UNICO I+D Project
6G-INTEGRATION-4

E15-6G-INTEGRATION-4

Critical 5G comms POD design

Abstract

This deliverable includes the preliminary design for a dedicated POD that will house the 5G and 6G systems, including the equipment necessary for their operation, especially power supply and environmental control systems. This design will be the first step for the design of a functional POD, focusing on the envelope and interior spaces, but without going into the details of the internal systems or communication interfaces with the rest of the aircraft on which it will be embarked.

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List of Acronyms

5G: Fifth Generation (of wireless technology)

6G: Sixth Generation (of wireless technology)

AAS: Active Antenna System

AIR: Antenna Integrated Radio

CATIA: Computer-Aided Three-Dimensional Interactive Application (software)

CFD: Computational Fluid Dynamics

CPRI: Common Public Radio Interface

DC: Direct Current

ECS: Environmental Control System

eCPRI: enhanced Common Public Radio Interface

FEM: Finite Element Method (analysis, implied from "Structural Analysis")

HAPS: High-Altitude Platform Station

LTE: Long-Term Evolution

MU-MIMO: Multi-User Multiple-Input Multiple-Output

NACA: National Advisory Committee for Aeronautics

NR: New Radio

POD: Payload/Pod (referring to the external module)

RAM: Ram Air

RAN: Radio Access Network

SF: Safety Factor

TDD: Time Division Duplex

TR: Transceiver

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Executive Summary

This deliverable provides a preliminary design for a POD, specifically engineered to integrate 5G and 6G telecommunications systems onboard High-Altitude Platform Station (HAPS) aircraft.

The POD design ensures the effective integration of antennas, power supplies, and environmental control systems (ECS). Aerodynamic considerations play a crucial role in the POD's design. The streamlined geometry minimizes drag and ensures stable integration on the aircraft's wing. The ECS adopts an air-cooling system with both free and forced convection mechanisms. Inlet and outlet nozzles maintain optimal internal temperatures, ensuring reliable operation of the integrated systems under various flight conditions.

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1. Introduction

The growing demand for ubiquitous, high-speed connectivity has driven the development of next-generation communication technologies, such as 5G and 6G. However, the deployment of these technologies in remote or hard-to-reach areas poses significant logistical and technical challenges.

This paper presents the conceptual design of an aeronautical POD, an external module designed to integrate 5G and 6G telecommunications equipment. The POD efficiently integrates antenna systems, power supplies, and environmental control systems, ensuring optimal equipment performance during in-flight operation.

The pre-design of the POD is based on conceptual 3D models, which allow visualizing and optimizing the layout of the components. Simulations have been performed to evaluate the power consumption simulations to properly size the power supplies and optimize the energy efficiency of the system.

This paper presents the conceptual design of the aeronautical POD, including equipment layout and ventilation systems adapted to flight conditions. The objective is to provide a solid basis for the development of a definitive design that can be integrated into the complete design of a HAPS aircraft, thus contributing to the expansion of next-generation communication networks in remote or hard-to-reach locations.

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2. 5G&6G POD design

The design of the specific POD to house the 5G and 6G systems will be based on the study of the different components to be shipped. This design seeks the integration of all the equipment in a compact format, which also allows adequate thermal dissipation and control of the integrated systems.

This POD will be designed so that the housed antennas can emit the signal without any problem. For this purpose, a section of the POD fuselage shall be covered by a surface permeable to the emission frequency. This material does not fall within the design scope of the POD, therefore only the geometry of this part will be designed.

Likewise, in order to perform the preliminary design, use is made of commercial 5G signal emitting equipment, which will serve as a sizer of the space and thermal dissipation requirements of this container.

For the ECS (Environmental Control System) study, we will start from an air cooling approach, visualizing the needs between free and forced convection systems.

2.1. Definition on aeronautical profile for 5G&6G POD

The external profile of the POD is meticulously designed to achieve optimal aerodynamic performance. A primary objective is to minimize drag during flight, thereby ensuring no detrimental impact on the carrying aircraft's overall efficiency.

The POD features an elongated form, characterized by a constant rectangular cross-section along the majority of its length. This core shape is complemented by carefully contoured forward and aft ends. This specific geometry is engineered to promote laminar airflow and mitigate boundary layer separation under typical operational conditions.

The selection of this profile considers the aircraft's target cruise speed, ensuring efficient integration into the overall aerodynamic envelope. A critical balance has been established between maximizing aerodynamic efficiency and providing the necessary internal volume to effectively house the 5G/6G equipment.

Given the POD's intended underwing mounting location, its profile has been precisely refined. This ensures seamless integration with the aircraft's wing airflow, specifically minimizing any detrimental aerodynamic interference that could arise from its positioning.

This defined aerodynamic profile directly influences the POD's structural design. Furthermore, an efficient aerodynamic shape not only reduces overall drag but also minimizes flow-induced turbulence and dynamic loads. This, in turn, lessens vibratory stresses on the internal structure, contributing to improved fatigue life and overall structural durability.

The integration of critical features such as the NACA inlet and the cooling system's outlet grille necessitates careful structural reinforcement around these apertures to maintain the POD's overall integrity and load-carrying capability. Additionally, the chosen constant cross-section contributes significantly to the POD's inherent torsional and bending stiffness, which is crucial for

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maintaining its form under flight loads and ensuring compatibility with the aircraft's performance envelopes.

2.2. Operation conditions

Altitude of 0 Meters (Summer Scenario with High Temperatures):

- **Atmospheric Pressure:** Approximately 101,325 Pa (1.01 bar). This is the standard atmospheric pressure at sea level.
- **Temperature:** 40-45°C.
- **Air Density:** At 45°C, the air density is approximately 1.109 kg/m³.
- On a hot and humid day, especially in coastal or tropical areas, the relative humidity could range between 60% and 90%.
- In arid or desert regions, the relative humidity could be much lower, even below 30%.

Altitude of 20,000 Meters:

- **Atmospheric Pressure:** Approximately 5,500 Pa (0.055 bar).
- **Temperature:** Approximately -56.5°C.
- **Air Density:** Approximately 0.089 kg/m³.
- At this altitude, the atmosphere is extremely dry. The relative humidity is very low, close to 0%. The air contains very little water vapor.

2.3. 5G&6G integrated equipment

The first step in defining the sizing is to outline the equipment that needs to be integrated into the POD design. The following components are proposed for this purpose:

- **Baseband 6648:** Baseband 6648 provides switching, traffic management, timing, baseband processing, and radio interfacing. The baseband unit is in the 19-inch format, with 12 Common Public Radio Interface (CPRI or eCPRI) ports, enabling increased connectivity for radio units.
- **Antenna Integrated Radio 3227 (AIR 3227):** AIR 3227 is a 32TR TDD AAS for LTE and NR, operating as standalone or as mixed mode. The AIR unit has beamforming and MU-MIMO technology, capable of fully utilize radio resources in both azimuth and elevation.
    - The main benefits compared to previous macro solutions are improvements in:
        - Enhanced coverage - High gain adaptive beamforming
        - Enhanced capacity - High-order spatial multiplexing and multi-user MIMO
        - Advanced RAN features - Vertical and horizontal beamforming
        - Improved network performance - Low inter-cell interference

The characteristics of the systems to be integrated are as follows:

- Baseband 6648:

- Nominal Voltage: -48 Vdc
- Operating Voltage Range: -38.0 to -58.5 Vdc
- Non-destructive range: 0 to 60 Vdc
- Maximum Power Consumption: 340 W

AIR 3227:

- Maximum nominal output power: 200 W (Power of the emitted signal)
- Máximun dissipation: 860 W
- Nominal Voltage: -48 Vdc
- Operating Voltage Range: -38.0 to -58.5 Vdc
- Non-destructive range: 0 to 60 Vdc
- Maximum Power Consumption (assumption): 200+860 W (1060 W)

The total Consumption Power for both systems is approximately 1400 W.

To power the equipment related to the antenna, we are looking for a lightweight power supply model designed for aeronautical environments, capable of providing more than 1400 W of power to the equipment, in order to propose a power reserve of 25% of the demand. A 1750 W power supply is selected for this purpose.

The system must be connected to a 400 Vdc power bus, which will be the main power bus of the aircraft. It will also provide voltage at 48-50 Vdc, falling within the functional range of both 5G systems.

DC/DC Power Source Vicor BCM4414VD1E5135C02:

- Input Voltage: 260-410 Vdc
- Output Voltage: 32.5-51.3 Vdc
- Output Current: Up to 35 A
- Maximum Power Output: 1750 W

2.4. Critical POD Model Design

This section outlines the critical aspects of the POD's model design. The primary objective of this phase was to create a comprehensive 3D representation using CATIA software, serving as the foundation for structural analysis, manufacturing considerations, and system integration. Key aspects addressed herein include the overall geometry and the integration of the Environmental Control System (ECS). The subsequent subsection will delve into the detailed specifics of the 3D model.

To provide context for the internal design, the following figure depicts the planned location of each major piece of equipment within the POD's structure.

