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MIURA 1 Avionics Development And Qualification

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Abstract

MIURA 1 is a sounding rocket, developed by PLD Space, whose mission is to provide microgravity environment to payload experiment. MIURA 1 has also another important goal: it will be used as a flying test bed for technologies that will fly with MIURA 5, PLD Space's micro launcher.

The development of the avionics of MIURA 1 and MIURA 5 was kicked off in January 2017 between PLD and GMV, since then working in a technological partnership paradigm, based on internal funding. GMV is in charge of the development and qualification of complete avionics, including not only all hardware vital subsystems of the launchers but also the Guidance Navigation & Control System and the On Board SoftWare System. MIURA 1 avionics shall be a scaled replica of MIURA 5' one. Thus, MIURA 5 avionics development shall benefit from lesson learned during the development and qualification of MIURA 1 but also from its in-flight experience.

The activities carried out in 2017 were focused in the identification of key elements and technologies of the developments. Some decision were taken about how to approach the commonalities and therefore some element were added to MIURA 1 although not mandatory for the success of its mission (e.g. Thrust Vector Control System). Several trade-off were also carried out, with a close look at COTS market, in order to finalize the 'make-or-buy' decision for different element of the avionics.

ESA has decided to support European private-led micro-launch service ventures in maturation of critical and enabling technologies. In 2018 ESA's Future Launchers Preparatory Programme placed a contract to co-finance the development and qualification of the Avionics system of the MIURA 1, which can be easily scaled up and re-used for other launchers, including small and micro-launchers. The project is now facing the finalization of the design phase while some elements are already under integration phase.

1. Introduction

The main goal of MIURA 1 mission is to provide a microgravity environment of about 4 minutes to a payload up to 100 Kg for performing the experiment and return it back to ground safely. Different phases are performed by MIURA 1 to reach this target (Figure 1) along the complete mission.
The following main high-level operations of MIURA 1 mission are reported below:

- Ground

In this phase, the MIURA 1 is prepared for launch campaign. Typical ground and pre-launch operations are executed; the launcher elements are powered up, all the system and payload elements (e.g. propulsion, avionics, telemetry, etc.) are verified at the launch pad, tanks are filled and pressurized and the ground operations are performed until transfer of the vehicle control to the On-board Computer (OBC).

- Lift off

The engine is started, motor ignition is performed and the umbilical is released from the launcher. MIURA 1 begins the lift-off phase.

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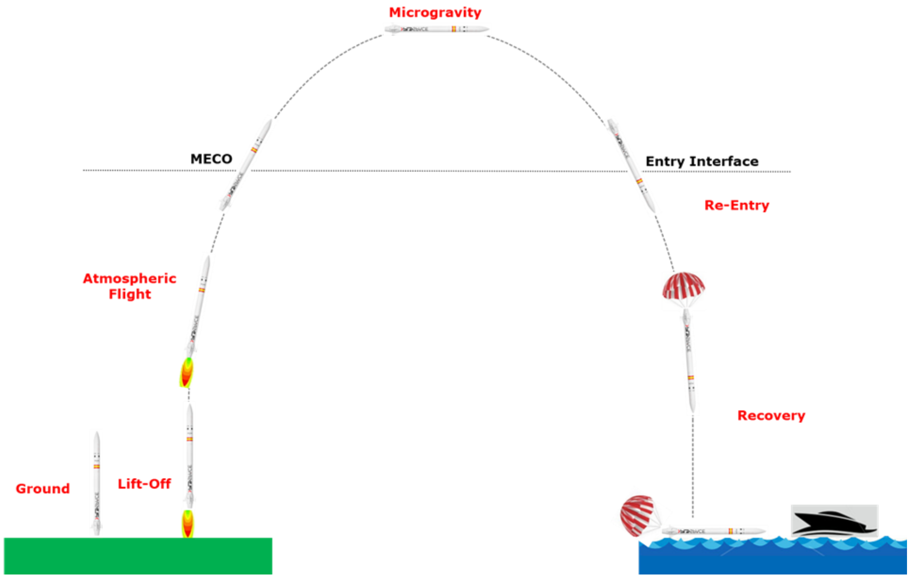

Figure 1: MIURA 1 Mission Overview.

- Atmospheric Flight - Controlled Propelled Phase

MIURA 1 starts the atmospheric ascent phase where the launcher is controlled (mainly via Trust Vector Control, TVC system) to follow an optimum pitch profile and yaw profile while Attitude and Rate Control System (ARCS) is activated to limit the roll rate.

- Atmospheric Flight - Controlled Ballistic phase

The Main Engine Cut-Off (MECO) condition is reached and the launcher reduces the residual angular velocities under a certain level to prepare the microgravity phase.

- Microgravity phase

During this phase launcher actuators are not active and the launcher follows the parabolic trajectory where the microgravity conditions are met. The payload executes its experiment.

- Re-entry phase

MIURA 1 reaches the end of microgravity and the edge of the atmosphere region. The correct attitude is acquired by the launcher to enter the atmosphere with a limited attitude error with respect to the reference trajectory (i.e. null angle of attack at entry interface).

- Recovery phase

After reaching a prescribed condition, MIURA 1 opens the parachutes to further decelerate the launcher till splashdown in the sea. All the systems are passivated and powered off waiting for the recovery boat to pick up the vehicle.

