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CALLISTO avionics overview: architecture principles, product development, validation, conditioning

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Abstract

The CALLISTO Vehicle is a flight demonstrator for future reusable launcher stages. The program involves three countries and their space organizations: CNES for France, DLR for Germany and JAXA for Japan. The first tests will be conducted in 2024 from the CSG, Europe's Spaceport for commercial launches. The challenge is to develop, all along the project, the skills of the partners. This know-how includes Products and Vehicle design, Ground Segment set up and post-flight operations for Vehicle recovery then reuse.

From Avionics standpoint, CALLISTO demonstration of a re-usable 1st stage launcher VTVL at small scale highlights specific and demanding needs such as:

- Navigation, with an accuracy performance vs. Vehicle velocity and location requiring a very stringent knowledge of real-time Vehicle states in order to be able to catch and compensate any errors through guidance and control, in particular during the landing phase;
- Telemetry and Telecommand covering the whole flight, including post-landing operations during which the Vehicle has to be put back to a safe state to enable access to staff for final operations ahead of Maintenance & Repair Operations themselves;
- Flight safety all along trajectory, from in-flight health assessment and monitoring to flight termination strategy which directly impacts avionics at system level;
- Robust management of avionics hardware environment inside the different Vehicle cavities in a wide variety of mission profiles and external conditions.

Avionics combine off-the-shelf products and devoted developments coming from the three Partners of the Project. It results in a decentralized Avionics architecture and different approaches in development management.
At system level, a dedicated hardware platform located at ArianeGroup premises (Les Mureaux - France) carries out unitary integration tests on each product along with chain and functional tests involving all equipment units.
This Avionics Validation Facility (AVF) contributes to system V&V and provides derisking and anomaly investigation possibilities.

In addition, a dedicated GN2 conditioning system is implemented to enable thermal (and chemical) environment management of avionics equipment units in pre-flight and post-landing phases.

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1. Introduction

The CALLISTO vehicle is a flight demonstrator for future reusable launcher stages. The program involves three countries and their space organizations: CNES for France, DLR for Germany and JAXA for Japan. The first tests will be conducted in 2024 from the CSG, Europe's Spaceport for commercial launches. The challenge is to develop, all along the project, the skills of the partners. This knowhow includes Products and Vehicle design, Ground Segment set up, and post-flight operations for Vehicle recovery then reuse.

Each Partner has its own heritage, work methods and expectations. To ease mutual understanding the project development is mainly based on a classical V model development cycle. To ensure system consistency, a dedicated team is responsible for system architecture definition and technical requirement specification while products or assembly of products (module) comply to these requirements during the design, verification and validation phases. Some products are developed either from scratch or reused or readapted from previous development or production whereas others are purely COTS to be validated under the conditions encountered during life phases of the program and especially during flights. To provide mutual confidence that the different development approaches will fit the Project objectives, some verification and validation data or method are shared by all 3 partners in the frame of a flight worthiness process.

As CALLISTO mission is ambitious, the vehicle has to manage many different flight phases such as take-off, boost phase, ballistic phase with low dynamic pressure, landing.
Consequently, the vehicle is equipped with many control systems to manage engine thrust vector control with the FCS/V controller, engine thrust throttling with the ECB controller, aerodynamic control with the FCS/A controller, reaction control with the FCS/R controller, landing system deployment with the ALS controller.

The controllers including the electronic power and command parts of each control device are located close to the related actuators to ensure sufficient dynamic control and to limit cable lengths in the vehicle. Avionic architecture of the vehicle is based on an Ethernet network enabling the communication between the different controllers and the OBC.

For the Assembly Integration and Tests (AIT) phases, each project partner procures avionics equipment units to be integrated in the different modules of the vehicle or directly in the vehicle at the final integration step for some of them. First steps of Integration will occur in Europe, then in Japan, then in French Guiana at CSG.

Before the flight product delivery, the same product configuration is submitted to the vehicle environment including the ability to perform several flights without replacement, which is a challenging objective for the COTS products. Vibration duration requirement has been defined accordingly to this objective.

