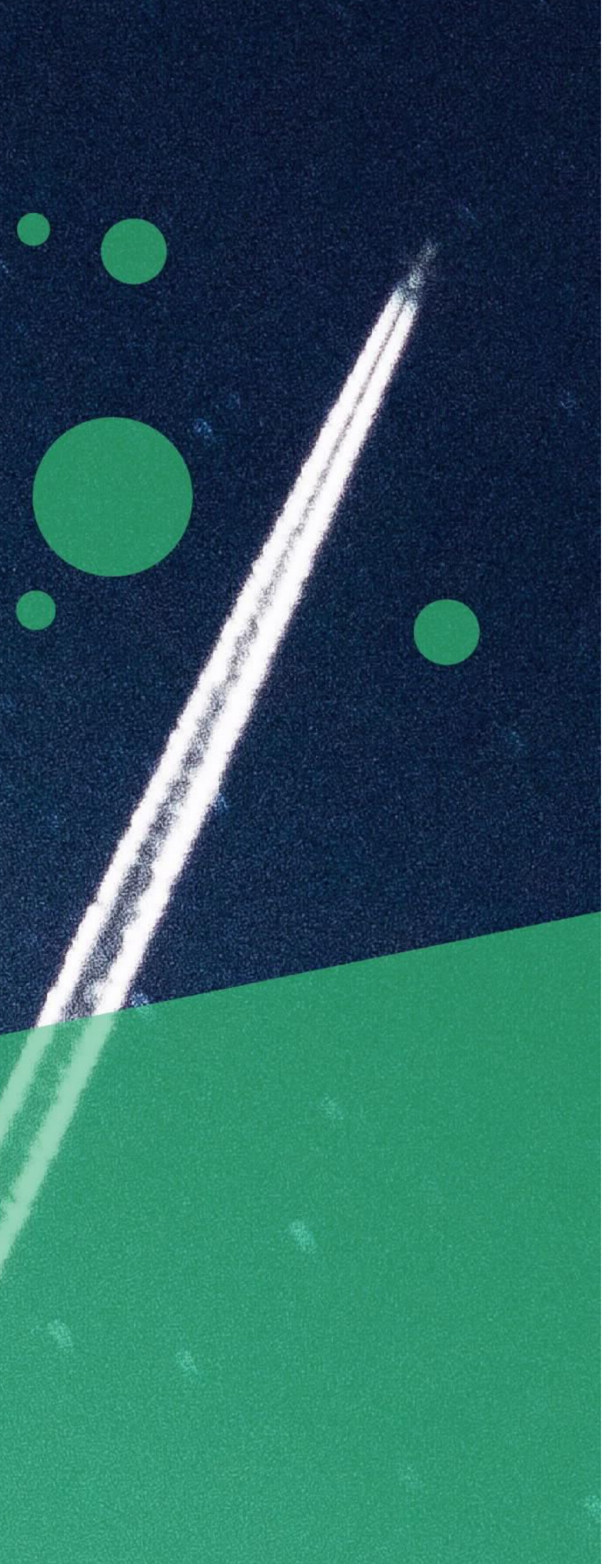

ENVOL

Project number: 870385

WP1 **D1.5: Executive Summary M24 (PDR1)**

Issue 2

WP Leader:	**Nammo**
Task Leader:	
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The ENVOL Consortium consists of:

NAMMO Raufoss SA (NAMMO)	Project Coordinator	Norway
CT Ingenierie (CT)	Beneficiary	France
GTD Sistemas de Información SA (GTD)	Beneficiary	Spain
SpaceTec Partners SPRL (STP)	Beneficiary	Belgium
Evonik Resource Efficency GMBH (EVO)	Beneficiary	Germany
Andoya Space Centre AS (ASC)	Beneficiary	Norway
ISIS – Innovative Solutions in Space BV (ISIS)	Beneficiary	Netherlands
GKN Aerospace Sweden AB (GKN)	Beneficiary	Sweden
Airborne Composites BV (ACB)	Beneficiary	Netherlands

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HISTORY OF CHANGES

Table 1: History of changes

Date	Version	Author	Change Description
21/01/2022	1	Kristian Lium	Report compiled
29/04/2022	1.1	Kristian Lium	The document is updated based on PDR1 RIDs and comments in the review report.

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Table 2: Acronyms and abbreviations

Acronym	Description
ACB	Airborne Composites BV
ASC	Andøya Space Centre
CAD	Computer-Aided Design
CFRP	Composite Fiber Reinforced Polymer
CONOPS	Concept of Operations
CRR	Customer Requirement Review
CT	CT Ingenierie
DoA	Description of Action
EC	European Committee
ENVOL	European Vertical Orbital Launcher
ERD	ENVOL Reference Design
EVO	Evonik Resource Efficency GMBH
FEP	Fluorinated ethylene propylene
FSW	Flight Software
GKN	GKN Aerospace Sweden AB
GNC	Guidance, Navigation and Control
GTD	GTD Sistemas de Información SA
H2O2	Hydrogen Peroxide (87.5 %)
HTPB	Hydroxyl-Terminated Polybutadiene
HW	Hardware
IDE	Implementation Development Environment
ISIS	Innovative Solutions in Space BV
LV	Launch Vehicle
MBSE	Model Based System Engineering
MoM	Minutes of Meeting
MPDA	Modular Payload Deployment Avionics
NAM	Nammo Raufoss AS
OBC	On-board Computer
PM	Person Months

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RACS	Roll and Attitude Control System
REA	Research Executive Agency
RTEMS	Real-Time Executive for Multiprocessor Systems
SDK	Software Development Kit
SRR	System Requirement Review
SSO	Sun-Synchronous Orbit
STP	SpaceTec Partners SPRL
SW	Software
TBC	To Be Confirmed
TPU	Turbo Pump Unit
TVC	Thrust Vector Control
WP	Work Package

LIST OF PUBLIC AVAILABLE DOCUMENTS

Deliverable Number	Deliverable Title
D1.4	Executive Summary Issue 1
D1.5	Executive Summary Issue 2 (This document)
D2.2	Website: https://envol-h2020.eu
D2.2	LinkedIn: envol-h2020/
D2.2	Twitter: @envol_H2020

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1 Summary of the ENVOL project progress at M24 – PDR1

The ENVOL is a Horizon 2020 project funded by the EU starting Feb 1st 2020 and will end 3 years later in Feb. 2023. ENVOL's main objective is to provide Europe its prime commercial, competitive and green launch service, utilizing a true New Space approach to offer low-cost, frequent and flexible access to space to small satellites in the range of 100 to 200 kg by 2024. The project started its actual work on starting date and the kick-off was arranged later in February at NAMMO's premises in Raufoss, Norway on Feb. 27th and 28th 2020. 9 industrial companies from 7 European countries are participating in the project and the total EC contribution is EUR 3,987,416. System Requirement Review (SRR at M12) was arranged at March 21st 2021 and Mid-Term Review (MTR at M18) at October 9th 2021, both reviews as a video conference.