2. System description

In order to accomplish the mission, MIURA 1 needs to use a complete avionics, similar in terms of function to an avionics system of classical launchers. Therefore the MIURA 1 avionics is composed by:

- Electrical Power Subsystem, containing the storage, conditioning, distribution functions;
- Data Handling, in charge of execute the mission but also collect data from sensors, actuate valves and format telemetry;
- Antenna systems, for the different RF links;
- Flight Termination System for Safety (common architecture);
- GNC subsystem, including GNC sensors and interface to actuators;
- Onboard Software (OBSW);
- Payload management encompassing power management and data and video storage;
- Harness.

The development of MIURA 1 avionics is being carried out keeping in mind the following characteristics:

- Scalability, it shall be easily scaled-up and fully re-used as avionics system for MIURA 5.
- Modularity, composed by a number of building blocks that can be selected and instantiated depending on the mission and the rocket characteristics in order to reduce the total number of equipment with the use of standard modules.

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- Low-cost approach, the use of Commercial Off the Shelf (COTS) elements that can radically reduce the cost and lead times of the avionics elements procurement and integration.
- Reliability, improved by the integration of real-time health management algorithms and an exhaustive process of Assembly, Integration and Verification/Testing (AIV/AIT), of both hardware and software, based on industrial standard elements and procedures.

In particular, scalability and modularity are the two key aspects in the MIURA 1 development also because they are the key for the upscaling of MIURA 1 architecture to MIURA 5' one. The idea of scalability and modularity has led to build a distributed system based on: a 'main part/assembly', concentrated in an avionic bay, where almost all the avionics function are necessary and therefore present; and on remote units capable of managing all the local interfaces in the different areas of the launcher.
It has to be noted that several sensors and valves, necessary for the correct functioning of the propulsion system, are distributed all over the launcher.
According to the description above, Figure 2 shows the zones of the launcher where the avionics will be distributed:

- Payload Bay
- Avionics Bay
- Intersection Bay
- Intertank Bay
- Motor Bay

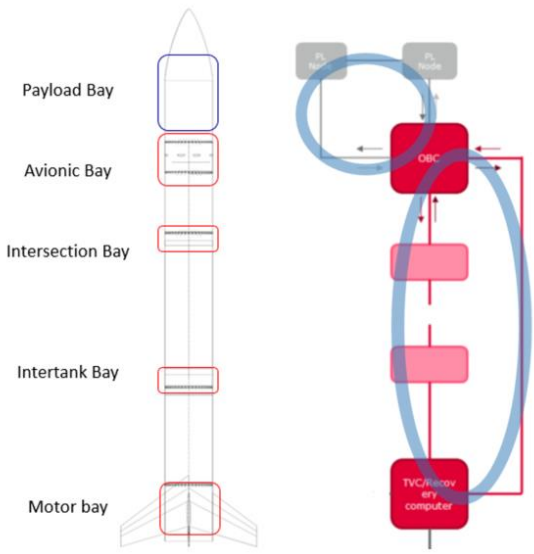

Figure 2: MIURA 1: Sections and equipment distribution (generic).

For the maiden flight, MIURA 1 will also be equipped with additional units (nodes) and sensors (analogue sensors but also video cameras) that will be used to gain more confidence in the knowledge of the environment of the launcher and to validate results of theoretical model and analysis. They will be part of the proto-flight kit. The high modularity of the system allows to introduce these additional elements without impacting or interfering with the baseline design and validation of the system.
As shown in the Figure 2, Data Handling is managed via three buses: the main avionics bus, the payload bus and one point-to-point connection to the ground segment. The avionics bus and the payload bus are realized via a redounded path (redounded physical cable) and therefore they are also referred as ring(s).
The main avionics bus (ring) is the key element of the avionics communication between avionics nodes: the On board Computer (OBC), in the avionic bay; the Engine Control Unit (ECU), in the motor bay; and other nodes in other sections of the launcher. Avionics bus is used to accomplish the mission (command actuators and monitor the propulsion system) but also to collect all the data from all analogue sensors and video cameras and send them to ground via the telemetry transmitter and the antennas.
The payload bus (ring) is segregated from the avionics ring and is used to send data from payloads to ground. All data from payloads are recorded on board and are transmitted to ground via an independent RF link. Payloads receive also some information from the OBC about the timeline (i.e. start and stop of microgravity).

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The ground link is a point-to-point link used to send commands to the launcher and to receive their acknowledgement, as well as monitoring launcher status and housekeeping necessary to ground operators to supervise the launch procedures.

2.1 Guidance, Navigation and Control

The GNC subsystem (Guidance, Navigation and Control) of a launcher is the module that is in charge of the vehicle control (mainly attitude control via Trust Vector Control, TVC, and Attitude and Rate Control System, ARCS) that will maintain the launcher in the desired mission trajectory and attitude.
A high level design of the GNC for MIURA 1 is reported in Figure 3.