In parallel of the product development, a dedicated avionics platform is set up in Europe at ArianeGroup les Mureaux premises in order to validate the communication between the avionics products connected to the network and the operations.

2. CNES sourced Avionics – development status

CNES is responsible for the telemetry products which include several Digital Acquisition Units (DAU), the Flight Data Recorder (FDR), the Ethernet switches, the S-band Transceiver and a set of antennae.

The Ethernet switches and DAU are COTS products provided by Safran Data Systems. A dedicated software customization is performed in order to configure the on board communication network along with a software development to cope with CCSDS standard for radiofrequency communication with the ground station through the on board S-band Transceiver and antennae.
Even if the switch and DAU have already been validated for other applications, environmental delta-qualification tests are currently being performed to cover the vibration spectrum and thermal specification of the product and assess the conformity to CALLISTO severe environmental requirements.

S-band transceiver is provided by Syrlinks, a long-standing partner of CNES. Syrlinks is a supplier of wireless and geolocation systems for harsh environments (Space, Defense, Save and Rescue). For CALLISTO, a specific FPGA is developed for data emission and acquisition in the required frequencies without interference trouble. Environmental tests of the product are also necessary.

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The Telemetry and GNSS antennae are provided by Anywaves, a CNES spin-off created in 2017. These antennae are based on COTS miniature antenna designed for CubeSats, with necessary complementary analysis and possible adaptation to the specific thermal, vibration environment, with dedicated supports for integration. Anywaves S-band TM/TC Antenna already has some flight heritage on EyeSat (launched in 2019).

S-band coupler and CNES OBC are purely COTS product purchased directly by CNES. Some risk reduction tests are necessary in order to get confidence that the products can sustain the vehicle environment. In particular, CNES OBC has been submitted to a complete hardware inspection of the component and quality assessment of the assembly before being tested under thermal, pressure and vibration tests.

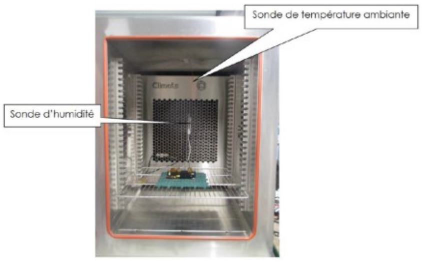

Figure 1: CNES OBC climatic tests

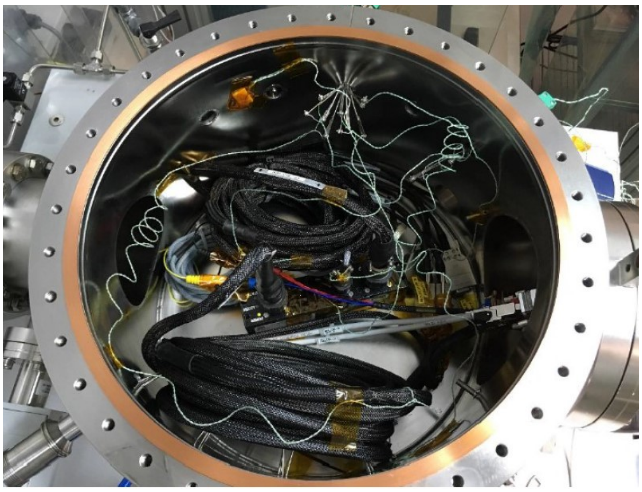

Figure 2: CNES OBC Pressure tests

Analysis and tests led to reinforce some areas in order to limit deformations or displacement of some components. After these limited modifications, CNES OBC has passed the vibration tests providing the greenlight to start software development and hardware procurement for more models.

CNES OBC software is developed by ArianeGroup Les Mureaux in order to benefit from previous development for Ariane and to gain experience for the future launcher programs to come. Regarding Guidance and Control algorithms (G&C) CNES and ArianeGroup have shared activities for the preliminary phase, concluded by a delivery to ArianeGroup of algorithms for specific flight phases.