The companies involved in ENVOL and that participated in the review are:

- NAMMO Raufoss AS (Coordinator), WP1, WP4 and WP7
- CT Ingenierie, WP5
- GTD Sistemas de Información SA, WP6
- SpaceTec Partners SPRL (STP), WP2 and WP3
- Evonik Resource Efficency GMBH, contributor to WP7
- ISIS – Innovative Solutions in Space BV, WP8
- GKN Aerospace Sweden AB, contributor to WP7
- Airborne Composites BV, contributor to WP7

The main outputs of ENVOL are:

- A detailed definition of an innovative and industrial low-cost European launch system
- A total of four ambitious launch vehicle demonstrators on the turbo-pump, tank and structures, launcher avionics and payload avionics, advancing the maturity of critical launcher technologies to ensure market readiness and competitiveness.
- A business plan grounded by industrial expertise, along with a development plan and the identification of the organization capable to attract investments and to ensure that the work performed in this project transforms into a commercial activity servicing the small satellite launch market in Europe and beyond.

The ENVOL project progress prior to Preliminary Design Review step 1 (PDR1 at M24) seen from the Consortium view is that we are on schedule with the development. For the deliverables some minor deviations exists, but hopefully this will be on track again at PDR1 or just after. The Consortium has now worked for 23 months, and the working environment and the collaboration between the Partners is very positive and has brought good new discussions and further development to the project. Also the MTR at M18 Review Report from EU/REA has been an inspiration and led to more focus in important areas of the ENVOL continuous development. Good efforts and enthusiasm has been showed during this short period since MTR and the preparations towards PDR1 is in good pace. The Partners activities and cooperation during numerous co-engineering meetings have been performed solely via telecons and video conferences due to the world wide Covid-19 pandemic travel limitations. So, despite the situation the partners have been able to work almost as planned to fulfil their obligations in the different Work Packages and contribute to the overall ENVOL Objectives. That said, the

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Consortium has more and more been aware that attracting investors to reach the tipping point of commercialization will need to be paid special attention. First flight by end of 2024 seems to be too optimistic knowing that the competition i.e. the larger RFA aims at development time to 1st launch will be 5-6 years at a cost of approx. M$ 100 and ISAR 180 M$. Given this, the ENVOL is working hard to attract investment in further development to be able to demonstrate the main UM2 hybrid engine to be used for stage 1 and 2. A new bi-liquid engine for the 3rd stage is introduced in order to meet the desired performance and needs time well beyond 2024 to be fully operational.

The plan for the first launch configuration is to develop a full hybrid solution, using an available hybrid motor in the third stage. This solution is not able to lift up the targeted payload, but will give valuable maturation experience for the complete launcher and shorten the time for the first maiden flight from 6 to 4 years. Next step is to develop the full capacity launcher, using the 6 kN motor in the third stage.

Examples of work that is performed since MTR (M18) and still in work is listed below, (details under each WP description in chapter 2, Description of the work done, results and forecasts):

- Project coordination, (financial reporting, assisting at document deliveries, chairing meetings, planning and follow up progress and document deliverables etc.)
- Andøya Space Port development is in good progress and the 1st out of 3 space pads are now under construction at their new space port on the South Western part of the Andøya Island. The launch pad capacity is designed for small launchers with payload of up to 1.5 T into Polar and Sun-Synchronous Orbits (SSO).
- Dissemination reporting, dissemination strategy and action planning for the various work packages. More effort is put into this WP to make ENVOL more visible in the market.
- Customer work-shop no. 2 (CW2) performed, and further market assessment and business model analysis work is performed before and after the 1st investor workshop aiming to improve ENVOL more attractive for investment.
- Established the High Level Requirements for the launch system, specification of the turbo-pump
- Launcher design, system engineering & analysis, propulsion system design, structures design and avionics.
- Ground support equipment modelling development and cost estimation work.
- Demonstrators further developed and HW/SW testing i.e. avionics, composite tank and turbo-pump
- Continued H_2O_2 compatibility testing and bonding tests of materials, and liners for the tank demonstrator finished.
- Further Payload development work on market research, requirements definition, concept definition and interface definition.

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2 DESCRIPTION OF THE WORK DONE, RESULTS AND FORECASTS

2.1 WP1 – PROJECT COORDINATION – NAMMO

2.1.1 Work done for the period and a brief description of the project results

As Coordinator Nammo has contributed to the project for the 2/3 of the project period mainly by follow up on progress based on the Consortium Agreement, the Objectives and managing progress meetings as well as arranging the main Milestones SRR, CRR and MTR. The coordinator work is seen as being a catalyst for all the other partners of the Consortium to maintain good development work and to have good progress within all WP's. The Coordinator is now focusing on the preparations and following up on the deliverables towards PDR1 (M24). The results from WP 1 is according to plan and in addition to the above, the 1st financial reporting has been performed. The work of keeping track and secure progress among all of the Partners has been done (as before) by performing the progress meeting based on WP leaders progress reports, achievements and how they have been engaged or arranged for co-engineering meetings across the Consortium. In addition every deliverable due dates have been reminded and kept track of to secure that work and results have been documented as expected and transferred.