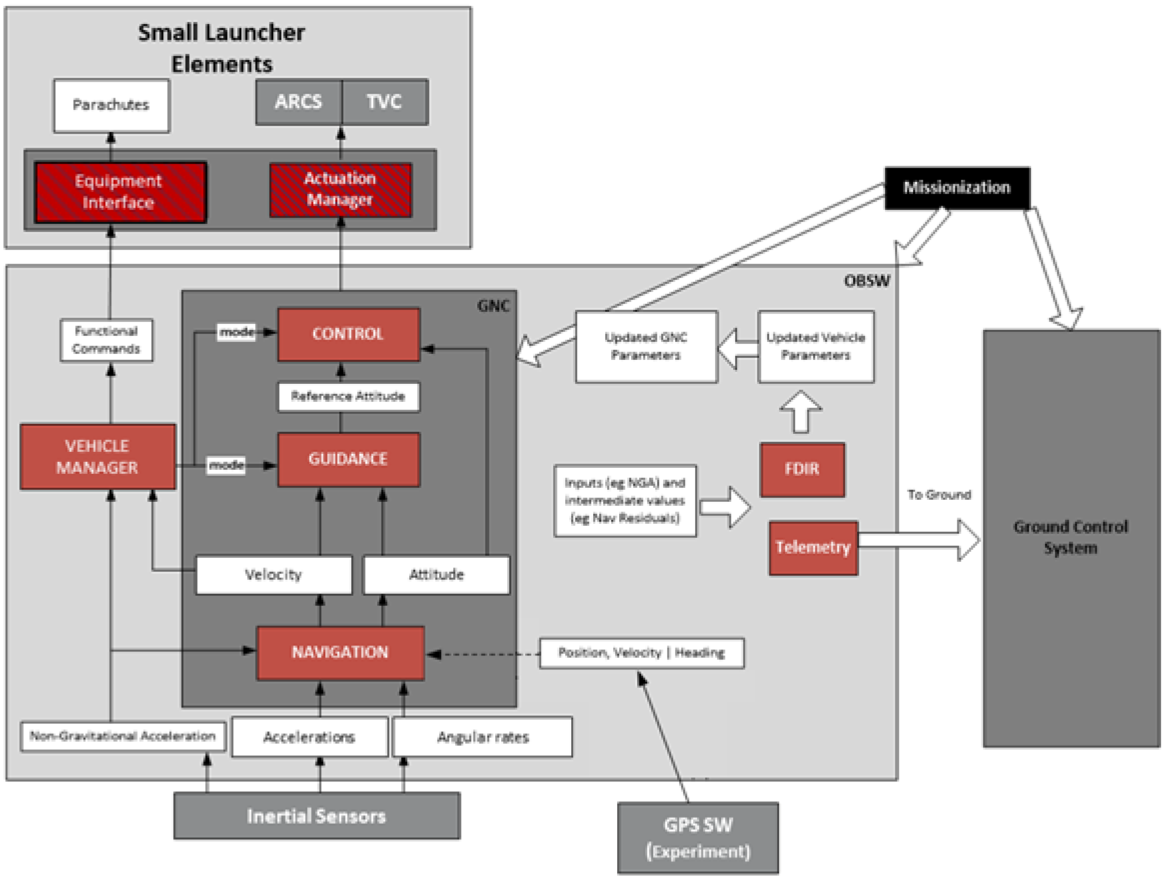

Figure 3: GNC Overview.

The GNC function is split into Guidance, Navigation, Control and Flight Manager that adopt the following approach:

Navigation
The Navigation function receives the measurements data from the inertial sensors and computes them to estimate the launcher state (e.g. attitude, attitude rate and non-gravitational velocity) needed by the GNC. The navigation algorithms integrate directly angular rates and accelerations measurements coming from the inertial sensor and no specific filtering techniques or full inertial navigation will be computed.

Guidance
The Guidance function computes the reference attitude (e.g. pitch and yaw) and reference angular velocity that the launcher has to follow to comply with the mission manoeuvres and timeline. For the ascent part of the trajectory an open loop scheme is used where the reference pitch and yaw profiles for the complete ascent flight are pre-loaded into the OBSW via parameters (i.e. look-up tables) and values are interpolated based on non-gravitational velocity. A different guidance approach is used from MECO till Entry Interface. The navigation data (e.g. attitude and attitude

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rate) are passed to the guidance function that computes this information to generate the reference attitude profile to be followed during the manoeuvres defined by the mission timeline (i.e. null rates, pitch residual and entry interface acquisition). In this case, the guidance will compute a profile for the manoeuvres that depends on the estimation of the current attitude provided by the navigation and desired attitude to reach for following the mission manoeuvres. For this part of the mission the guidance tries to compensate the errors due to ARCS thrusters' actuations.

Control

The control function computes the attitude control for the TVC and ARCS system based of the information processed by the navigation and guidance to follow the desired trajectory and attitude profiles. The control function receives the reference thrust direction and reference attitude (attitude and angular velocity) from the guidance and the estimated attitude from the navigation (attitude and angular velocity) and it computes commands for the TVC and ARCS.

Flight Manager

The flight manager function is in charge of detecting the mission events related with GNC based on time from ignition or detecting particular conditions based on non-gravitational velocity. This module implements the logic for selecting the different GNC modes or functions to be executed during the flight for following the target mission timeline.

The GNC equipment adopted by the MIURA1 are based on COTS products. The IMU (Inertial Measurement Unit) that provides the acceleration and angular rates to the navigation function is a STIM300 (3 axis gyro and 3 axis accelerometer). The TVC system that is in charge of controlling the launcher pitch and yaw channel during propulsive phase is based on Electro Mechanical Actuators (EMAs) that shall gimbal the whole engine (including the combustion chamber) around a pivot point. The ARCS system that performs 3-axis stabilized launcher control is based on cold gas thrusters with high pressure/flow small solenoids valves and pressure regulators. Taking into account the short part of MIURA 1 mission where GNC has to actively control the launcher (about 7 minutes) and from GNC equipment analysis (performance and environmental) the use of the selected equipment is compatible with the mission requirements.