CNES is also responsible for the FCS/R Controller, developed and provided by KN Systèmes. KN Systèmes (now part of SERMA Group) is specialized in embedded systems engineering. The role of the FCS/R Controller is to drive the electrical currents to open or close electrovalves in order to manage the in-flight thrust reaction control and also to isolate or open the propellant to the FCS/R tubing.
For this a software development is based on previous heritage from Research and Technology (R&T) led by CNES. A complete environmental qualification test is foreseen.

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Harness design, routing, manufacturing and integration along with general equipment lay-out of the VEB module is also a task under responsibility of CNES. Preliminary studies have alreay been conducted and final flight configuration will be finalized this year based on product definition feedbacks.

In addition, to fly and land safely in French Guiana and comply with French regulation, CALLISTO vehicle embeds a flight neutralization system under CNES responsibility. The avionics part of this system is provided by Thales Alenia Space Belgium in coordination with ESA program and CNES team. The neutralization system has the particularity to be located in different areas of the vehicle and involve a large number of products to be validated, delta-qualified for some of them and finally integrated in several parts of the vehicle.

Finally CNES is also in charge of avionics system architecture and ensures global consistency of avionics functions shared between equipment units, modules and therefore partners at Vehicle level.
This is in particular the case for the communication network over Ethernet for which CNES provides a set of design rules and implementation principles to enable communication between products from different sources located in different modules.
It also applies to electrical functions defined at Vehicle level such as grounding logic or electrical interfaces between modules.

3. DLR sourced Avionics – development status

DLR is responsible for the development of mainly four avionic items: The DLR/JAXA OBC, the Hybrid Navigation System (HNS), the controller for the aerodynamic flight control system (FCS/A) and the controller for the Approach and Landing System (ALS). In the following we will present shortly the state of some of these items in terms of design, manufacturing and verification.

The DLR/JAXA OBC is provided by DLR Institute of Space Systems in Bremen. It is based on a commercially available PCI/104-Express single board computer in a ruggedized housing, which is being used for other DLR missions as well. Due to the high environmental loads, especially the challenging vibration spectra, an extensive qualification program needs to be performed, since the COTS parts are tailored to industrial and avionic applications. During Phase B of the subsystem development, a prototype assembly of the OBC has been built and environmental pre-qualification tests with limited scope for assessing the capability of the COTS components to withstand the expected vibration and thermal-vacuum environments have been performed. The OBC has successfully passed all performed tests, whereas it has to be noted that the random vibration testing could only be performed up to 2 kHz so far due to constraints of available test facilities for the pre-compliance testing. The formal qualification is foreseen at the end of Phase C.

The HNS is developed under the lead of the DLR Institute of Space Systems in Bremen with major contributions coming from the GNSS Technology and Navigation Group of the German Space Operations Center (GSOC) at DLR's Facility for Space Operations and Astronaut Training with the design and development of a Differential GNSS (DGNSS) system and from the On-Board Software Systems Group of the Department of Software for Space Systems and Interactive Visualization at the DLR Institute for Software Technology with the design and development of the base software running on the On-Board Computers (OBC) of the HNS.

The HNS is designed as a standalone system providing the navigation function for the distributed GNC system, time reference and synchronization, as well as navigation for the correlation of experimental data. The central component is the HNS Box that contains a tetraxial IMU, the navigation on-board computing and data handling components, power distribution, GNSS receivers and auxiliary electronics. The internal electronics are a mix of COTS and custom design components. The HNS developed for CALLISTO is based on the HNS of DLR's Reusability Flight Experiment (ReFEx) with several adaptations to meet the demanding requirements imposed by the CALLISTO mission.
During Phase B, the system architecture development has been concluded and a preliminary design of the algorithms, hardware and software has been established. Most of the development for the internal electronics has been completed and the basics of the planned verification program have been extensively worked out. Phase B has been successfully concluded with the subsystem Preliminary Design Review (PDR) in August/September 2021. However, due to the high environmental loads, the HNS Box enclosure remains a main design challenge with respect to mechanical properties to ensure a proper internal environment, especially for the IMU and in terms of thermal performance. This issue could not be fully solved so far and will be treated with high priority in early Phase C.