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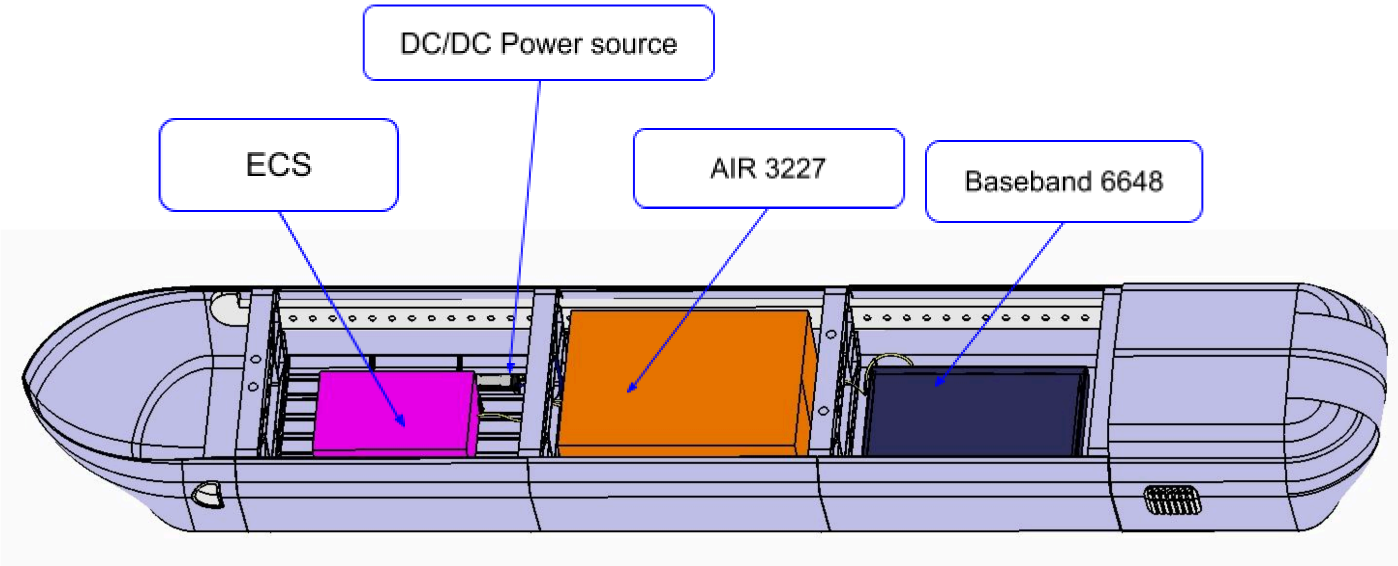

Figure 2.4-1: Internal Equipment Layout

2.4.1. Critical POD 3D Design

2.4.1.1. General Geometric Description

The external profile of the POD is meticulously designed to achieve optimal aerodynamic performance. A primary objective is to minimize drag during flight, thereby ensuring no detrimental impact on the carrying aircraft's overall efficiency. The selection of this profile considers the aircraft's target cruise speed, ensuring efficient integration into the overall aerodynamic envelope. A critical balance has been established between maximizing aerodynamic efficiency and providing the necessary internal volume to effectively house the 5G/6G equipment. This defined aerodynamic profile directly influences the POD's structural design, as the contouring dictates the distribution of aerodynamic pressures, which constitute primary external loads. Furthermore, an efficient aerodynamic shape not only reduces overall drag but also minimizes flow-induced turbulence and dynamic loads, lessening vibratory stresses on the internal structure and contributing to improved fatigue life and overall structural durability

2.4.1.1.1. Overall Dimensions and Aerodynamic Profile

The POD exhibits an elongated and aerodynamic configuration, measuring approximately 2700 mm in length, 580 mm in width, and 365 mm in height. This configuration is engineered to promote laminar airflow and mitigate boundary layer separation under typical operational conditions. Given the POD's intended underwing mounting location, its profile has been precisely refined to ensure seamless integration with the aircraft's wing airflow, specifically minimizing any detrimental aerodynamic interference that could arise from its positioning.

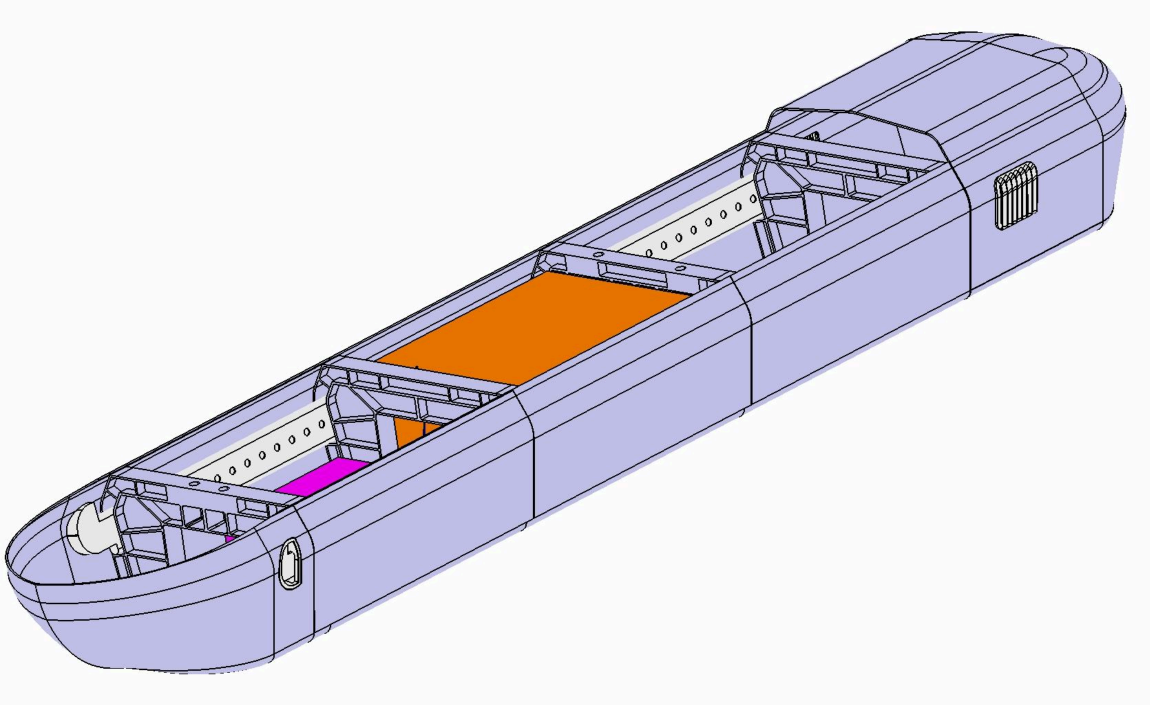

Figure 2.4.1-1: Overall View of the POD 3D Model

2.4.1.1.2. Cross-Sectional Geometry

Its cross-section, as depicted in the provided cutaway, remains constant along the majority of its length, facilitating the integration of internal components and simplifying manufacturing processes. This rectangular cross-section, with approximate dimensions of 365 mm in height and 580 mm in width, optimizes the internal space available for housing equipment and the airflow circulation of the cooling system.

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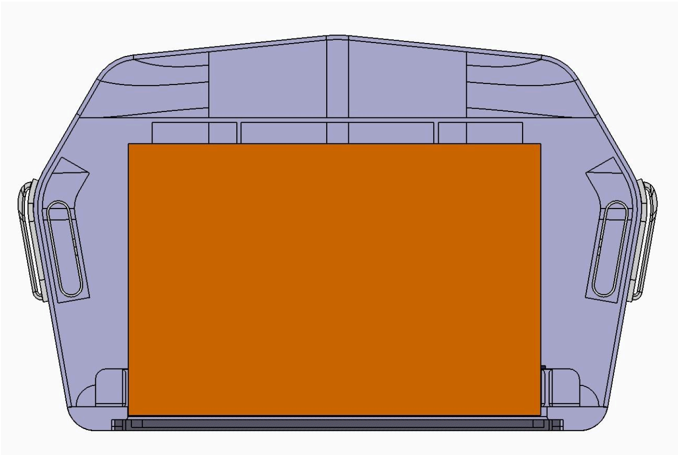

Figure 2.4.1-2: POD Cross-Section

2.4.1.1.3. Forward End Design

At the forward end (bow), the POD features a curved aerodynamic shape, designed to minimize drag and facilitate air intake through the NACA inlet integrated into the upper fairing. This curvature extends over a limited distance until it transitions into the constant cross-section.

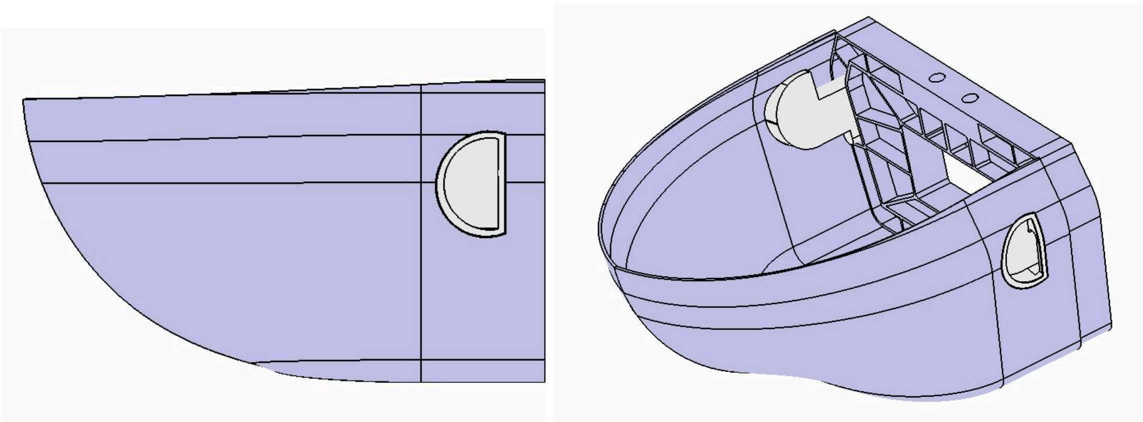

Figure 2.4.1-3: Forward POD Zone Detail

2.4.1.1.4. Aft End Design

Similarly, the aft end of the POD adopts a curved shape as well, albeit with a different configuration, incorporating the outlet grille of the cooling system. This shape aims for a smooth transition with the external airflow and to optimize the exhaust of cooling air.