2.2 WP2 – DISSEMINATION – SPACETEC PARTNERS

2.2.1 Work done for the period and a brief description of the project results

The Dissemination action plan ("Communication Strategy and Action Plan") has been pursued further and efforts have been made to inspire the Consortium to take more action to follow up on the ENVOL visibility to the Space community in Europe. This has resulted in acceptance of a paper for the IAC in Dubai, which was presented on the 28th of October 2021 in the session "D1.4B Space Systems Engineering - Methods, Processes and Tools (2)" with the title "ENVOL: Application of effective systems engineering methodologies within ENVOL — the European Newspace Vertical Orbital Launcher". Further representatives of the Consortium have participated in a Webcast aired on the 20th of July 2021 featuring the first manned flight of Blue Origin's New Shepard rocket.

As of November 2021, ENVOL is regularly providing project updates and insight articles on Twitter and Linked-In to reach out to any interested parties, be they space professionals and/or the general public. The upcoming messages have been assembled in a dedicated ENVOL Social Media Calendar.

As from before the Dissemination action plan identified the tone and the core objectives to guide each communication pieces, and has identified four key target audiences: NewSpace players, potential investors, the scientific community, and the general public and stakeholders. The characteristics of each audience type has been examined and we have developed a simple architecture to manage the way in which we communicate with these different groups. This includes distilling of the specific messages and communication channels that will be employed to reach each audience effectively.

The website has been given more information of the ENVOL status and can be reached via www.envol-h2020.eu

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2.3 WP3 – Commercial Opportunities – SpaceTec Partners

2.3.1 Work done for the period and a brief description of the project results

A thorough market assessment has been performed. To ensure that the ENVOL launch system is in line with what the market needs, several interviews have been performed and customer workshop 2 (CW2) has been successful to obtain even more information. The market assessment has been done earlier, and results have led to more precise market and trends overview. The analysis of the international and a European market includes an overview of the global space economy, the global satellite market outlook, space-launch industry and micro-launcher landscape. In addition, an assessment of the Total Addressable Market (TAM) for ENVOL shows a 10-year demand forecast, a comprehensive competitive analysis, preliminary pricing, and cost targets.

The customer workshop 2 had the goal to provide a more detailed description of the customer needs allowing to optimally align them with the launch system design. Still given the unforeseen impact of COVID-19, the planned 2nd customer workshop has been replaced by individual stakeholder interviews with potential customers and relevant stakeholders in the (New-)Space sector to gather the required information to assess the needs of potential customers to steer the system design in the right direction.

The work to build the business model and to attract investors to ENVOL for the future has been in progress but it is too early to tell what will be the result. Still more work to do and as the project is close to 2/3 of its development duration this is considered a high priority to be solved for the next year to come.

2.4 WP4 – Launch System – NAMMO

2.4.1 Work done for the period and a brief description of the project results

The main objective of this WP is to cover the definition of the complete launch system (launch vehicle, ground support equipment and payload systems) meeting the commercial feasibility criterion (mission, RC, NRC, time-to-market, potential for future evolutions).

This includes:

- The definition of the high level requirements for the launch system
- The coordination of all the interfaces between the technical WP related to the launch system, i.e. launch vehicle (WP5), ground system (WP6), propulsion maturation (WP7), payload interfaces (WP8)
- The cost assessment (recurring and non-recurring costs) and development plan of the launch system.

The activities in this WP is done in continuous dialog with WP3:

- Inputs
  - Heritage from past H2020 projects
  - Market needs assessment from WP3
- Outputs
  - High level requirements and general concept of operations
  - Cost assessment for the launch vehicle and the launch service
  - Development plan for the launch system
  - Launch system definition

The timeline for the ENVOL project and its milestones is on track when it comes to the High Level Requirements (HLR) and the Consept of Operation (CONOPS). HLR for ENVOL is defined based on the heritage from SMILE, WP3 and the experience from the development, manufacturing and successful launch of the Nammo hybrid

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rocket NUCLEUS utilizing the 1st generation of the UM1 hybrid engine from Nammo. The requirements identified focuses on minimizing the launch cost. These are linked to the creation of a simple launch system, with minimal ground infrastructures, interfaces and dedicated equipment, being able to guarantee at the same time responsive and flexible launch solutions. Moreover, the definition of the reference targeted mission (200 kg payload to 600 km SSO) has been essential for the definition of the launch vehicle design architecture and its continued work up to PDR1 (M24).

The objective (CONOPS) has been taking into account every aspect of the whole mission such as reference orbit, launch vehicle architecture and characteristics, environment to withstand, interfaces between the launch system subassemblies, operations to carry out, logistics etc. The low-cost and flexible launch system can be outlined as follows:

- Simple systems, simple steps, simple checks
- A small team can run the show
- Common equipment is sufficient
- Reducing the number of days on the pad
  - Fewer operations performed at the launch site
  - No payload work at the launch site
  - More robust and resilient launcher (can wait out any no-go's)
- No need for dedicated pad infrastructure

Below you can find the illustration explaining the flexible low cost launch system.

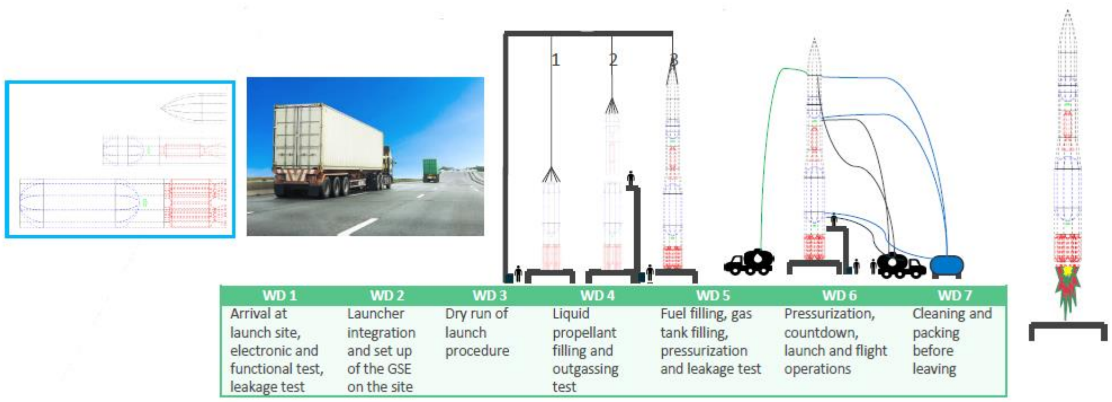

Figure 1: The flexible low cost launch system described for CONOPS

The objective recurring (RC), non-recurring (NRC) and operation costs are building the cost figure of the complete launch system to assess the profitability of the system in a competitive environment. All costs will be assessed. The task will consider both the first launch configuration and its future evolutions. The costs takes input regarding RC and NRC from WP5, WP6, WP7, WP8 and the output is used to consolidate the business model in WP3.