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The FCS/A Controller is an in-house development of DLR Institute of Flight Systems in Braunschweig. The actuator control box houses the driver electronics for the four FCS/A Permanent Magnet Synchronous Machine (PMSM) actuators and their small unfolding actuators. To lower the peak currents on the 28V vehicle power bus an internal 48V power supply with DC-link capacitors is used. Communication with the vehicle is handled by an Ethernet gateway that takes care of mode management and control of the different power electronic components.

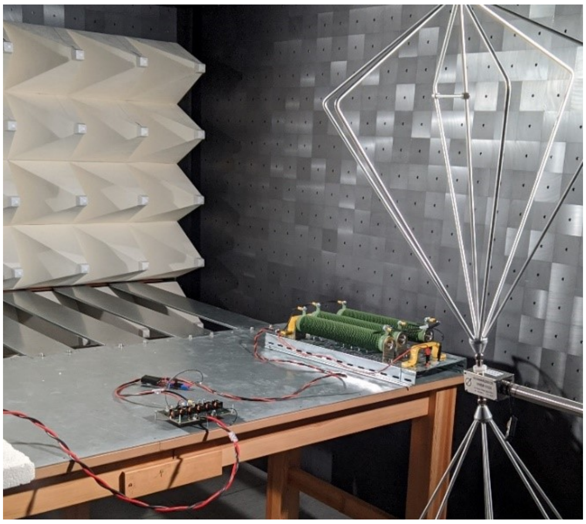

Figure 3: FCS/A controller power supply module during EMC pre-compliance testing

For all components prototype hardware has been manufactured and software for basic functions has been implemented. These functions include

- communication between the different electronic boards by CAN bus
- communication by Ethernet to interface the vehicle avionics
- analog and digital interfaces to the various sensors of the actuators
- motor control algorithms

Currently the different parts of the controller are undergoing first functional testing. As EMC is of major concern for the power electronic parts, preliminary testing has shown good compliance to CALLISTO requirements. The test setup for pre-compliance testing of the power supply module is shown in Fig. 3. Also, the large electrolytic capacitors have undergone some preliminary testing to show compliance against rapid de- and repressurization as outgassing and breakdown are known failure modes of such parts. However, no sign of degradation was observed after several life cycles.

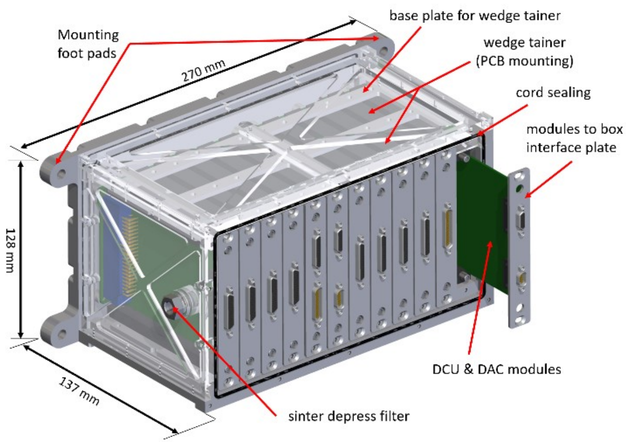

Figure 4: Overview of the ALS Common Electronic Box (Ebox). For clarity reasons, front plate and connector sealing gasket not shown. Design based on DLR MASCOT heritage featuring plug-in module cards and two backplanes.