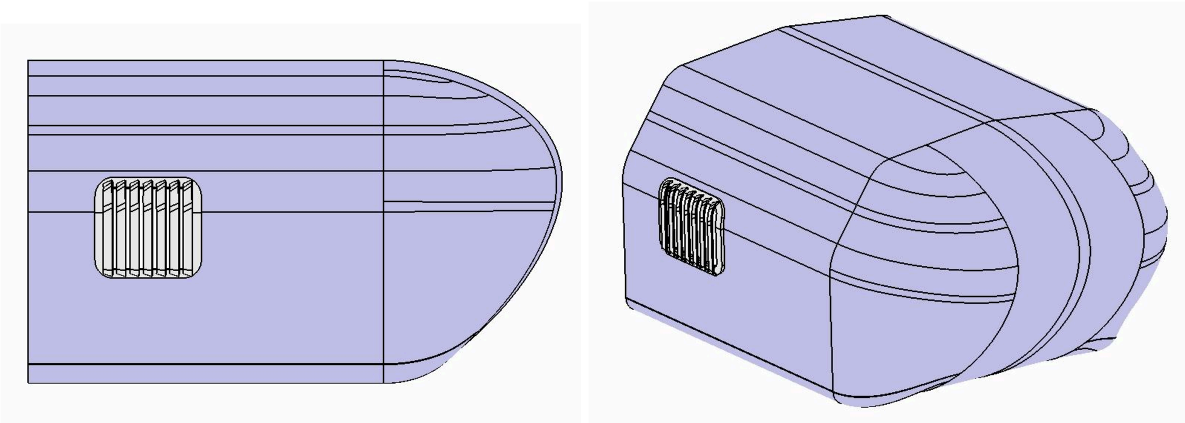

Figure 2.4.1-4: Aft POD Zone Detail

2.4.1.1.5. Cooling System Integration

In the cooling system design for the POD's interior, a primary duct is proposed to channel airflow captured via the forward-mounted NACA inlet. This duct is intended to run longitudinally through the POD, distributing the airflow sequentially into each of the internal compartments. Following the circulation of air through these compartments to manage equipment thermal loads, the airflow will then proceed towards the aft end of the POD, where it will be expelled through the outlet grille.

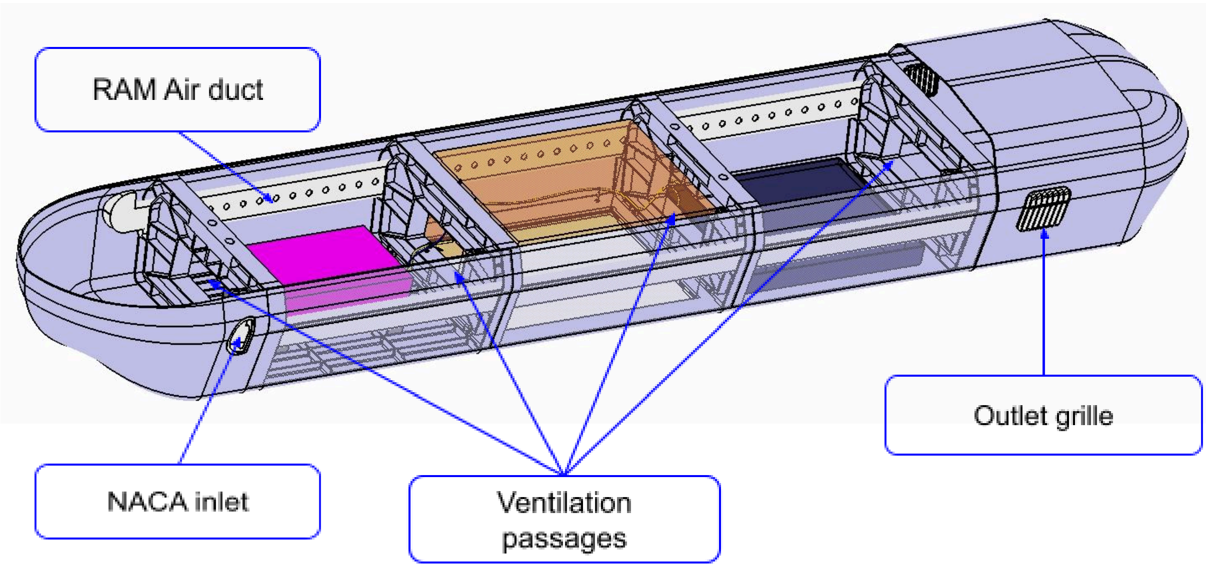

Figure 2.4.1-5: Cooling System Design

2.4.1.2. Main Structural Elements

The structural integrity of the POD is fundamentally achieved through a combination of its external skin, transverse frames, and longitudinal stiffeners. These elements collectively form a robust and lightweight structure capable of withstanding various operational loads while efficiently housing the internal equipment.

2.4.1.2.1. External Skin

The external skin forms the aerodynamic outer surface of the POD, serving as the primary interface with external airflow and providing environmental protection for internal components. Along the lateral walls of the constant cross-section, distinct lines separate various panels, indicating a modular construction. The following image highlights the separation lines between these modules. This modularity streamlines manufacturing, assembly, and potential in-service maintenance or repair.

The skin is designed to effectively carry aerodynamic loads and significantly contributes to the POD's overall structural stiffness and strength through its stressed-skin design. Its smooth surface finish is critical for maintaining optimal aerodynamic performance. The skin is securely joined to underlying transverse frames and longitudinal stiffeners, ensuring a rigid and cohesive primary structure capable of withstanding diverse flight loads.

Internally, transverse structural elements (frames) are arranged at regular intervals. These frames provide support and rigidity to the skin structure and define the different internal compartments.

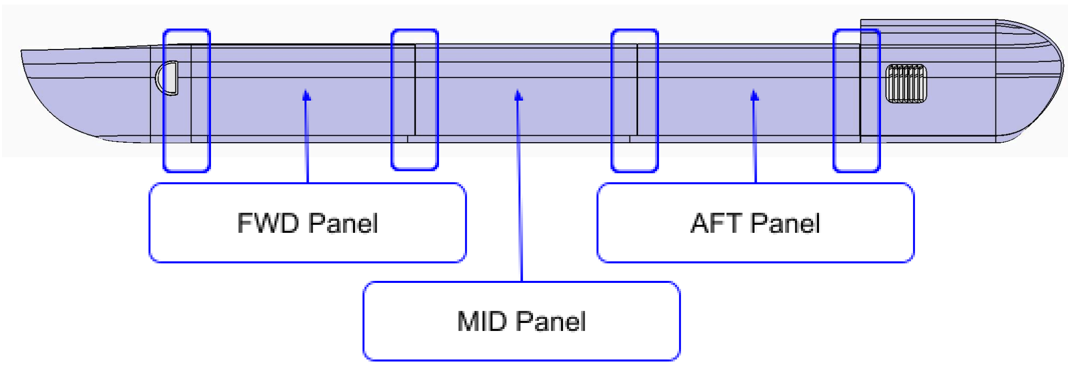

Figure 2.4.1-6: Modular Panel Construction

2.4.1.2.2. Transverse Elements (Frames)

Internally, frames are arranged at regular intervals, providing crucial structural support and rigidity to the external skin, while also defining the various internal compartments of the POD.

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These elements are fundamental in maintaining the POD's cross-sectional shape and distributing loads.

Generally, each frame is characterized by a robust internal rib structure, ensuring high stiffness and strength, and maintaining a symmetrical design. They incorporate strategically placed openings, including lateral cutouts to facilitate the passage of the RAM air duct, and a larger central opening to enhance air movement towards the rear of the POD, supporting the internal cooling system.

Due to specific design requirements, particularly concerning the POD's secure attachment to the aircraft's wing rib, three distinct types of frames have been designed and implemented. These specialized frames are strategically positioned along the POD's length to manage concentrated loads and ensure robust connection points. Their varied configurations are tailored to accommodate the unique interface demands at the wing-to-POD attachment zones.

The overall layout of these transverse frames, highlighting the placement of each specific type within the POD structure, is illustrated in the figure below.

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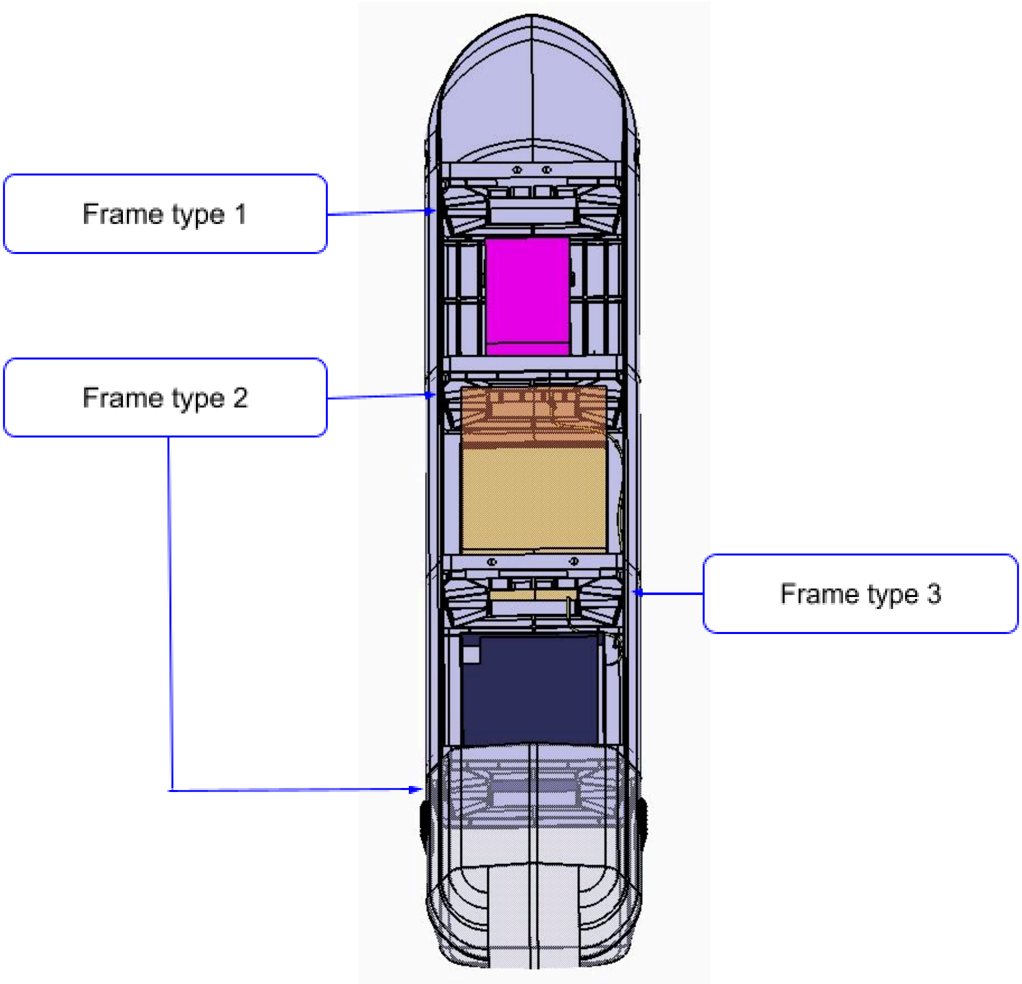

Figure 2.4.1-7: Transverse Frames Layout and Types

Detailed views of each individual frame type are presented in the following figures, showcasing their specific geometry and design features:

- **Type 1 Frame:** This frame features a solid upper section specifically designed with precision-drilled holes. These holes are intended for the secure attachment of bolts that facilitate the primary connection between the POD and the wing rib. This configuration ensures a robust and rigid load transfer at the main suspension point.