2.5 WP5 – Launch Vehicle - CT

2.5.1 Work done for the period and a brief description of the project results

The 5 subtasks of WP5 run in parallel and information exchange is done via co-engineering sessions and other meetings organized between partners. An online platform has been created in order to ease data and information exchanges.

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In the frame of CT's system engineering activities of WP5, the architecture of the launch vehicle (LV) has been defined. The Model Based System Engineering (MBSE) model developed for WP4 under the Capella tool has been used. The launch vehicle was modeled at physical level, i.e. definition and further development of the elements of the launcher. This modeling has been done down to equipment level, in order to show the different interfaces between different equipment, their location in the LV (via the CAD model) and to be able to draw budgets (mass, cost, power) and requirements allocation in future phases. The further developed architecture has been the baseline for the work on the LV elements.

2.5.1.1 Task 5.2 System Analysis, (Launch Vehicle)

CT has been devoted to the optimization of the ENVOL launch vehicle design since the beginning of the project. A 2nd optimization loop has taken place following Loop 1 at SRR (M12), i.e. Loop 2. ERD-2 (Envol Reference Design) is now the baseline for the LV design.

Loop 1:

Use of ALTAIR heritage to model the system behaviour:

- ALTAIR last Multiphysics Optimisation Process used
- ALTAIR set of hypotheses used:
  - Constructive Ratios to estimate inert masses
  - Aerodynamic coefficients
  - General architecture: Cluster + single motor
- Multiple iterations with NAMMO to converge to a set of HLR
- Definition of the optimal Operating Point w.r.t NAMMO's technology
- Overall Geometry and masses assessed
  - Number of motors / Fairing dimensions
  - Propellant needs / Constructive Ratio
- Estimation of design's performance Trajectory analysis
- Validation of constraints: acceleration, GLOM, minimal performance, orbit etc.
- Thousands of designs evaluated -> Convergence to an optimal design
  - ENVOL Reference Design 1 (ERD-1) established

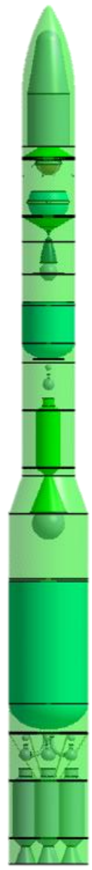

Figure 2: Aerostructure and Tank design lay-out at SRR (M12)

Loop 2:

Design consolidation:

- ERD-1 characteristics used as inputs by partners to design their sub-systems: TPu, FSW, Tanks, Payload avionics etc.
- Preliminary design for critical sub-systems
- Identification of "blocking points" -> Main deviation from mass targets
  - Structures and especially H_2O_2 Tanks
- Despite mass deviations, 200kg target @SSO600km still reachable

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  - Higher mass for structures
  - Lower mass for Avionics
- Structure mass deviations
- Important General loading acting on LV
  - High angle of att ack -> Important bending fo rces
  - Improvement of atmospheric model for trajectory
  - Refinement of LV Aerodynamic model -> Use of CPS_C© , CT in-house tool
- Technical Requirement Specifications established for all sub-systems
- Continuous improvement of sub-systems design
- New set of mass targets established
- Identification of external and internal interfaces

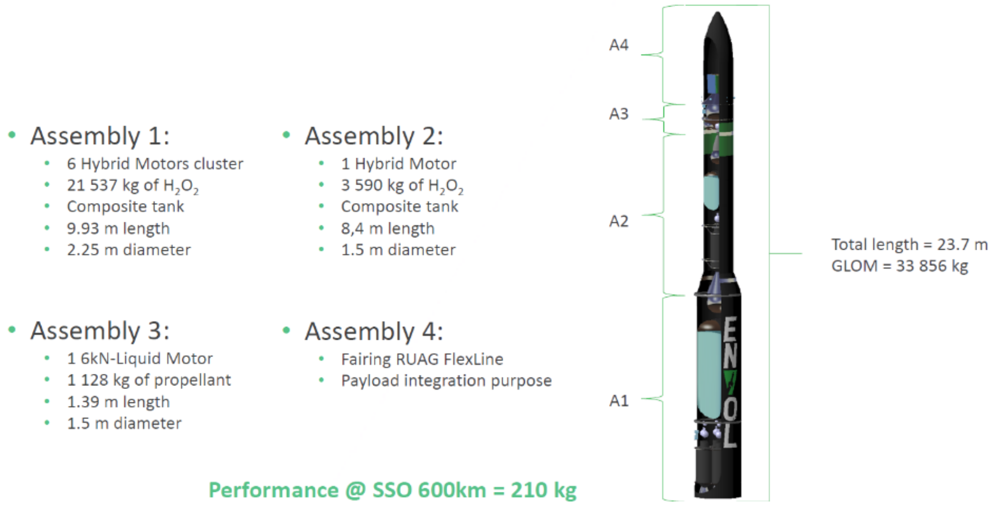

Figure 3: Aerostructure and Tank design lay-out at PDR1 (M24)

The resulting Mass Budget serves as baseline for the rest of the project. The values will obviously evolve with the detailed design of the different equipment, but the objective is to improve the range established at this point in Loop 3 to come for the next year of the project.

2.5.1.2 Task 5.3 Propulsion System Design

After having agreed on some baseline characteristics (e.g. thrust class, type of engines), during Nammo development a design of the hybrid motors has been completed. This design doesn't include yet the matured feed system whose development will be affected by the results of WP7. In parallel, some preliminary data on the liquid engine "Reliance" for the 3rd stage has been provided to allow the preliminary design of the launch vehicle in Task 5.2. Figure 4 below explains the optimum motor configurations for the ENVOL LV.