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The ALS Controller is specifically designed for CALLISTO as an in-house development. It basically consists in two functionally separated equipment units in a single enclosure. These two are the Deployment Control Unit (DCU) in charge of actuator control and handling of operationally used telemetry and the Data Acquisition Central Unit (DAC) which acquires sensor data for performance analyses and health monitoring. Additionally, 4 removable Data Acquisition Landing Gear Units (DALs) serve as local data acquisition nodes, one on each landing leg. The DCU and DAC are integrated in a custom designed Common Electronic Box (Ebox) shown in Fig. 4. Whereas the DCU and Ebox are newly developed by the DLR Institute of Space Systems in Bremen, the data acquisition components will be provided by the DLR Institute of Aerodynamics and Flow Technology, Supersonic and Hypersonic Technology in Cologne and are based on flight proven equipment used for DLR MORABA sounding rockets (e.g. ROTEX-T, ATEK). At the time of writing, the Ebox and part of the internal electronics have been manufactured and functional verification is ongoing. Mechanical and thermal testing will start soon after.

4. JAXA sourced Avionics – development status

JAXA is responsible for developing following (sub) systems:

- Electric power: Batteries of LPS/HPS (Low/High Power System);
- Electric power distributer: PSDB (Power Source Distribution Box);
- Engine system controller hardware: ECB (Engine Control Box);
- Propellant supply System controller: PSC (Propulsion System Controller);
- Gimbaling System: FCS/V.

On CALLISTO vehicle, the key concept of JAXA electric (sub)system is to apply common/popular (COTS) electric technologies for less power consumptions, smaller/lighter hardware, shorter delivery and smart/flexible functionalities, instead of applying conservative technologies which is often the case for typical launch vehicles. Even with disadvantages of not applying heritage processes such as standards and certified components, JAXA is trying popular technologies believing this approach can be the main feature of future launch vehicle especially for reusable vehicle operation. All of JAXA electric system controllers are working with Linux OS on ARM processor. Hardware IOs works on GPIOs, SPIs, CAN bus and typical analogs through AD for any of effectors and sensors, aiming API programs to be common between each sub-systems even for different usage.

For reusable vehicle, we assume that the health (or tendency) analyses (inspections) play more important role than typical QT/AT processes because these conservative (and reliable) concepts are not practical for long life hardware such as reusable vehicle. We believe that acquiring huge data during flight dedicated for health analyses will provide QT/AT like mission assurance for next flight. All acquired data and system logs will be stored separately in each internal memory which is downloadable at aft-landing operations, thus the JAXA component will keep the in-flight vehicle network load to be minimum even with huge data. Any of the operation such as subsystem test, component test, sensor test, pre-flight check, post-landing check are all carried by plugging windows PC into the Vehicle Ethernet network.

5. ArianeGroup Avionics Validation Facility

ArianeGroup is in charge of providing the facility for full avionic integration and validation tests. Such a facility is mainly made of power supplies, simulators and measurement or observation means (oscilloscope, bus recorders, etc.). Lifecycle of such a platform can be summarized in four major phases. First, integration phase sees each avionic equipment unit being deployed on platform. Unitary tests are performed to ensure that communication of the equipment with test means is running properly for each involved interface. This includes of course Ethernet bus communication, but also some lower level interfaces such as digital and analog signals or CAN bus depending of specificities of each equipment.

Second phase consist in chain validation campaigns, where proper communication between all avionics equipment is verified. This is usually done by injecting a stimulus from one side of a functional chain and observing proper propagation and processing of this signal through one or several functional chains of the system.

Third phase consists in running closed-loop simulation. This step is especially important since it is the first time that the flight software running on its hardware target OBC is in interface with real hardware navigation system. Such a configuration needs advanced simulation models, able to compute representative dynamic behavior of the launcher based on commands sent by OBC towards the controllers. From results of this computation, corresponding navigation

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parameters are evaluated and forwarded to the navigation system hardware, so that flight software can receive consistent navigation information to feed its guidance algorithms.

Last use-case consists in anomalies investigation. When unexpected behavior of the system is observed before, during or after flight, the next step is generally to reproduce the anomaly on AVF, so that investigation and validation of the fix can be done in an efficient and safe environment before going back to production environment.