For MIURA 1 mission the GNC subsystem is active and controlling the launcher from the pre-launch phases where the GNC and related equipment are powered on and verified till reaching the entry interface where the launcher is controlled to start the atmospheric re-entry phases with correct attitude. After the entry interface point (at the beginning of the atmospheric re-entry phase) the GNC is maintained powered on but it does not actively control the launcher attitude (i.e. the TVC and ARCS commands computations is disabled) while the navigation module will still generate TM data that can be transmitted to ground.

The GNC algorithms are developed and validated into a simulator in the Matlab/Simulink environment (i.e. FES) following a model-based component approach exploiting the Matlab potentiality for algorithms modelling and validation. The GNC models are then autocoded (by means of automatic techniques) and the production code generated is used and validated in real-time test benches. The entire process of transforming a Matlab/Simulink model to optimized code components (typically C code) ready to be embedded in a target HW or facility is performed according to a methodology and standards that is specified and applied during all the SW development process for GNC SW of MIURA1.

The Figure 4 reports the GNC modes defined by MIURA 1 mission and the autonomous transitions.
The implementation of the GNC modes logic and transitions is performed in the Flight Manager subsystem.
The design of the GNC for MIURA 1 accounts for dedicated subsystems for guidance and control according to the specific manoeuvres to be performed during the mission timeline (e.g. null rate manoeuvres, pitch residual manoeuvres, entry interface acquisition manoeuvres, etc.) where ad-hoc algorithms have been implemented for each one of the GNC modes. While, the Flight manager and navigation functions will execute the same type of algorithms along the mission and no specific modules have been defined.

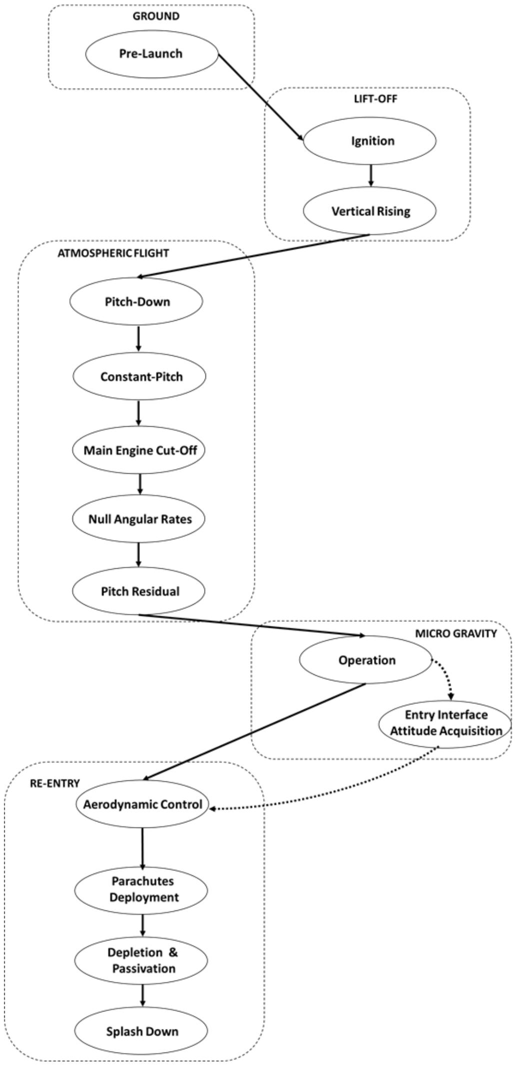

Figure 4: GNC Modes Overview.

2.3 On Board SoftWare

The On Board Software is divided into three well defined layers:

- The Higher level layer is the Application layer. The Application layer contains the high level mission dependent logic for the mission, including the GNC code (generated by means of GMV heritage Autocoding techniques) and the Mode Manager. Furthermore this layer contains the specific unit management for the mission.
- The intermediate level layer is the Service Layer, The Service is the middle layer and is intended to provide a friendly and hardware independent interface between the Application Layer and the Basic/HDSW layer. This layer shall be mission independent and shall be valid for each of the units in the system, i.e no dedicated modifications for a specific unit are allowed.
- The Basic/HDSW layer contains all the software modules that are hardware dependent, i.e the operative system (RTEMS) which is explicitly compiled for the arm processor architecture and the Zynq SoC. Furthermore this layer contains the drivers for all the interfaces such as the buses (CAN, TSN), the interfaces with the inertial sensors (Accelerometers and Gyros of the IMU), the interfaces with the Telemetry transmitter (TME) and the interfaces to the Digital Outputs.

Figure 5 shows OBSW architecture with all possible functions included. The figure refers to the OBC SW (i.e. GNC SW is only present in OBC) but the architecture is the same for all nodes.

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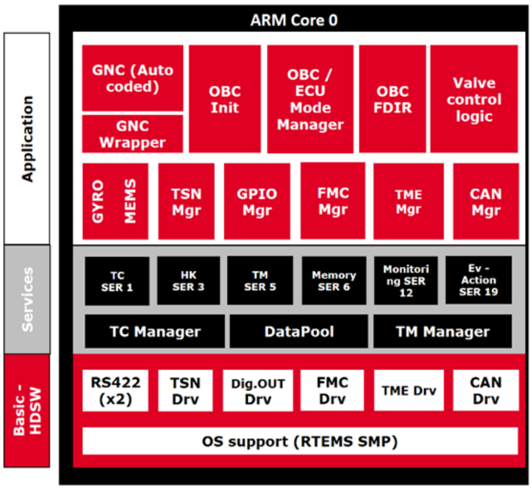

Figure 5: OBSW Architecture.