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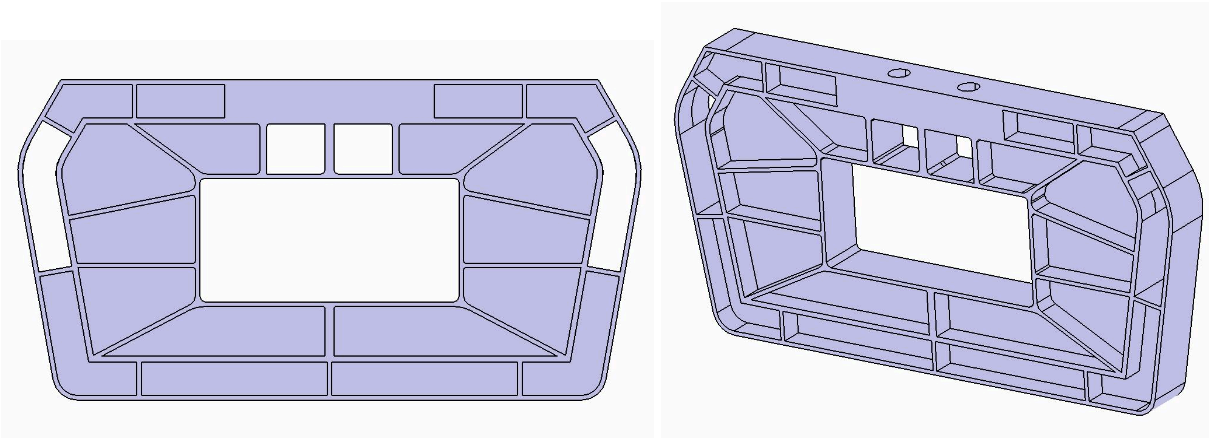

Figure 2.4.1-8: Detail of Type 1 Frame

- **Type 2 Frame:** This frame represents a more standard or intermediate configuration, characterized by its general structural support role without specialized features for direct attachment to the wing rib. Its design primarily focuses on maintaining the POD's cross-sectional integrity and supporting the external skin and internal components.

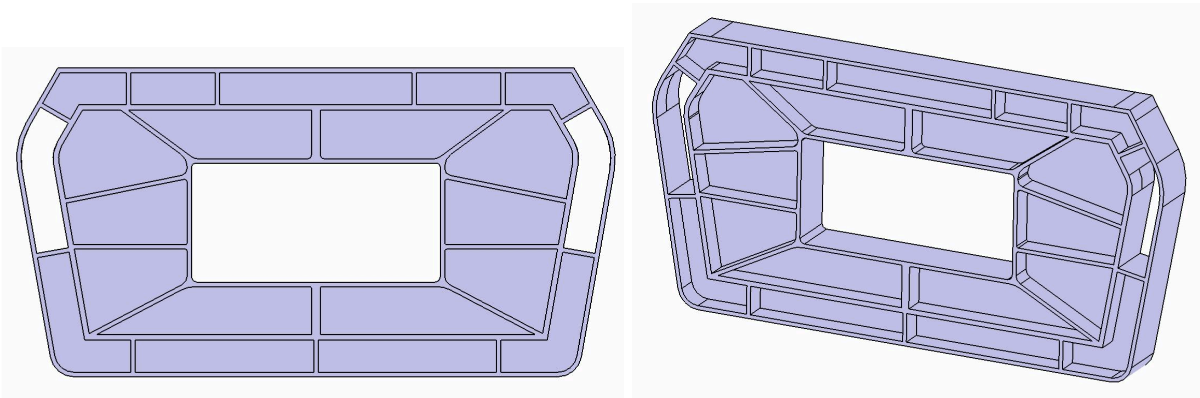

Figure 2.4.1-9: Detail of Type 2 Frame

- **Type 3 Frame:** Similar to Type 1, this frame also incorporates a reinforced section with drilled holes for attachment. However, these features are positioned in a different location due to the difference in the rear attachment point of the machined wing rib, which will be detailed later in this document. This specific placement allows for optimized load distribution and secure fastening at alternative points along the POD's length.

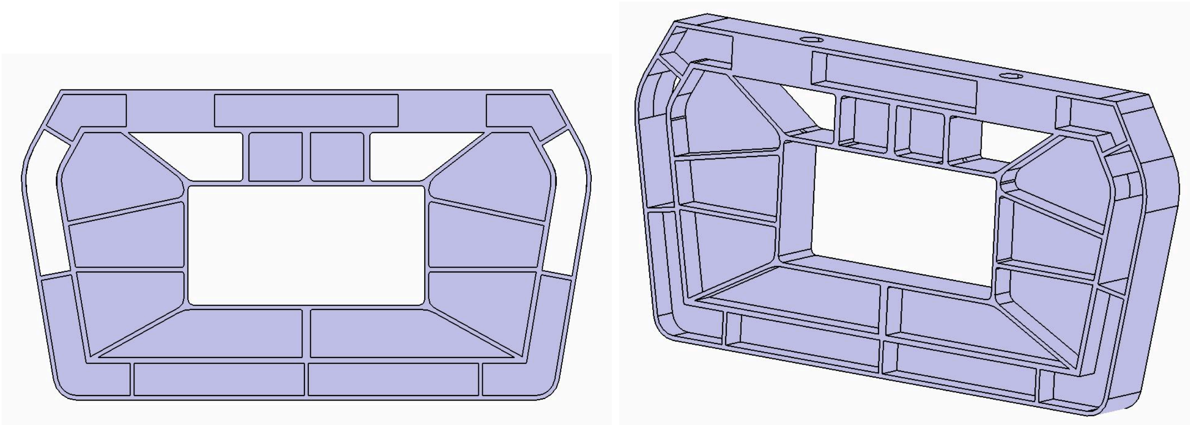

Figure 2.4.1-10: Detail of Type 3 Frame

2.4.1.2.3. Longitudinal Elements (Stiffeners)

The POD's internal structure is reinforced by longitudinal elements, primarily in the form of different floor sections that connect transversally from frame to frame. Longitudinal stiffeners on these floor sections serve a dual purpose: providing enhanced structural support and acting as a robust mounting base for the anchoring systems used for securing and correctly distributing the weight of the equipment or payload housed within the POD. These stiffeners are typically arranged in a bidirectional pattern to provide rigidity in two directions, effectively increasing the bending stiffness and load-carrying capacity of the floor panels.

A notable exception to this typical floor configuration is the section directly beneath the antenna. In this specific area, the floor is designed to be completely solid, deviating from the standard reinforced panel. This solid design is crucial as the space directly below the antenna cannot accommodate a conventional floor structure. Instead, it is covered by a panel made of a different material, specifically chosen to allow for optimal signal transmission, thereby ensuring the unhindered operation of the antenna system.

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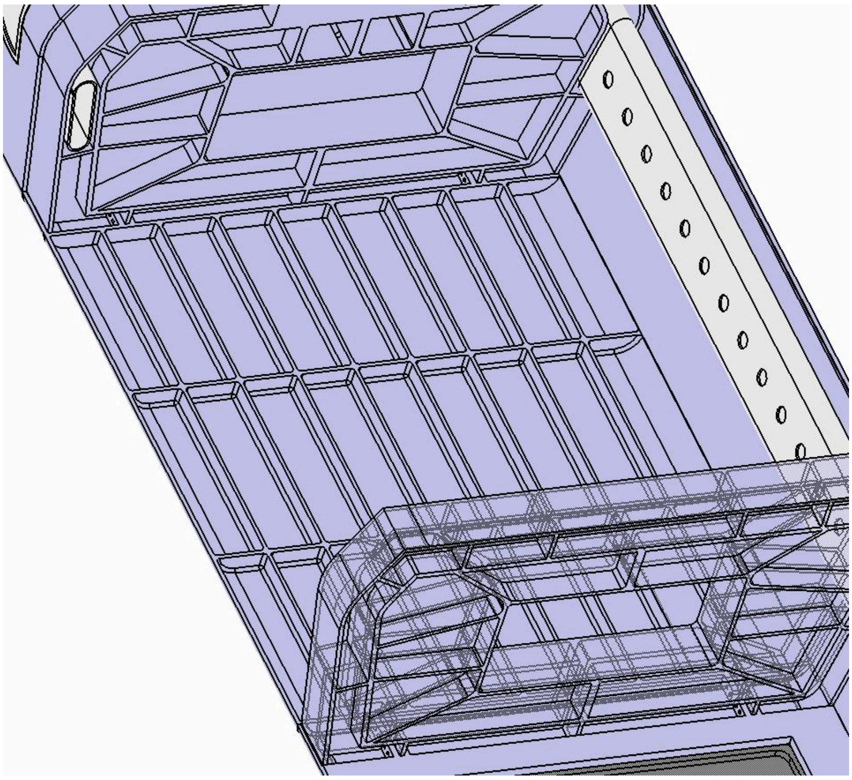

Figure 2.4.1-11: Longitudinal Stiffeners

2.4.1.3. Internal Connections and Equipment Anchoring

The secure integration of all internal equipment is paramount to the POD's operational stability and integrity under various flight conditions. Equipment units are systematically anchored to the POD's internal structure, primarily utilizing supports that interface directly with the longitudinal stiffeners and floor sections. This method ensures that the equipment remains firmly in place, preventing any movement that could compromise its functionality or the POD's structural integrity.