Real-time simulation is a major contributor of AVF functional scope. It allows to inject stimuli, to observe system behavior and react consistently when needed. Objective is in the end to host the system under test in an environment representative enough for the verifications to be performed. Models hosted by AVF simulation have been categorized in three types. First, a purely predictable (open-loop) stimulus generator, based on data table text files provided as simulation scenario. Such a model allows to inject precisely data on any of the system interface, making it ideal tool for integration and most of chains validation phases.
Second type of model has been called “stateful responder model”, where logic of what data is sent as output on each interface of the model (analog, digital, Ethernet, etc.) depends on model inner state and data observed from the system. Such a model is generally used when it would be too heavy to write a static open-loop model (time indexed data table feed) for each test case, or too hard to guess in advance exact chronology and values to be sent.

Last type of model has been defined as “closed-loop” simulation model and is related to all the models involved in simulation of flight dynamic. Such models are usually already implemented from numerical simulations and must be integrated in AVF real-time simulation framework. Such integration consists typically in connecting them with the real world, meaning injecting engineering values extracted from observed bus messages or digital and analog input signals and convert navigation engineering values generated as outputs into proper Ethernet messages towards flight software.

CALLISTO AVF platform faces also some specific challenges related to its particular context. First of all, real-time simulation is not centralized in a single software running on a single machine, but is rather distributed, where flight dynamic is computed on ArianeGroup real-time simulator, but evaluation of corresponding navigation parameters is performed on a separate real-time simulator provided by DLR. This might lead to challenges in terms of performance and synchronization between the system under test and the test means.

Second difficulty is to build such a platform with an AGILE approach. Such an adaptive project management is definitely an advantage since it allows to build a platform more suited to exact user needs as it grows and maturate. The drawback is that software developments and hardware components needed for such a platform (models, I/O boards, harness adaptors, etc.) need sometimes significant production delay (and cost), which makes development and procurement process more difficult to optimize.

Last point is that CALLISTO program will imply several teams from several countries working together on a platform hosting and running a launcher flight software, which is generally considered as a critical element in terms of export control regulation and industrial property. Significant work is thus needed to enforce processes and tools related to facility accessibility, data exchange and traceability.

6. GN2 conditioning system

Avionics system is supposed to face as much as 10 flights in a row with minimal Maintenance & Repair Operations in between. Beside mechanical loads, it has to sustain thermal loads, either cold or hot, at each flight. And, as explained earlier in this paper, some products are off-the-shelf or adapted from other applications and it is hardly possible to get them hardened vs. thermal loads. Moreover and according to Vehicle size, avionics is located in compartments that are quite tiny and then local atmosphere may be rapidly hot due to heat from outside and heat generated by avionics itself. Then, even during ground phases and Vehicle resting for hours at Lif-off Pad and Landinz Zone (after flight), avionics items may be rapidly pretty hot considering weather conditions in French Guiana, close to the equator line, and then exceeding operational limits. So along design iterations, it became rapidly obvious that a conditioning system should be activated at least for ground phases ahead (at Lift-off Pad) and after flight (at Landing Zone). Meantime, it was also decided to not develop a devoted active Thermal Control System for flight phases, motivation being to avoid extra development costs and an additional mass on board the Vehicle.

When connected to the Ground Segment Equipment ahead and after flight, CALLISTO vehicle compartments are flushed with GN2 as per figure 5. CALLISTO features 5 different compartments that are bounded with one another: the bottom volume, the Inter Tank Space, the Top Volume and the 2 cable ducts. The GN2 conditioning system on vehicule side is very simple: its is a pipe travelling from the bottom to the top of the vehicle and flushing each

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compartment via a nozzle. There are no active tuning devices on the vehicle to avoid unnecessary dry mass. The nozzle sizes have been determined so as to ensure the appropriate GN2 flow rate to each compartment.
Depending on the compartment, the flow rate need is either driven by thermal management or by maintaining a neutral dry GN2 atmosphere. In order to optimize thermal management capability, the inlet temperature of the GN2 can be set to any temperature between 6°C and 13°C thanks to a heat exchanger of Ground Segment. It is also possible to by-pass the heat exchanger and to flush with GN2 ambient temperature.