2.4 Data Handling System

The Data Handling system is based on distributed system of Nodes that are communicating between them via separated bus (rings, Figure 2) of GEthernet made deterministic by a light implementation of the Time Sensitive Network (TSN) standard. Each of them with its proper configuration and functions.
The On Board Computer is the most 'complete' between all nodes. It is in charge of executing the OBSW including the GNC SW. Therefore, the OBC is connected to the GNC sensors (IMU, GNSS receiver) and it sends commands, via a CAN bus, to the TVC system in the motor bay, and via digital commands, to ARCS valves. The OBC is also capable to collect the data, via its own Sensor C&A Board or from the bus, and to organize them in a CCSDS frame (with different virtual channels) that is sent directly to ground via umbilical (RS-422) or to the Telemetry System that is made of an S-Band transmitter and an Antenna System.
Another key-element of the avionics bus (ring) is the Engine Control Unit (ECU). The ECU is the nearest node to the motor and therefore is in charge of the execution of the ignition and its monitoring. The ECU is also in charge of acquiring propulsion and house-keeping sensors and to send them via the TSN bus (formatted in PUS packets) to the OBC for the retransmission to ground. The ECU is also in charge of the point-to-point connection to the Mission Control Center.
The avionics bus in its baseline configuration is composed of two other nodes that are allocated in the inter-tank and inter-section of MIURA 1. Their main 'job' is to acquire the analogue sensors in their proximity and send them to the OBC for further retransmission. Some of the pressure sensors acquired by the node are also used locally to close the pressure regulator loop of the propulsion valves that are present in that section. Those loops are designed by PLD.
As anticipated, for the first flight a set of additional nodes (named 'proto-flight') will be also present. They will only condition and acquire sensors that are foreseen for the first flight, usually referred as technological measures.
The payload bus (ring) is segregated from the avionics ring and is used to send data from payloads to ground.
Each Payload Node, or Payload Computer, is capable of interfacing two different payloads via two independent Ethernet ports. Payloads data are stored on board the payload computers and transmitted to ground. One of the two payload node/computer is in charge of formatting each of the payload data stream into a different virtual channel of a CCSDS frame. As for the avionics, the payload telemetry is sent directly to ground via an umbilical connection, during launch preparation, and via RF transmission by means of a dedicated RF transmitter and an antenna system in S-Band. This RF link is independent from the RF link of the avionics.
Payloads receive also some useful information from the OBC about the timeline (i.e. start and stop of microgravity) in order to coordinate their internal activity with the mission timeline.
All the nodes that have been described are different configuration of composing elements that are hardware, software or firmware. In terms of hardware, excluding the external casing (mechanical box), each node is made of two boards:

- The processing board that hosts the 'intelligence' of the node and all its interfaces toward the external world. This board has been designed by Seven Solution, upon GMV' specification and it is based on a Zynq System-on-Chip: XC7Z030.
- A daughter board dedicated to the analogue sensor conditioning and acquisition is connected to the processing board via an FMC connector. This board is designed and manufactured by GMV. Depending on the sensors distribution along the launcher, slightly different versions of this board are used to interface with a different set of sensors.

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The On Board Software of each node is organized according to the architecture presented in Figure 5, and it is encompassing only the elements that are necessary for the specific node.
The OBSW interfaces also with the firmware necessary for the Bus Communication (developed by Seven Solutions), the one used for the generation of the CCSDS frame (present only in the OBC and in one of the Payload Computer) and the firmware that is used for the management of the sensor conditioning and acquisition board.

Avionics bus Communication
Three different kind of traffic have been identified:

- Commands, High priority traffic to which a 10% Bandwidth is allocated
- Housekeeping, High priority traffic dedicated only to analogue sensors and House-keeping to which a 10% Bandwidth is allocated
- Video, Best Effort traffic to which is dedicated the residual bandwidth (80%)

Each kind of traffic has dedicated time slots in the bus, a problem in any of the kind of traffic cannot impact the others. The same profile is repeated every 5 ms, first millisecond is reserved for the command traffic, the second millisecond is dedicated to housekeeping traffic and the last 3 ms for video. All the nodes are synchronized with the gPTP protocol.

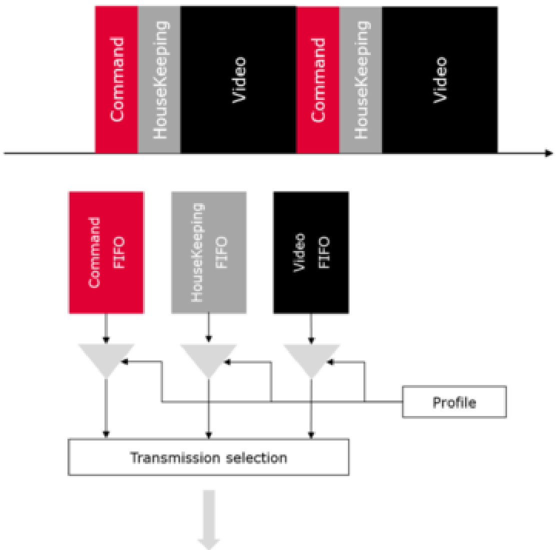

Figure 6: Bus Communication: Traffic Scheduling.