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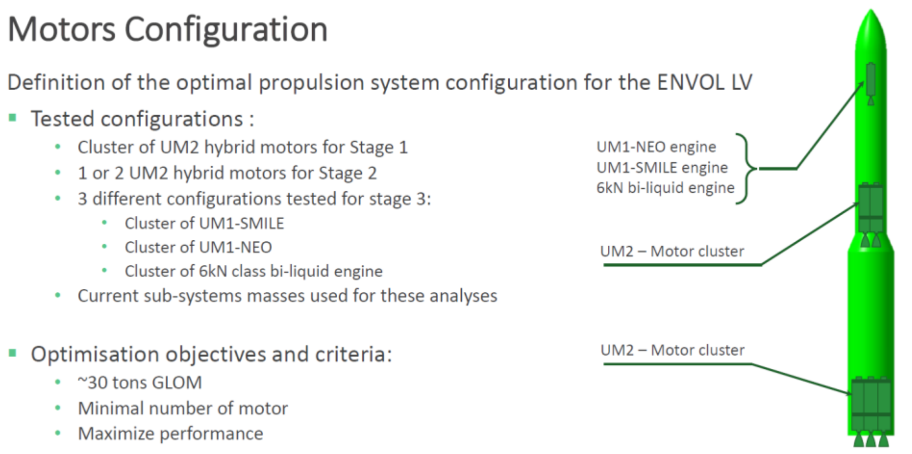

Figure 4: Motors configuration lay-out at PDR1 (M24)

2.5.1.3 Task 5.4 Structures Designs

The main activities concerning the structures design concern the development of the H2O2 tanks and the design of the 3 stages, also see Task 5.2. Defining the 3rd stage early in the project has been important as it allowed refining the LV design and has a huge impact on the LV performances. Every idea has been explored and some are still under evaluation. The ultimate goal is to free the maximum space for the payload and to minimize the length of the 3rd stage, to minimize its structures mass. The figures below explains the current status and main areas of the structures design.

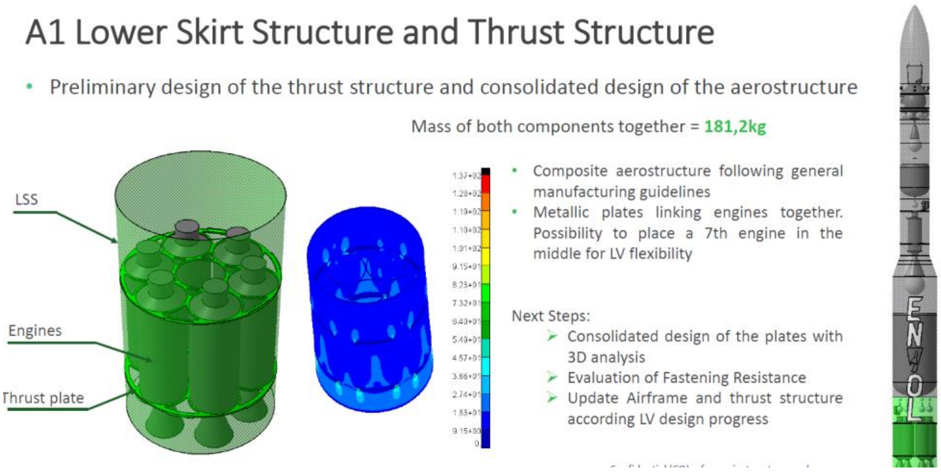

Figure 5: Lower skirt and Thrust structure (A1) at PDR1 (M24)

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Public

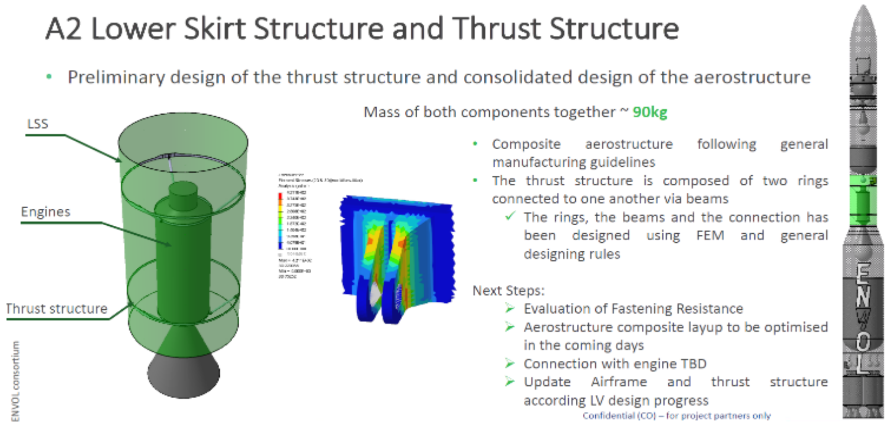

Figure 6: Lower skirt and Thrust structure (A2) at PDR1 (M24)

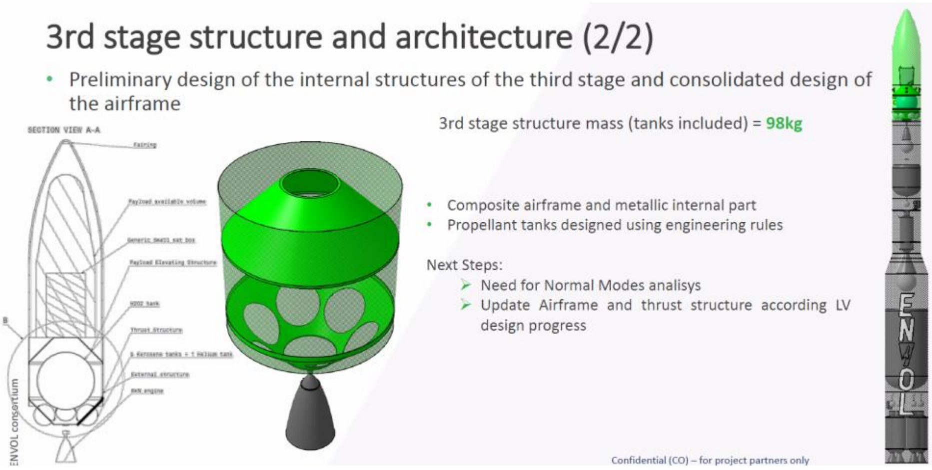

Figure 7: 3rd stage structure and lay-out (A3) at PDR1 (M24)