While the minute details of each specific anchoring point were not individually designed for every component, the overall strategy focuses on robust connection points that efficiently transfer the static weight and dynamic loads from the equipment to the primary structural elements of the POD. This approach guarantees a stable environment for the sensitive electronic and mechanical systems housed within.

The following figure illustrates the general arrangement of equipment and their supports within the POD's interior, demonstrating their attachment to the internal floors and stiffeners.

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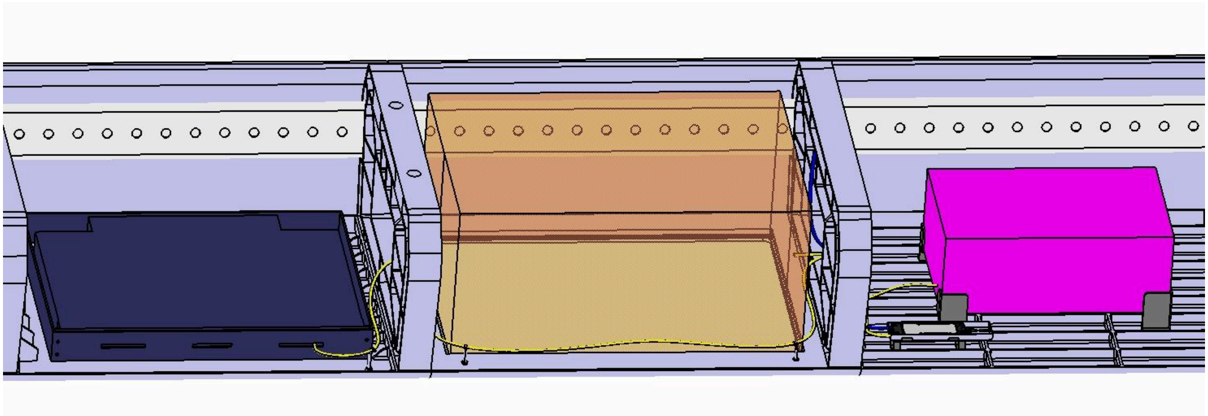

Figure 2.4.1-12: Internal Equipment Mounting and Supports

2.4.1.4. Equipment Cabling and Routing

Effective management of internal cabling is crucial for ensuring the reliable operation, maintenance, and safety of the POD's integrated systems. The routing strategy focuses on systematically organizing all necessary electrical connections. This includes the principal inter-equipment connections within the POD, as well as the power supply lines transmitting energy from the POD's systems to the aircraft's interface.

The main power and data lines from the POD's internal equipment are routed longitudinally along the structure. These cables are designed to ascend towards the wing attachment point, specifically at the height of the second transverse frame, where they interface with the aircraft's systems. To ensure the cables remain securely in place, prevent chafing, and mitigate potential electromagnetic interference, custom-designed clamps have been developed. These clamps provide fixed attachment points, maintaining the desired cable pathways throughout the POD's operational lifecycle.

The following figure illustrates an example of the cable routing within the POD, showcasing the use of these dedicated clamps for organized and secure wire management.

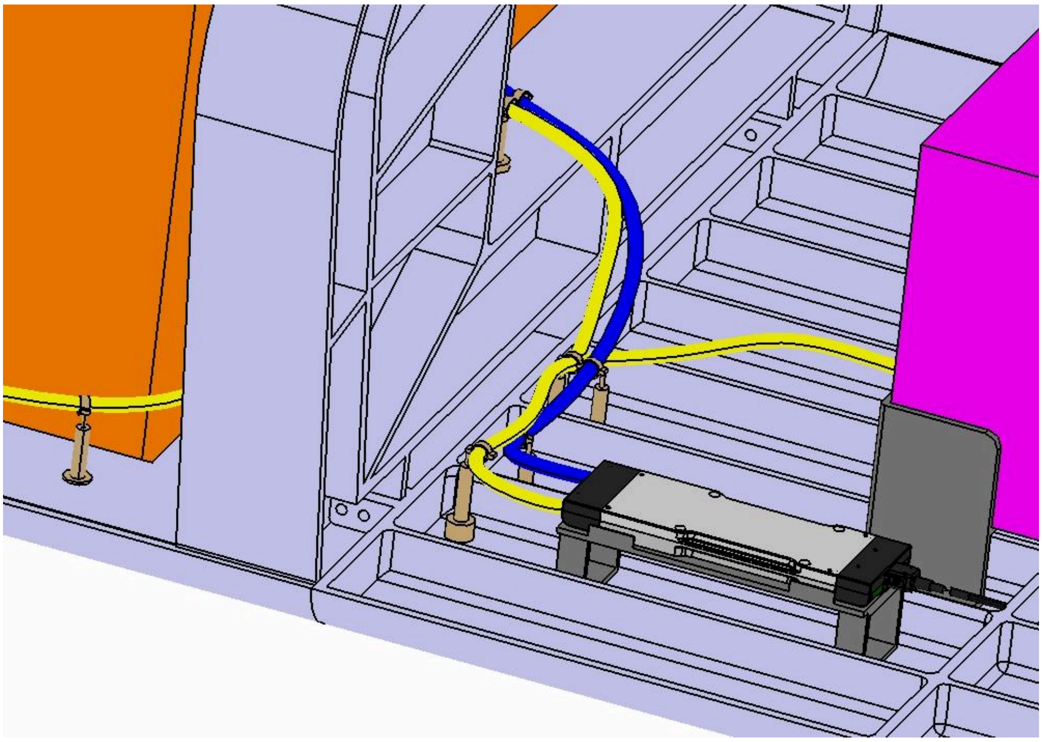

Figure 2.4.1-13: Internal Cabling and Clamp Design Detail

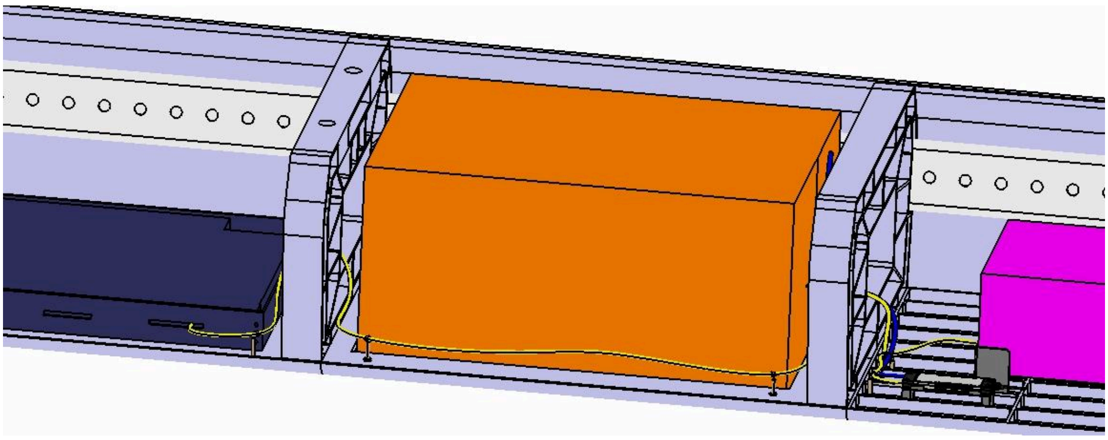

Figure 2.4.1-14: Internal Cabling and Clamp Design General

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2.4.1.5. Wing-to-POD Attachment Rib Design

The secure and robust attachment of the POD to the aircraft's wing is achieved through a precisely engineered interface centered around a specialized wing rib. This crucial connection is facilitated by a system of four bolts: two positioned at the forward attachment point and two at the aft attachment point.

The wing rib itself is a custom-machined component, meticulously fabricated to possess a unique and adapted shape that perfectly accommodates these specific connection points. This bespoke design ensures optimal load transfer and aerodynamic integration between the POD and the wing.

On the POD's side, the attachment utilizes the solid, reinforced sections of the transverse frames, specifically designed with integrated holes to align with the bolts from the wing rib. This direct engagement with the robust parts of the frames guarantees a rigid and reliable connection.

The machined wing rib, illustrating its adapted form for these attachments, is shown in the figure below.