All packets in the network are tagged with a priority and a VLAN identifier. In case two kinds of traffic are enabled in the same time, the traffic with the highest priority is processed first. Traffic from a VLAN can be re-routed to the processor or to other IP cores following configuration rules. For example, if a TLM packet is received in the OBC, it is directly redirected to the TLM Engine to be transmitted to ground without intervention from the processor.
The VLAN identifiers are configured from the software at initialization.

2.5 Power System

The power subsystem of the avionics comprises all the elements that are required to provide the different loads of the launcher with electrical power in a reliable manner, as well as those which are required to store energy. Three different busses are used: main avionics bus dedicated to all avionics components; the Actuators bus dedicated to electromechanical actuators; the payload bus dedicated to power the payload experiments. Each bus, working at a nominal voltage of 28V is powered by an independent battery based on a commercial cell (COTS).
For each of the three busses, the Power Conditioning and Distribution Unit (PCDU):

- conditions and distributes power to the different loads;
- performs the switching between external power supplies and internal batteries upon external command sent via umbilical connection;
- performs On/off switching with soft start capabilities for each load in order to provide a fully controlled power on sequence;
- ensure protection against short-circuits in non-critical loads;

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– ensure house-keeping monitoring (Voltage and current measurements for the power buses and internal temperature measurement).

2.6 Flight Termination System

Flight Termination System (FTS) is introduced in the launch vehicle to limit the potential damage caused by a malfunction, over-performance, or unexpected event. This system terminates the flight of the vehicle either when is commanded by the range mission control officer or automatically by using 'fail-safe' logic, in case of lack of RF link with the ground station or lack of power supply.
As shown in Figure 7, the FTS system is fully redundant with the exception of the antennas systems and of the C-Band transponder. The FTS' architecture has been designed by PLD taking into account guidelines coming from the standard "Flight Termination System Commonality Standard" (Range Commanders Council 319-14), where it is adviced that 'single-fault tolerance shall be met using redundancy except for any passive component such as an antenna or radio frequency (RF) coupler'.
The C-Band Transponder (together with the C-Band antennas system) is devoted to reinforce the localization function carried out by the ground segment.
After a trade-off carried out by PLD, the termination method chosen for MIURA 1 corresponds to the elimination of the vehicle thrust by actuating five independent valves situated in different sections of the launch vehicle. Redundancy is taken into account also in the termination method because at least the actuation of one of the valves would be enough to achieve the termination action.
For the FTS system, GMV is in charge of the development and the integration of the common architecture while PLD Space, as Launcher Prime, stays in charge of the whole system including all safety aspects related to safety ground means and under control of ground segment. According to this, Flight Termination Receiver (including Fail-safe' logic approach) and Radar Transponder are also under PLD responsibility. Therefore they are also CFI from PLD (black boxes in Figure 7).
Moreover the FTS is completely segregated and independent from the avionics of MIURA 1. The only interface between FTS and MIURA 1 Avionics is due to housekeeping monitoring acquired by the data handling sub-system.
The common architecture devoted to termination will be placed in the avionics bay (Section S-09); while the localization architecture will be located in a lower section (S-07).
All redundant components will be mounted in different locations (in case of MIURA 1 this is meaning diametrically opposed as far as possible) in order to achieve a higher level of reliability of the system.

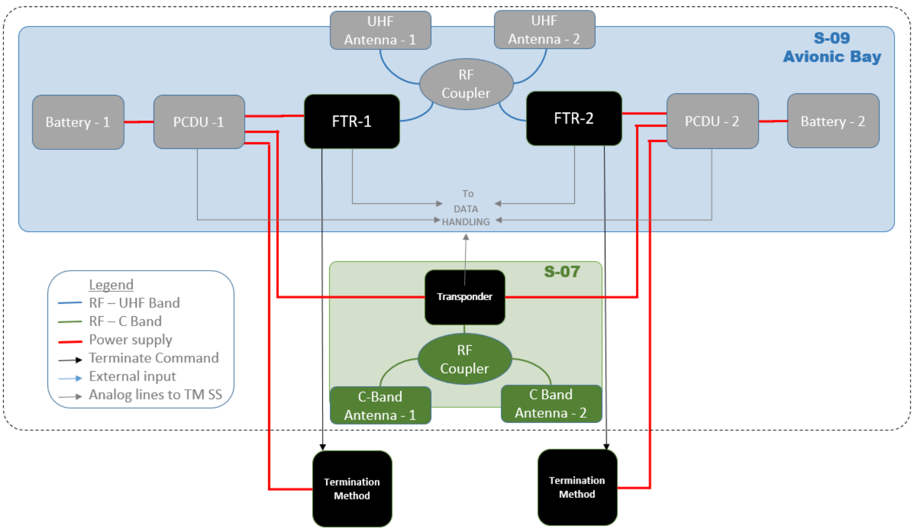

Figure 7: MIURA 1: Flight Termination System Architecture.

The power input to the two Flight Termination Receivers (FTRs) is also cross strapped (not shown in the picture). According to inputs provided by PLD, each FTR is already provided of two power inputs for power supply cross strapping.