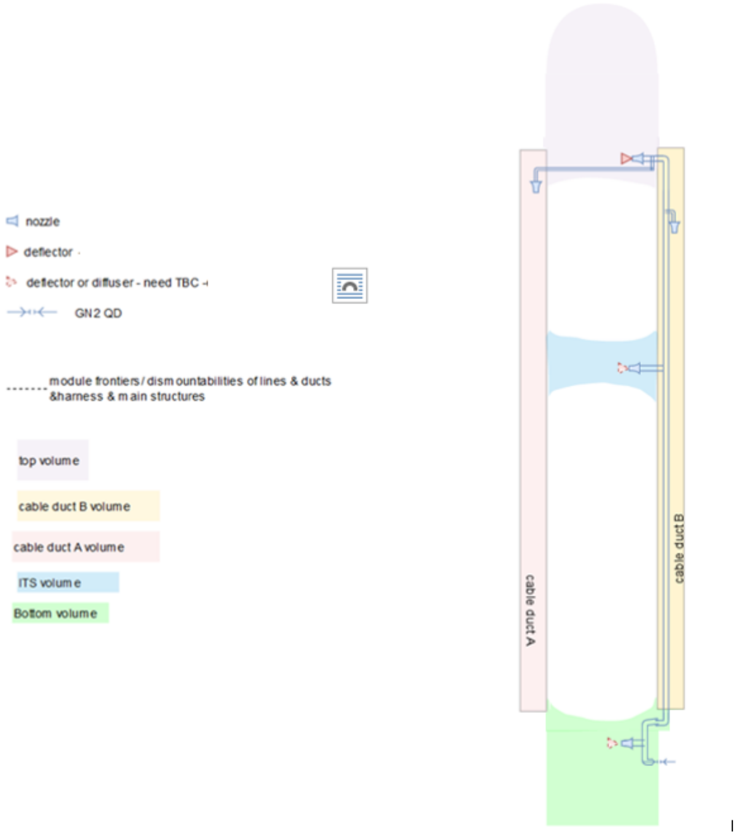

Figure 5: GN2 conditioning schematics – simplified view

In order to fine tune cooling capability at a given place and according to local lay-out, deflectors are designed based on CFD computations (see figure below).

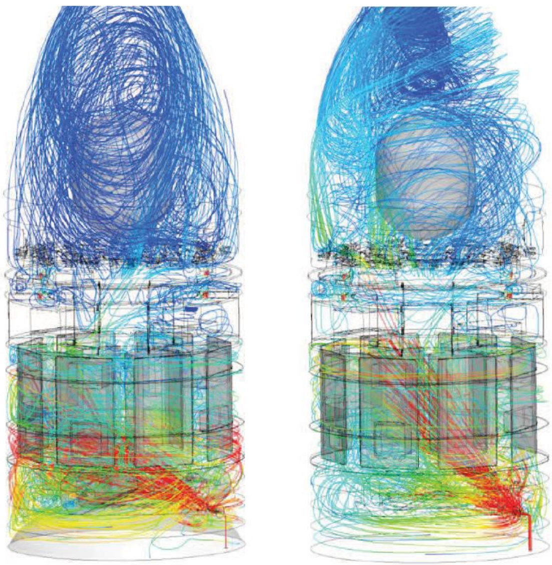

Figure 6: Streamline visualisation for different GN2 deflectors for top volume conditioning

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7. Conclusion

The avionics products embedded in the CALLISTO demonstrator vehicle have different levels of maturity and have to sustain the environmental conditions encountered during ground and flight phases with limited maintenance operations. Some products are specifically developed for this purpose, while some are reused from other use or are purely COTS. These avionics products will be tested all together in a dedicated Avionic Validation Facility. First integration campaigns have already been carried-out early 2022 and incremental integration process is on-going.
Activities related to avionics system architecture are also being conducting at the moment, with the contribution of all partners, in particular regarding the construction of numerical interface and data exchange between equipment units.
On top of that, to ensure that the avionics equipment will operate in a well controlled environment, analysis are on-going to adapt the GN2 conditioning system design with the thermal management needs.