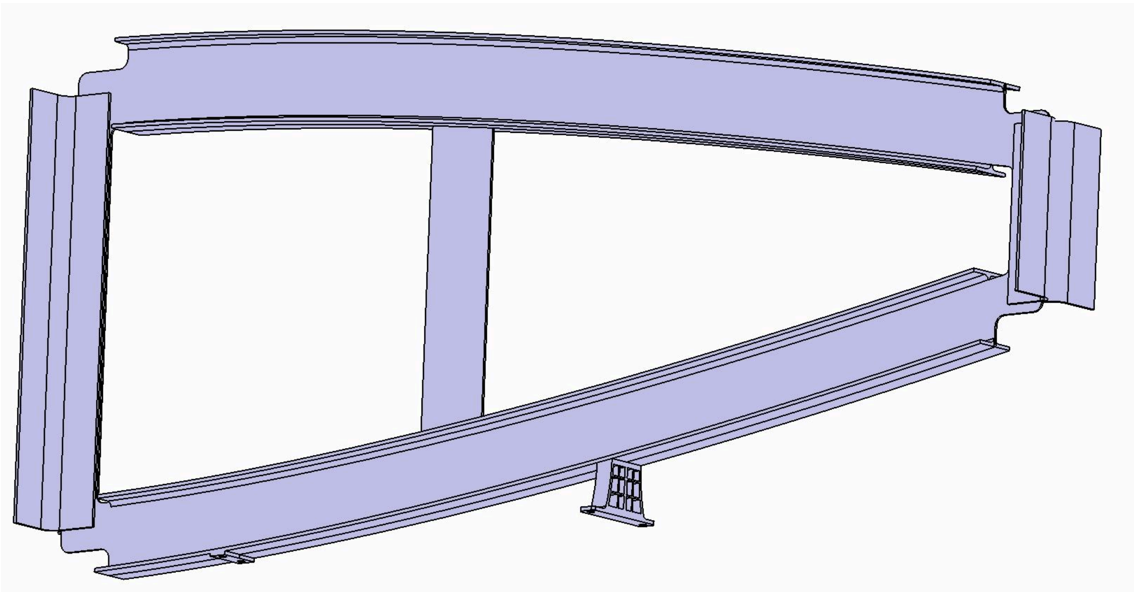

Figure 2.4.1-15: Machined Wing Attachment Rib

The successful integration of the POD hanging from this specialized wing rib, with the connection points utilizing the solid sections of the POD's frames, is visually confirmed in the subsequent figure.

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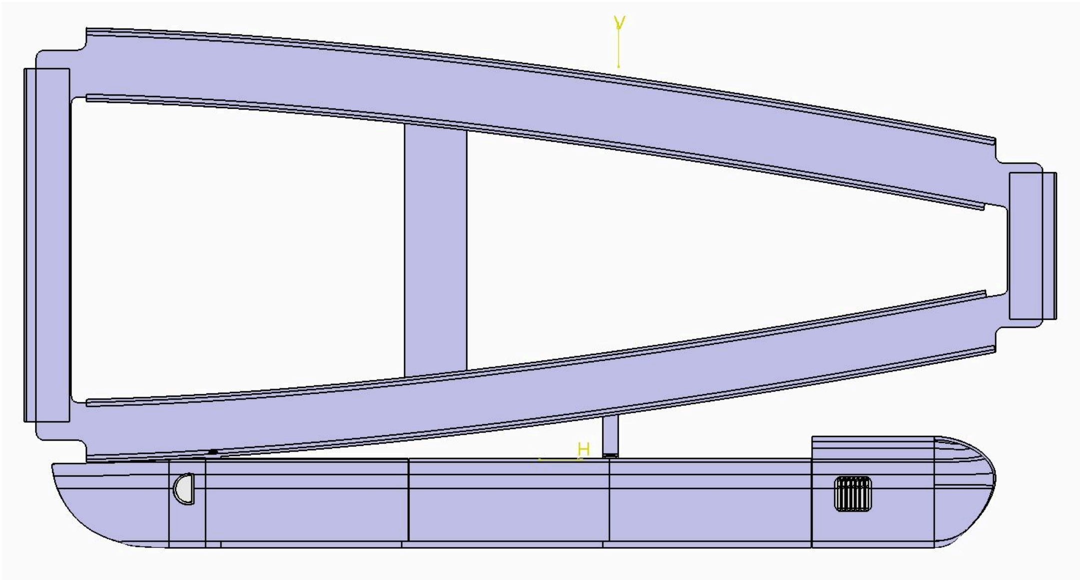

Figure 2.4.1-16: POD Attached to Wing Rib I

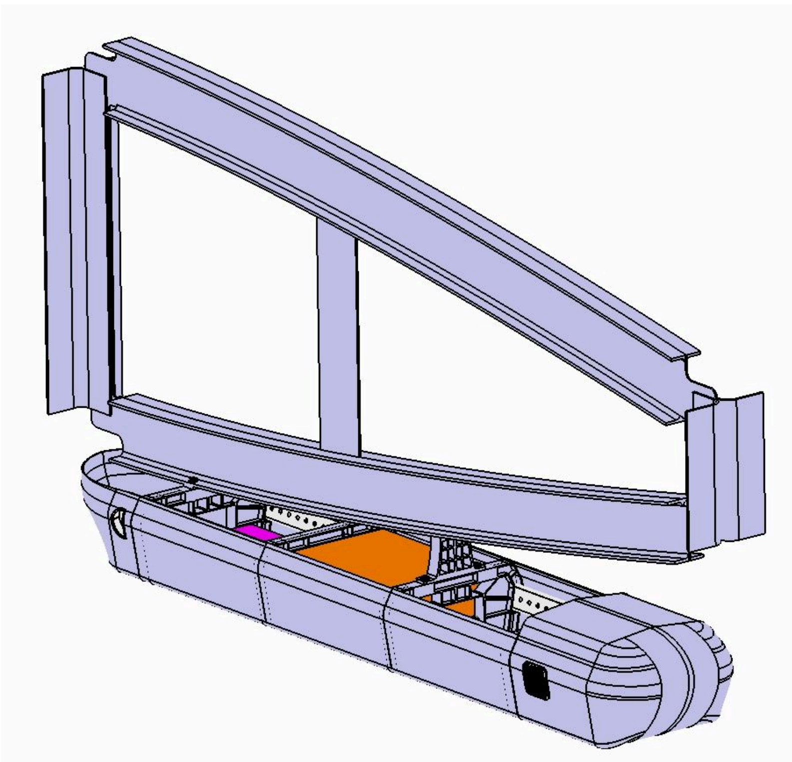

Figure 2.4.1-17: POD Attached to Wing Rib II

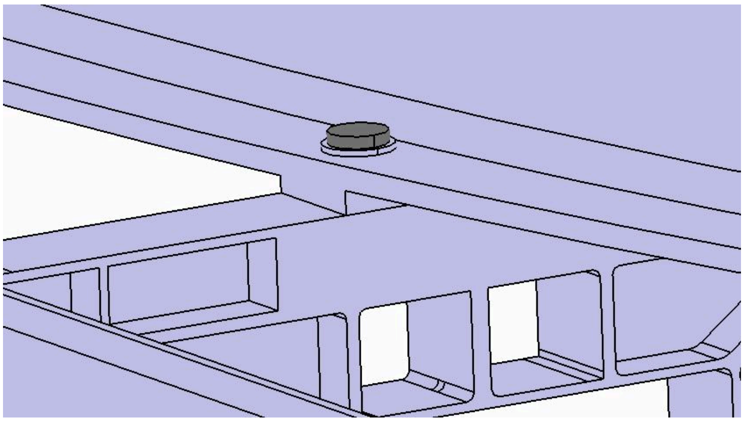

Figure 2.4.1-18: Detail of Forward POD-to-Wing Attachment

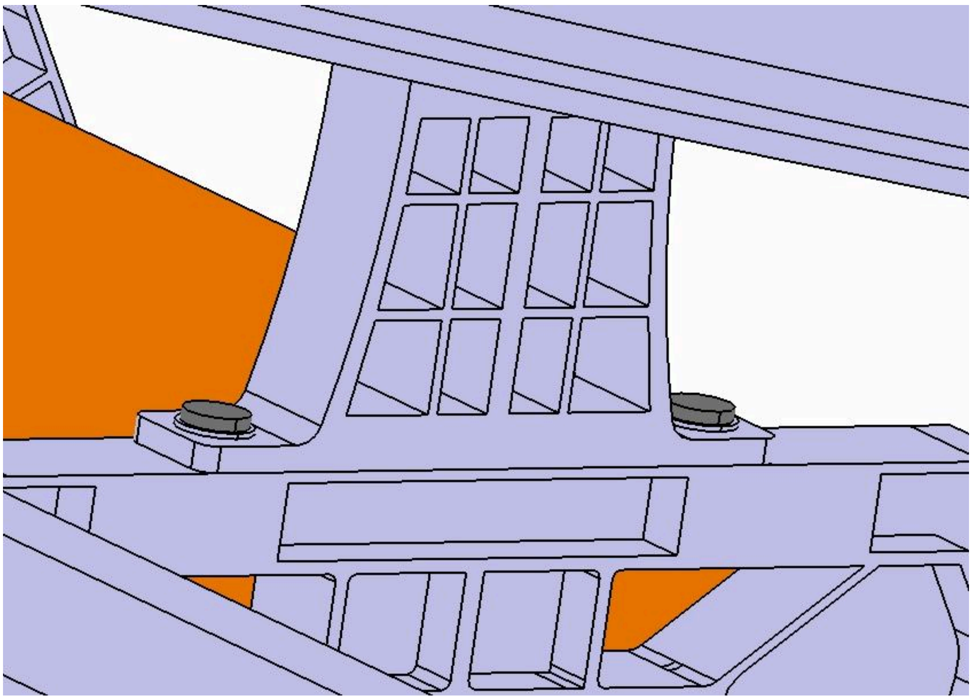

Figure 2.4.1-19: Detail of Aft POD-to-Wing Attachment

2.4.1.6. Wing-to-POD Fairings Design

The junction between the POD and the aircraft's wing requires specialized fairings to maintain the overall aerodynamic efficiency and ensure a smooth transition of airflow. These fairings are custom-designed components, meticulously shaped to seamlessly blend the contours of both the POD's upper surface and the wing's lower surface. Their primary function is to prevent aerodynamic discontinuities that could lead to increased drag, turbulence, and noise, while also protecting the structural attachment points and internal systems (such as cabling) housed within the interface zone.

The design of these fairings is crucial for minimizing aerodynamic interference and contributing to the integrated performance of the POD-aircraft system. They effectively smooth the aerodynamic surface, reducing airflow separation and ensuring an undisturbed flow over and around the attachment region.

The following figures illustrate various aspects of the wing-to-POD fairings design, showcasing their integration and aerodynamic forms.