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2.7 Antennas systems

All Antennas are designed and manufactured by Anteral, a Spanish company with offices in Pamplona.
MIURA 1 is equipped with three different sets of antennas:

- Telemetry and GNSS antennas (S Band and L Band)
- FTS antennas (UHF Band)
- Localization antennas (C Band)

The selection of the configuration of the antennas and how they are grouped has been part of a trade-off performed at the beginning of the projects having in mind the scalability to MIURA 5 configuration and taking into account how different needs (i.e. telemetry, localization,...) are usually distributed along a launcher wrt its typical mission and stages division.
Antennas have been also designed to be embedded in the launcher structure with the principal aim to minimize the criticality of the thermal environment due to the aerothermal fluxes.
Each antenna set is composed by two antennas, positioned in opposite side of the launcher in order to assure a uniform coverage along the roll plane. The Telemetry and GNSS antennas are located in the avionic bay section. They are part of the walls of the avionic bay. They are connected via a standard SMA connector to RF harness and hybrids to the two telemetry transmitters (one for the avionics and one for the payload) and to the GNSS receiver.
The FTS antennas are also positioned in the avionic bay section. They are tilted of 45º wrt Telemetry and GNSS antennas. They are connected via a standard SMA connector to RF harness and hybrids to the two redounded Flight Termination Receivers (Customer Furnished Item, CFI, Figure 8).
The antennas in C-Band that are used for the localization function are mounted in a lower section of MIURA 1. They are connected via a standard SMA connector to RF harness and hybrids to the Transponder (CFI from PLD, Figure 8).
All antennas are simulated in representative environment and simulations are validated with representative hardware.

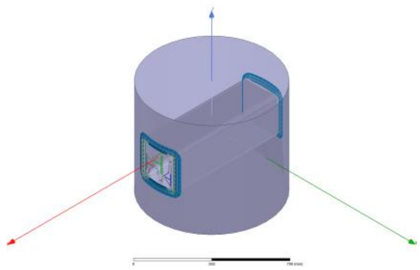

Figure 8: MIURA 1: Telemetry and GNSS Antennas.

2.8 Verification and Validation approach

The Verification and Validation approach is a fundamental step when qualifying the overall avionic systems. In this view we are defining an environment which assembles SW and HW components whose main purpose is to validate at system level the overall avionics of MIURA 1.
In particular the validation and verification activities, especially related (but not limited) with the OBSW are here addressed considering different and incremental tests facilities that are placed at GMV Headquarters in Tres Cantos.
According to mission phases and incremental specific verification and validation activities, this infrastructure integrates the following different configurations:

- *FES: Functional Engineering Simulator*

The Functional Engineering Simulator (FES) allows the verification of critical elements of a baseline system design (such as Sensors/Actuators, AOCS/GNC algorithms). The FES is generally used for concept definition, preliminary design, and GNC elements specification. The Mathworks suite is a well-established and de-facto standard for developing and executing simulation models, which make it the selected tool for the implementation of the Functional Simulator in most of the cases.
In line with this, capitalising GMV heritage from previous ESA projects (e.g AUTOCOGEC), a special attention has been paid to define modelling rules/guidelines (associated with the development in Matlab/Simulink) for later compatibility with the auto-coding tools and porting of the models to next level configurations.

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- *SVF: Software Validation Facility*

The Software Validation Facility (SVF) aims at the validation of the OBSW, which needs to be performed in a context that is representative of MIURA 1 and also considering the ground interfaces. The OBSW interacts with the vehicle system and surrounding environment as it evolves during the mission.
In the SVF this context is simulated, and contains a fully functional and performance representative simulation model of the vehicle hardware (using a real time computer) and its dynamic behaviour in space. The SVF configuration includes a physical OBC in the loop that runs the flight OBSW. This facility is dedicated to the validation of some of the avionics and its constituents at the level of the On-Board Computer (OBC).
This configuration is also used to validate the onboard GNC SW (it also sometime referred as GNC-PIL) when the GNC algorithms run on an OBC (e.g. a flight representative motherboard). The main activities are related with the GNC design, verification and validation in a real-time environment, and support to GNC flight operations.

- *ATB: Avionic Test Bench*

The Avionic Test Bench (ATB) supports the validation of the avionics and its constituents at unit level with representative sensors and actuators. In particular, the ATB is also used for the Assembly integration and testing of the avionics before the actual V&V. Almost all avionics equipment are included in this configuration with exclusion of the redundancies of the FTS.
The ATB configuration includes the use of HW in the loop with full real interfaces as sensors emulators to be acquired and sent via launcher telemetry and actuators (real or emulated) to be commanded. It is important to notice that the ATB facility is built in an incremental manner from the SVF by adding avionics components and needed test equipment for their stimulation.
The complete block diagram is given in Figure 9.