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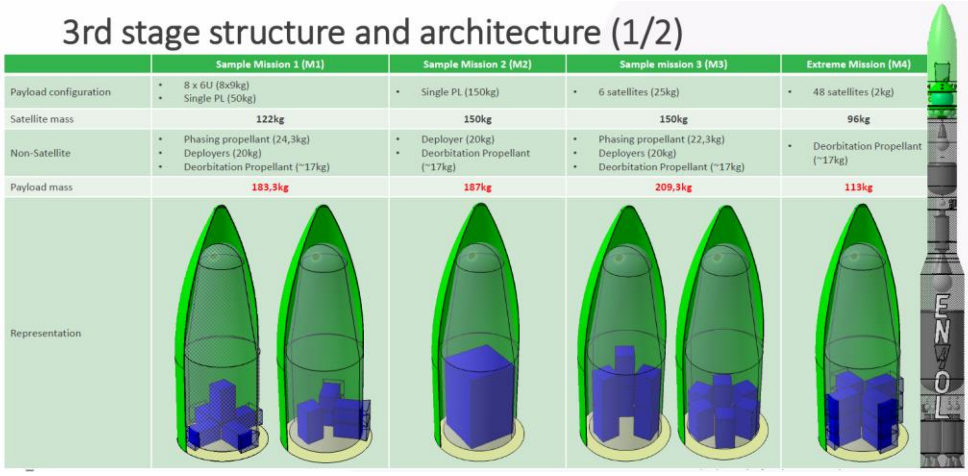

3rd stage structure and architecture (1/2)

	Sample Mission 1 (M1)	Sample Mission 2 (M2)	Sample mission 3 (M3)	Extreme Mission (M4)
Payload configuration	• 8 x 6U (8x9kg) • Single PL (50kg)	• Single PL (150kg)	• 6 satellites (25kg)	• 48 satellites (2kg)
Satellite mass	**122kg**	**150kg**	**150kg**	**96kg**
Non-Satellite	• Phasing propellant (24,3kg) • Deployers (20kg) • Deorbitation Propellant (~17kg)	• Deployer (20kg) • Deorbitation Propellant (~17kg)	• Phasing propellant (22,3kg) • Deployers (20kg) • Deorbitation Propellant (~17kg)	• Deorbitation Propellant (~17kg)
Payload mass	**183,3kg**	**187kg**	**209,3kg**	**113kg**
Representation				

Figure 8: 3rd stage pay-load structure and lay-out (A3) at PDR1 (M24)

The study carried out to establish the best solution for the cylindrical structures of the LV, between metallic, full composite and anisogrid/isogrid is at a preliminary stage still and the refinement will continue in the last phase of the project up to PDR 2 (M36). The result of the trade-off up to now is that full composite, even though it is not the best solution in terms of mass, is the preferred solution. Indeed, maturity and current means within the consortium (AA core activities) are much better for full composite components.

The H2O2 Oxidizer tank arcitecture is shown below. Every elements contributing to the feeding system are placed below the Oxidizer tank. Nevertheless, the pressurization system is place on top of the tank. Placing the tank there has a negative impact on the height of the stage and thus its mass, however, too few space was available between the engines and the tank to place a pressurization sphere. Keeping the pressurization system on top of the tank significantly reduces the complexity of the tank design as no holes are to be drilled in the composite weakening the structure. Moreover, the polar opening can be used for both interfaces with the feeding system and pressure system.

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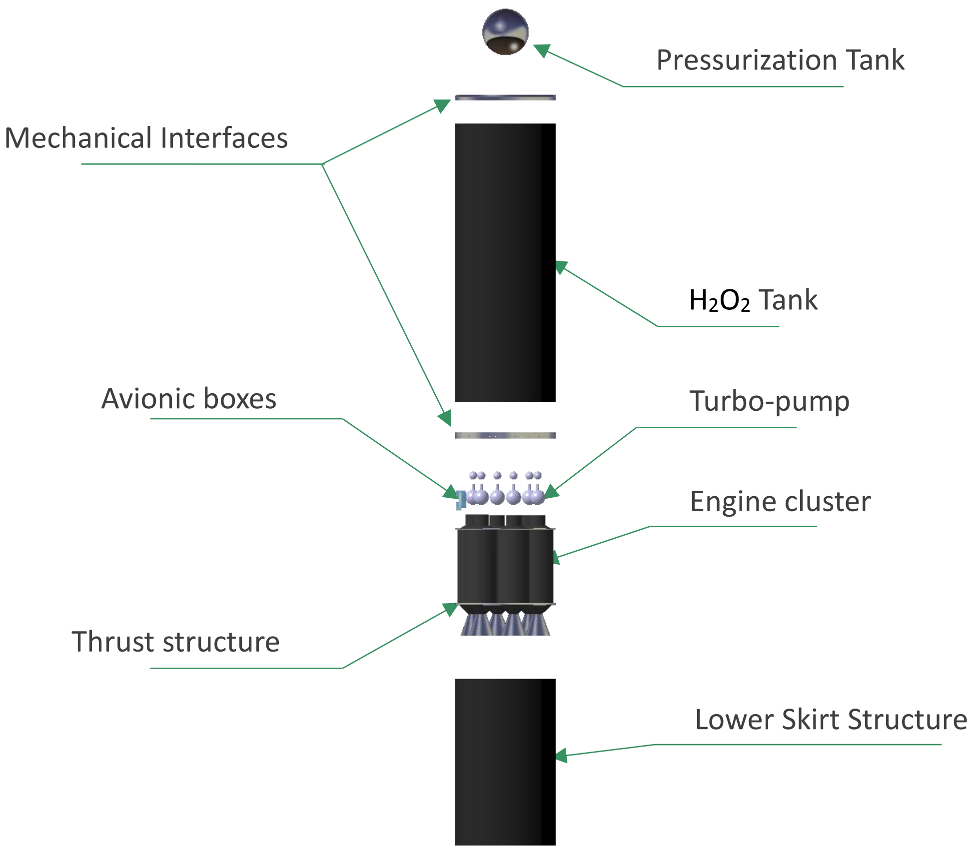

Figure 9: Stage architecture

Activities on the H2O2 tanks and the tank demonstrator for Stage 2 by end of 2021:

- Composite optimized design as a baseline implementing general manufacturing rules
- Composite material shows significant mass reduction over aluminum material
- Discussions and Trade-offs regarding tank design and manufacturing progress
- Agreement to freeze the technical requirements by the end of October 2021
  - Agreed to freeze the tank general design by the end of October 2021. Each modification done on the tank design should be investigated case-by-case to evaluate the impacts and the necessity of implementation on the tank demonstrator.
- As a result, the mass of the first stage tank is evaluated to 339,6kg. The mass of the second stage tank (demonstrator) calculated is 84,4kg. The mass is given without considering the H2O2 protection (thin aluminum liner).
- First manufacturing trials performed by end of 2021.