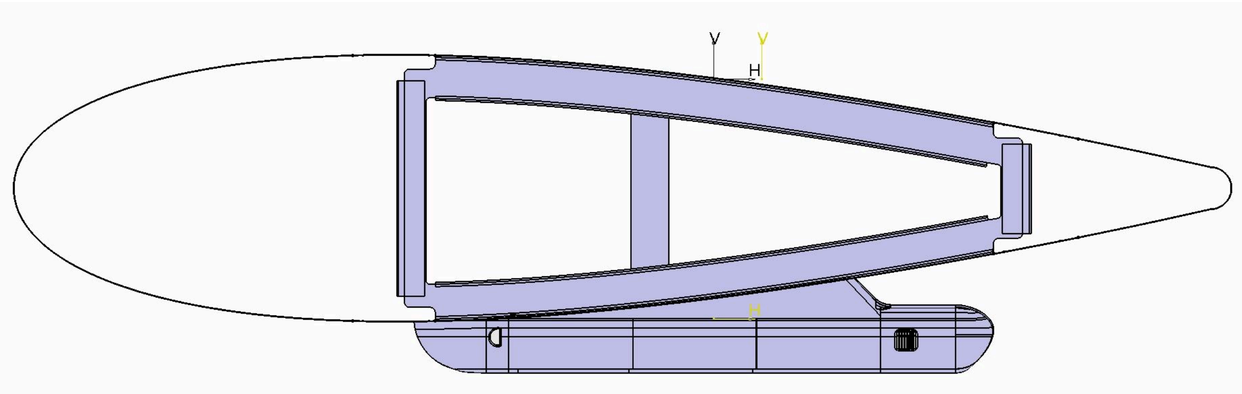

Figure 2.4.1-20: Wing-to-POD Fairing Contour Design

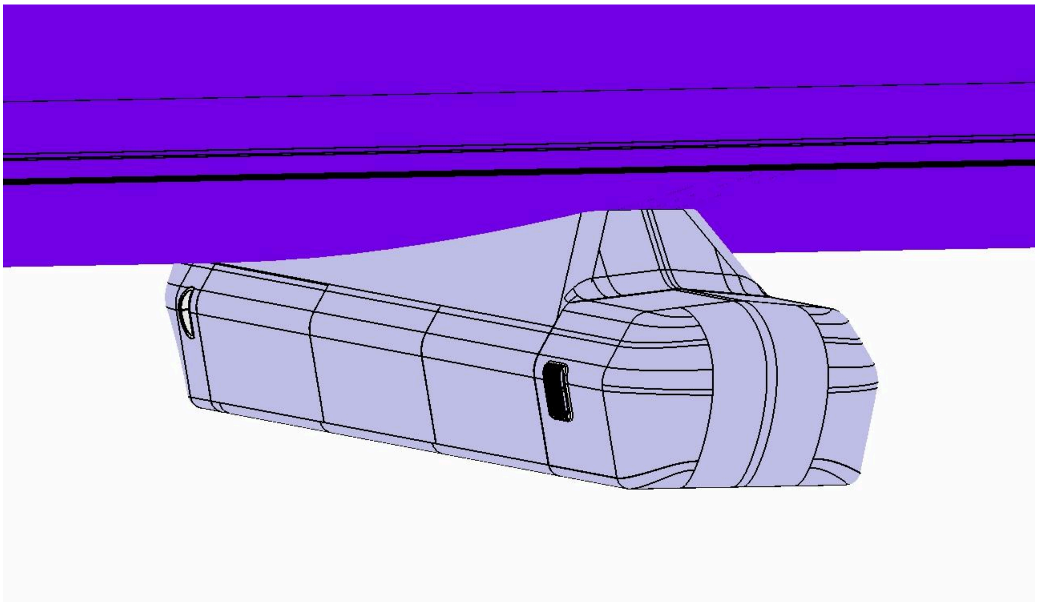

Figure 2.4.1-21: Lateral Fairing Profile

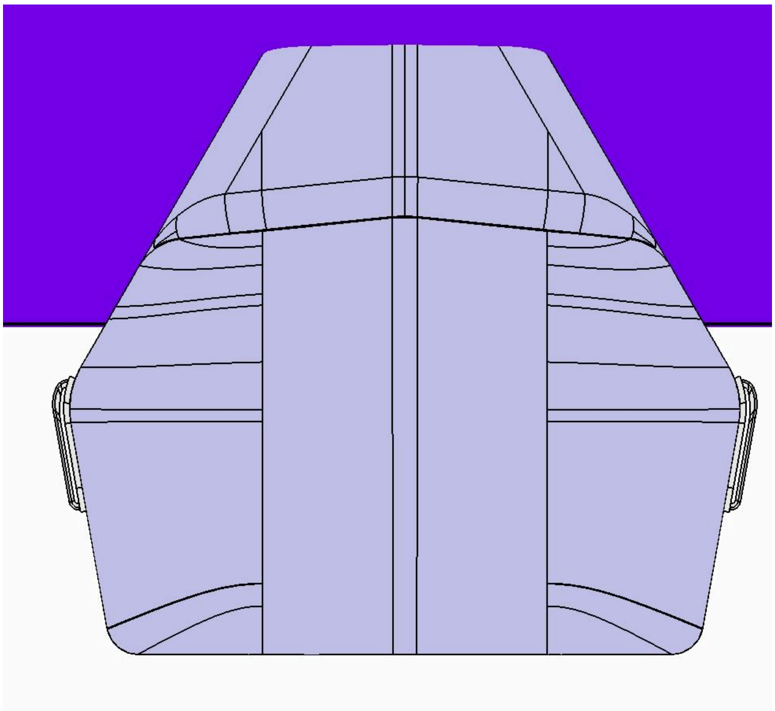

Figure 2.4.1-22: Fairing Integration Detail

2.4.2.Critical POD FEM Analysis

The structural analysis of the POD takes into account the following;

- Weight of the entire POD with systems (Antenna, Baseband, Power Supply, etc.)
- Materials and allowables
- External pressures evaluated by CFD models (ANSYS CFX)

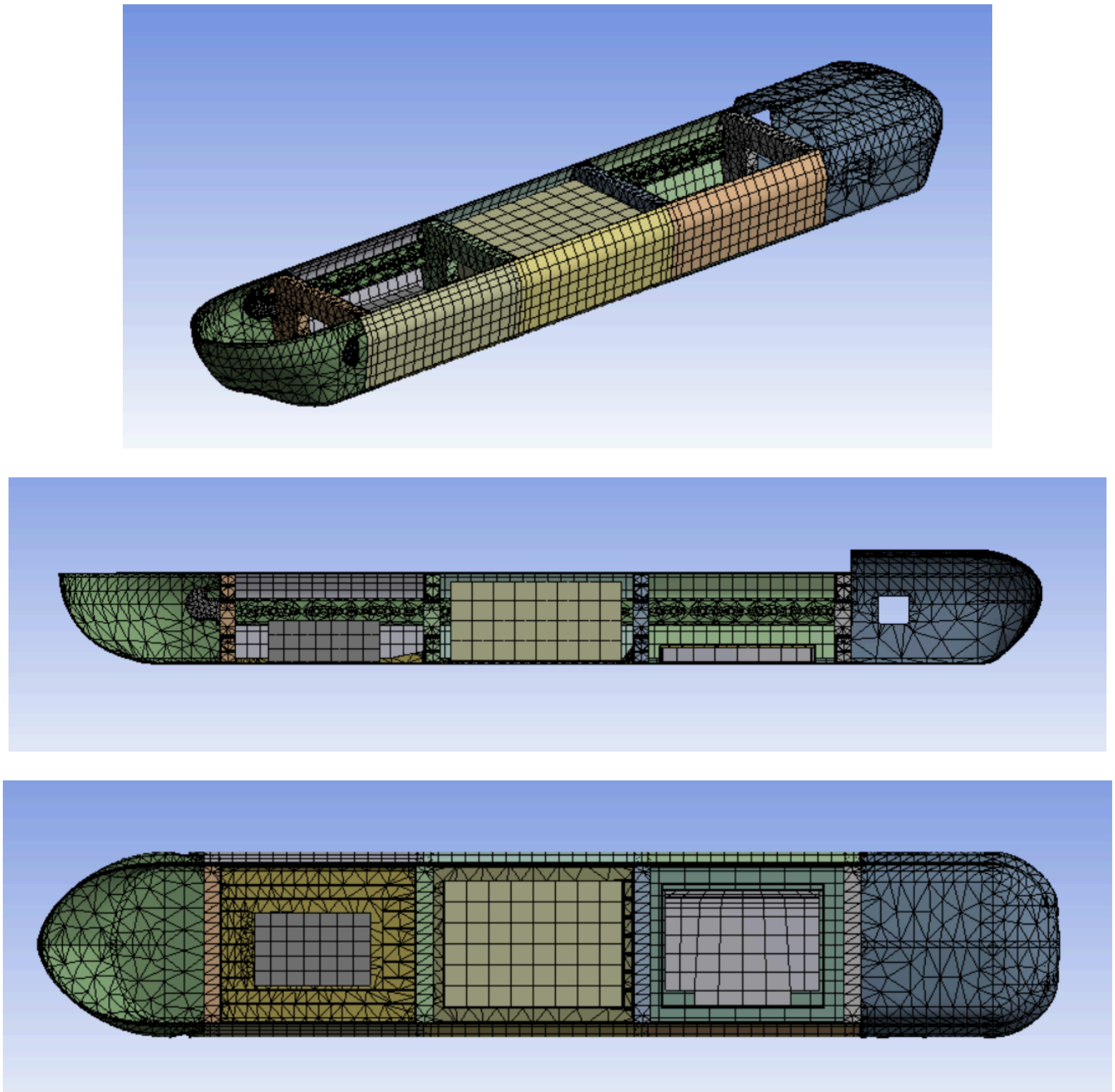

Figure 2.4.2-1: Structural Mesh

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2.4.2.1. Load Case. Description

The load case considered has been the pod attached to the wing with the weights of itself and the internal equipment plus the wind action over the external surfaces at maximum velocity of 100 km/h and near the ground where the air density is the maximum.