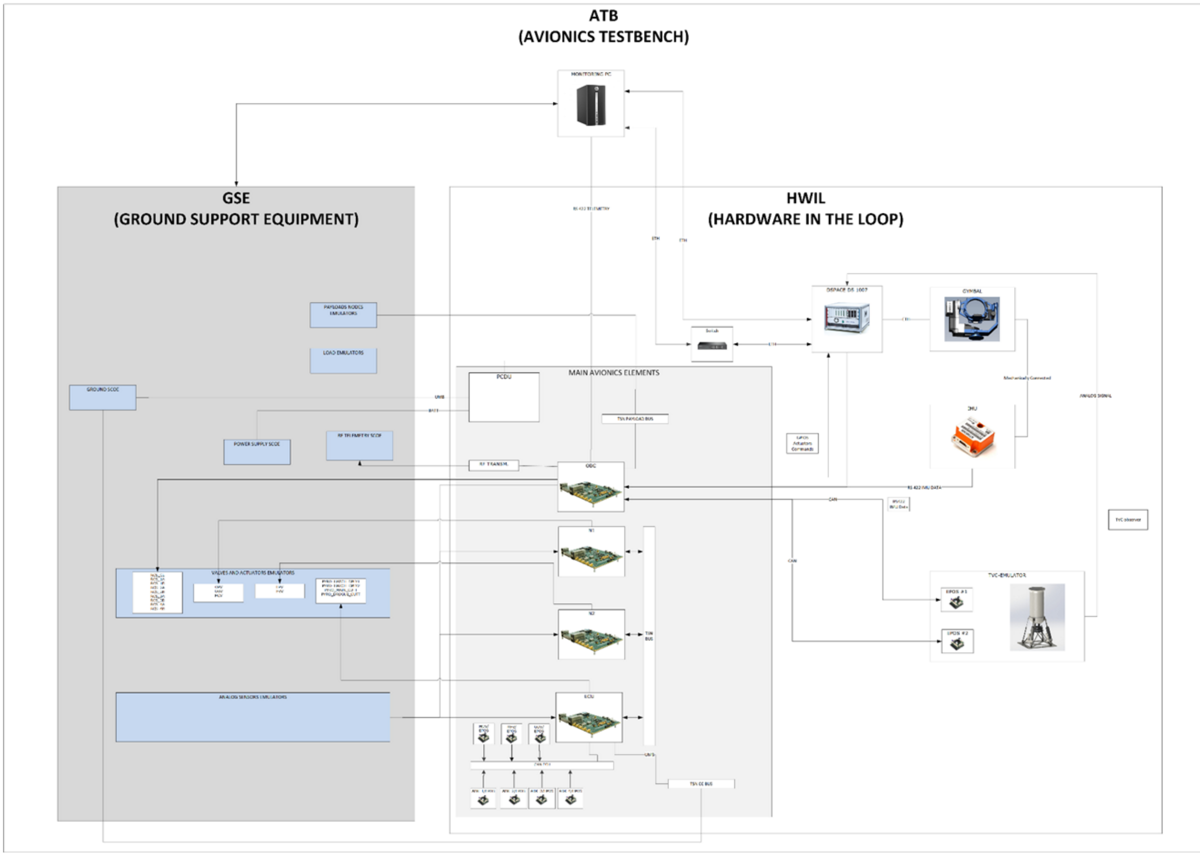

Figure 9: Avionic Test Bench block diagram.

This cascade instantiation of the facilities (required to qualify the avionics) counts on the auto-coding process that is largely used within this program.
The development of the space flight critical software is nominally performed following the SW lifecycle (e.g. V-cycle) that accounts for different phases according to the ECSS-E40 (Specification, Design, Implementation and Verification and Validation). This lifecycle is affected when model based-design is adopted and autocoding techniques are involved in the SW development. In fact an efficient way of producing SW (typically GNC) is to develop a simulator in the

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Matlab/Simulink environment following a model-based component approach exploiting the Matlab potentiality for algorithms modelling and validation. The models are then autocoded (by means of automatic techniques) and the production code generated is used and validated in real time test benches. The entire process of transforming a Matlab/Simulink model to optimized code components (C) ready to be embedded in a target HW or facility is performed according to a well-defined methodology.

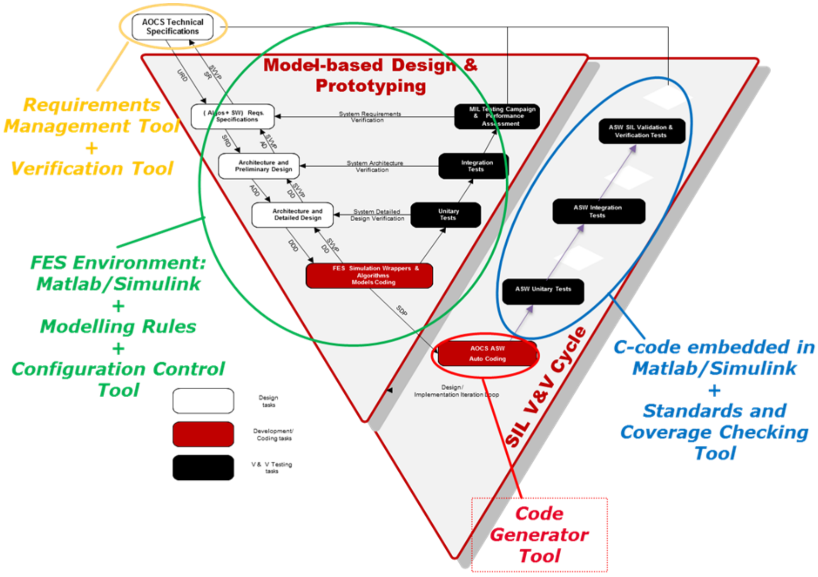

Figure 10: GNC SW Lifecycle Using Model-Based Design and Autocoding.

This approach allows fast design iterations and feedback and the possibility to correct design problems from the beginning of SW development minimizing the required effort.

3. Conclusion

An overview of the architecture of MIURA 1 has been described together with a description of the facilities that will be used for the verification and validation phase.
The Detailed Design is finished and some component are already under testing in different facilities at GMV or at Subcontractors' premises. Final integration and qualification of MIURA 1 avionics is foreseen by Q3 2019.

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References must be numbered in the text in the following style [3] and listed at the end of the paper in the following way.

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