The life cycle phases identified are the following:

- Storage
- Transportation

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- Test
- Filling Draining
- Stand up on Launch Pad
- Utilization (in flight)

The TRS available for any partners and EC. This life cycle has been used to evaluate the different requirements the tanks must fulfil.

The General Load evaluation activities are crucial for task 5.4. Based on several activities performed at CT, general loading can be evaluating via fluxes on many sections of the launcher. General loads relies on trajectory data, aerodynamics of the LV, Center of gravity and masses of the components forming the LV and the geometry of the LV. It is the starting point for the structure sizing activities. It allows to size the different structures composing the LV and looping with CAD and LV design allows to reach a final configuration for ENVOL.

At PDR1, a consolidated design of the structure and more specifically the aerostructures and tanks is done. Optimizations were performed in order to reach an optimal design considering mass and cost. Indeed, the current design of the structures have been an input of discussion with Airborne to estimate the cost of their manufacturing. In addition, the impact of this manufacturing on the structural strength of the structure have been evaluated and guidelines have been set.

2.5.1.4 Task 5.5 Avionics

The Flight Software (FSW) development and design are well on track and detailed design, testing and design validation has been performed.

The objectives for the FSW are:

- To develop a FSW demonstrator focused on the Guidance and Navigation Control (GNC), Flight Manager (FM) and Safety algorithms.
- Contribution to the launcher design demonstrating its controllability and mission safety.

This has been achieved by:

- Establishing the Software Validation Facility (SVF) design and implementation.
- Perform FSW design and implementation (LN1/LN2) to execute in PIL environment.
- Developing the Flight Manager and Safety algorithms design and implementation (LN3).
- Defining Guidance, Navigation and Control algorithms design and implementation (LN3).

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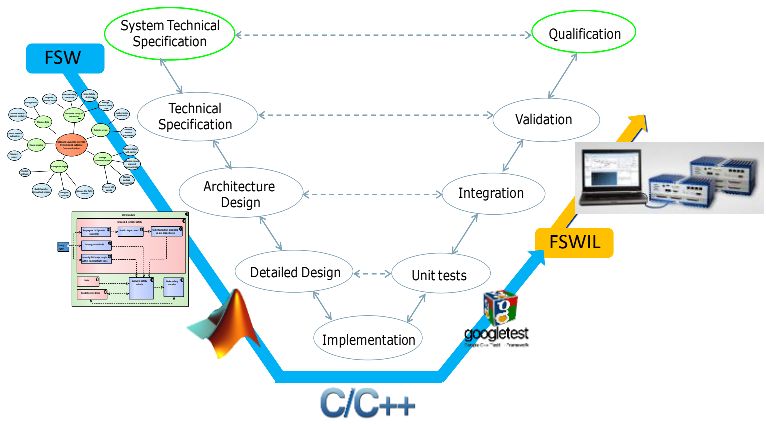

Figure 10: Flight Software design process

The results from the testing and validation listed above has contributed to the launcher design demonstrating its controllability.

2.6 WP6 – Ground Support Equipment – GTD

2.6.1 Work done for the period and a brief description of the project results

2.6.1.1 Modelling approach

MBSE methodologies are based on the axes: tool/language/method. The method itself concerns the formalisms and concepts applied to the modelling (interfaces definition, components, relationships between components, how to define information flows, ground operations etc.)

That modelling method being aligned and able to reflect:

- the project needs
- the system framework
- the partners requirements

In that sense, interfaces with the MBSE method and tool used at CT for the launcher are assessed in co-engineering sessions with good results.

Modelling method:

- SysML based
- CMMI procedure
- CAPELLA/ARCADIA

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2.7 WP7 – Propulsion Demonstrators – NAMMO

2.7.1 Work done for the period and a brief description of the project results

Task 7.1-Composite structure demonstrator CT and AA

See Task 5.4 Structures Designs

Task 7.2-Turbo-pump development GKN

In agreement with the preliminary UM2 hybrid engine design a set of requirements necessary for the design of the turbo-pump system has been identified. This led the technical specification for the pump demonstrator linked to the design and also the test rig. From the development and design process at this stage it can be outlined as described below.

Main technologies to be demonstrated:

- Hydrodynamic design of turbo-pump
- Design for axial load balancing of pump
- Mechanical design of pump components (inducer, impeller, pump case)
- H2O2 material compatibility

Limitation to be highlighted:

- Pump demonstrator will be a rig design
- Analytical verification in:
- One nominal design point (mid-values of range for mass flow and pump head)
- With throttling (+/-10% of mass flow)

The concept of the purchased base of the pump demonstrator is explained below and is now under construction for the test to be performed later in 2022.

Modify a COTS pump hardware with new design of:

- Inducer
- Impeller
- Volute

Pump type is a high power pump comprising:

- A gearbox to increase the rotational speed
- A pump unit

The COTS pump fulfills the demonstrator requirements wrt:

- Rotational speed of pump shaft
- It is a one-stage radial pump
- Shaft power
- Material compatibility of wetted components(Will be confirmed by material compatibility tests of selected materials)

See Figure 11 and Figure 12 below for more details of COTS and the GKN design and manufactured parts.

