demonstrator in the ESA studies and as test bench in the Internal Research activities). TAS-I presentation will focus on these DH architectures describing and evaluating advantages and limitations of the different configurations.