8. Acronyms

ALS	Approach and Landing System
CNES	Centre National d'Etudes Spatiales
CCSDS	Consultative Committee for Space Data System
COTS	Commercial Off-The-Shelf
CSG	Centre Spatial Guyanais
DAU	Data Acquisition Unit
DLR	Deutsches Zentrum für Luft- und Raumfahrt
ECB	Engine Control Box
EMC	Electro-Magnetic Compatibility
ESA	European Space Agency
FCS/A	Flight Control System Aero
FCS/R	Flight Control System Reaction
FCS/V	Flight Control System Vector
FDR	Flight Data Recorder
FPGA	Field Programmable Gate Array
GNSS	Global Navigation Satellite Systems
GN2	Gaseous Nitrogen
HNS	Hybrid Navigation System
JAXA	Japan Aerospace Exploration Agency
OBC	On-Board Computer
PSDB	Power System Distribution Box
SDS	Safran Data Systems
VEB	Vehicle Equipment Bay
VTVL	Vertical Take-off Vertical Landing
V&V	Validation and Verification

References

[1] Ishimoto, S., Illig, M. and Dumont, E.: Development Status of CALLISTO, 33rd International Symposium on Space Technology and Science (ISTS), Oita, Japan, 2022-g-15, 2022.
[2] Dumont, E., Ishimoto, S., Illig, M. and Saito, Y.: CALLISTO: Current Status of the Development of Key Technologies for Reusable Launch Vehicles, 33rd International Symposium on Space Technology and Science (ISTS), Oita, Japan, 2022-g-13, 2022.
[3] Giagkozoglou Vincenzino, S. et al.: Development of Reusable Structures and Mechanisms for CALLISTO, 33rd International Symposium on Space Technology and Science (ISTS), Oita, Japan, 2022-g-14, 2022.
[4] Krummen, S., et al.: Towards a Reusable First Stage Demonstrator: CALLISTO – Technical Progresses & Challenges, 72nd International Astronautical Congress (IAC), Dubai, United Arab Emirates, IAC-21-D2.6.1, 2021.
[5] Guédron, S., et al.: CALLISTO DEMONSTRATOR: Focus on system aspects. 71th International Astronautical Congress (IAC), Dubai, IAC-20-D2.6.1, 2022.

DOI: 10.13009/EUCASS2022-7311

[6] Oswald, J., Kheng, K., Pineau, L., Bahu, J-M. Economic analysis of a semi reusable launcher for Europe, 71th International Astronautical Congress (IAC), Dubai, IAC-20-D2.2.4
[7] Dumont, E., et al.: CALLISTO: A Demonstrator for Reusable Launcher Key Technologies, Trans. JSASS Aerospace Tech. Japan, 19 (2021), pp. 106–115.
[8] Ishimoto, S., Tatiossian, P. and Dumont, E.: Overview of the CALLISTO Project, 32nd International Symposium on Space Technology and Science (ISTS), Fukui, Japan, 2019-o-1-05, 2019.
[9] Desmariaux, J., Bourgeois & al.: Design of CALLISTO Tilt and Re-entry flight sequences, 8th European Conference for Aeronautics and Space Sciences (EUCASS), 2019
[10] Frenoy, O., Hiraiwa, T.: Concept of Operations - CALLISTO demonstrator, 8th European Conference for Aeronautics and Space Sciences (EUCASS), 2019
[11] Tatiossian, P., Desmariaux, D., Garcia, M. CALLISTO Project, Reusable First Stage Rocket Demonstrator, 7th European Conference for Aeronautics and Space Sciences (EUCASS), 2017
[12] Dr. Baiocco, P., Louaas, E., Bourgeois, E., Bonnal, C., Bouilly, T. Reusable rocket stage experimental vehicle and demonstration. 67th International Astronautical Congress (IAC), Guadalajara, IAC-16-D2.6.6