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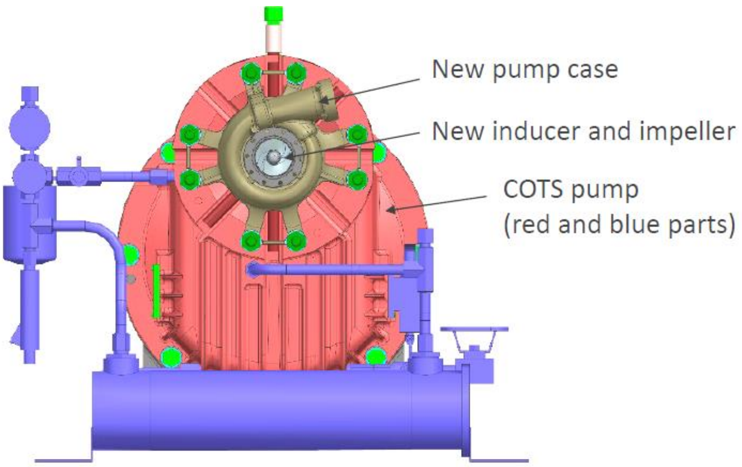

Figure 11: Turbo-pump demonstrator showing COTS and parts designed and manufactured by GKN

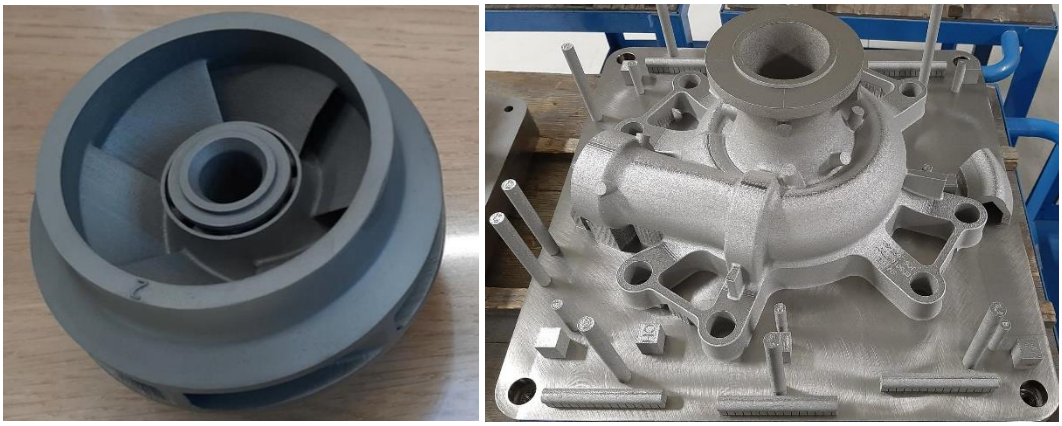

Figure 12: Turbo-pump demonstrator showing parts designed and manufactured by GKN

Task 7.3-Hydrogen Peroxide Compatibility EVO

Existing H2O2 compatibility classification standards have been studied and a test procedure has been identified for use in ENVOL and for future selection of materials as well. Different materials have been tested from the list of those of most interest for the project. A selection of materials with very good compatibility has been done to fit the H2O2 compatibility for the components (HW demonstrators) in contact with H2O2 for further use in the project.

2.8 WP8 – Payload – ISIS

2.8.1 Work done for the period and a brief description of the project results

Within WP8, the following status of work has resulted in the main concept definition, interface definition, preliminary design of the MPDA as well as further development of the customer service model and the

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missionization process. The MPDA is programmed with a deployment sequence to send signal to the deployment systems. After deployment, the MDPA can gather confirmation signals that go to the LV avionics via a telemetry (TLM) harness, se figure below.

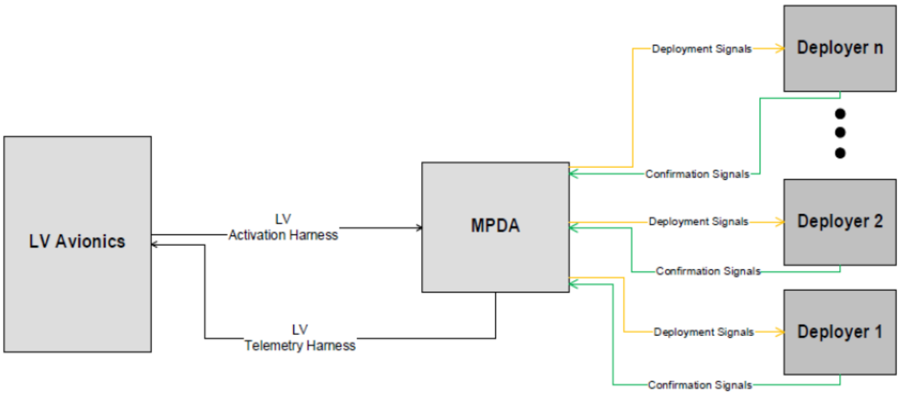

Figure 13: MPDA/LV avionics communication and deployment signals lay-out

The design concept is to decouple the design and operation of the main launcher from the diverse deployment systems and payloads that come with different requirements.

Four modules are foreseen initially:

1. Battery module (BM) – Housing the batteries which supply power to the system.
2. LV Command module (LCM)
   - Interfacing to EGSE/Launch Vehicle.
   - Power switches and all activation signals
3. LV Telemetry module (LTM) – Interfacing to the launch vehicle and EGSE (combined telemetry feedback from deployment systems).
4. Deployer interface module (DIM) – Interfacing to the deployment systems.

The Battery Module is formed by one or several ISIS standard battery packs and a mechanical enclosure. The LCM houses interface to the system battery, the LV command connector, the stack connector(s) and the external service connector(s). For the LCM the building of the prototype is almost completed and will be followed by testing and qualification in 2022. The LTM gathers information of system power state from LCM and each of the attached DIM and it provides status feedback to the LV avionics. The design and the mechanical enclosure are completed and testing and qualification will be performed later in 2022. The DIM has redundant interface in terms of commanding (opening) as well as telemetry status monitoring for deployer ports. The deployment pulse signal characteristics can be adapted to the requirements of a broad range of COTS deployment systems. The design of DIM is completed as well as the mechanical enclosure and the PCB. The prototype is now under construction and the testing and qualification will take place later in 2022.

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