2.4.2.2. Load Case. Boundary conditions

The boundary conditions considered are the fixation of all degrees of freedom at the top surface of the ribs that support the POD-to-Wing Attachments.

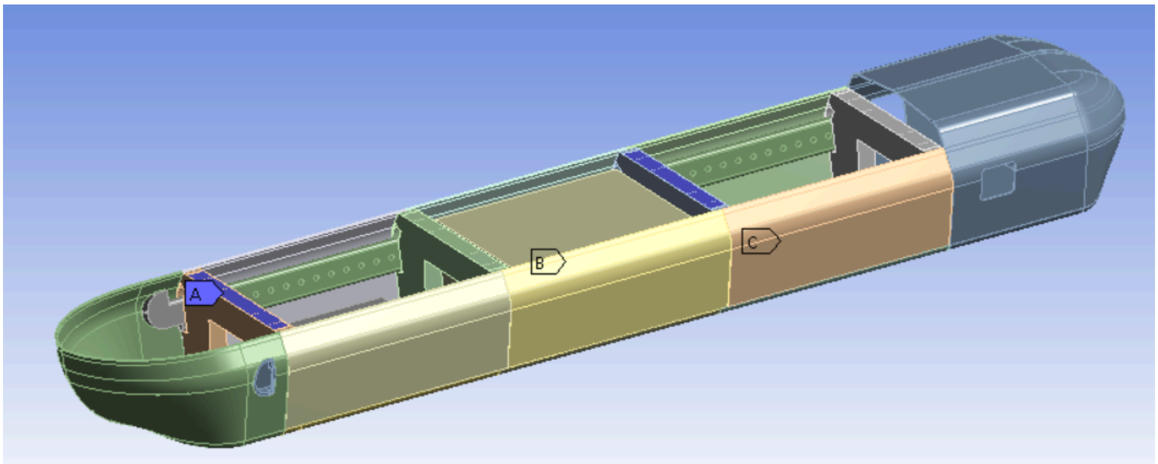

Figure 2.4.2-2: Structural boundary conditions (blue surfaces)

2.4.2.3. Load Case. Applied loads

The applied loads have been of two types.

- Gravitational loads including weights of equipment
  - Antenna : 25 kg
  - Baseband: 7.5 kg
  - Power source: 15 Kg
- Pressure forces due to wind velocity over external surfaces obtained by CFD model

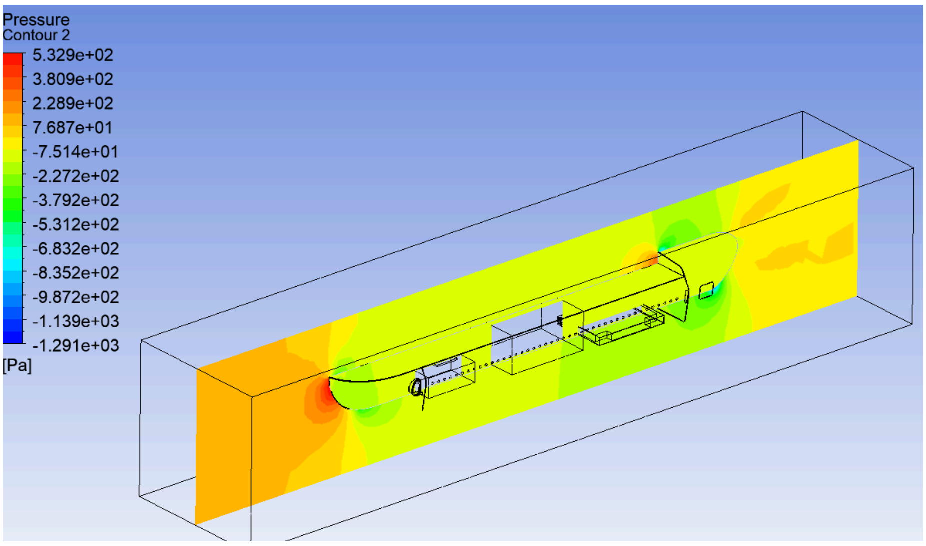

Figure 2.4.2-3: Contour of air pressures in a central plane (CFD)

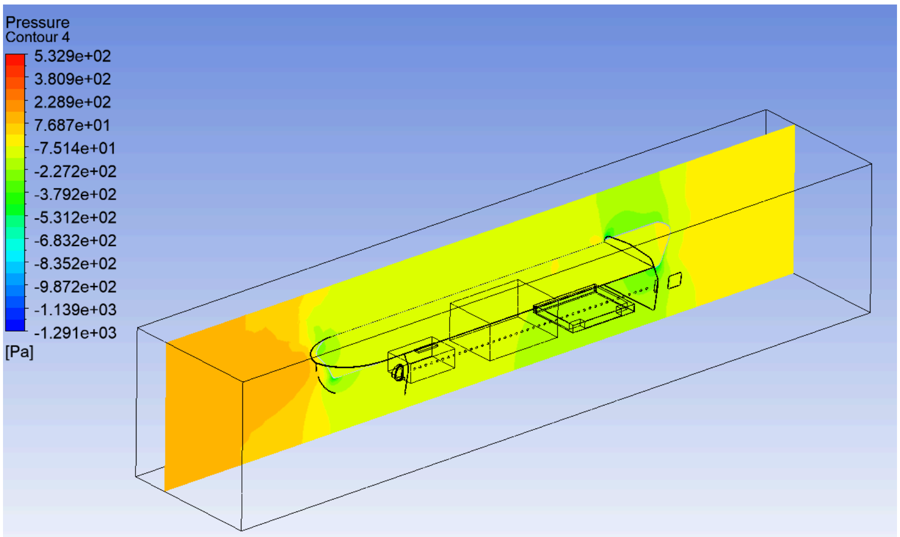

Figure 2.4.2-4: Contour of air pressures in a lateral plane (CFD)

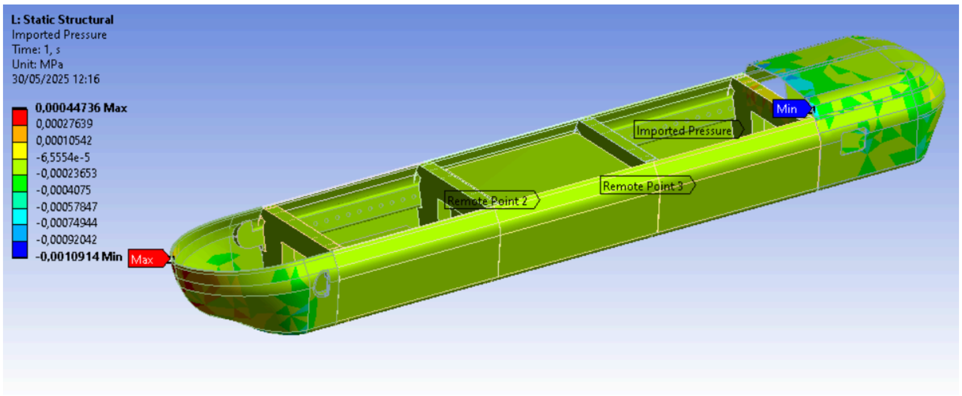

Figure 2.4.2-5: Imported pressure map for structural analysis

2.4.2.4. Results

The considered results to be presented are:

- Global deformations of the model
- Equivalent Von Mises Stress of the structure.

The material considered for the external structure of the pod is a fiberglass - epoxy resin composite with general stress limits values in each direction. It is clear that Von Mises criteria is mainly defined for isotropic materials and composites laminates are by nature orthotropic materials.

Anyway this failure criteria will be used because two main reasons:

The final laminate of the structure would include layers in different directions which convert the global wall in a near to isotropic material at least in the laminate in-plane directions.

The values of stress obtained are low enough to affirm there will not be substantial problems whatever the failure criteria is used.

Fiberglass-epoxy laminates limit stress would be about 200 to 400 MPa.

2.4.2.4.1. Global deformations results

Under the considered load case, the maximum deformation obtained is **0.03 mm.**

The scale of the following image has been augmented for clarity.

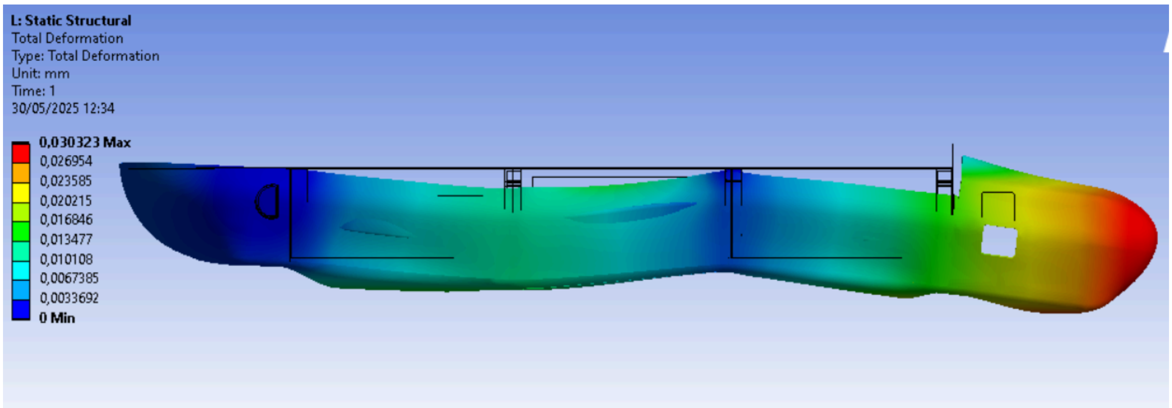

Figure 2.4.2-6: Global deformations (figure not in scale)

2.4.2.4.2. Von Mises Stress results

Under the considered load case, the maximum Von Mises stress obtained is about **7.5 MPa.**

That maximum value would imply a safety factor of:

$$SF=200/7.5 = 26.67$$

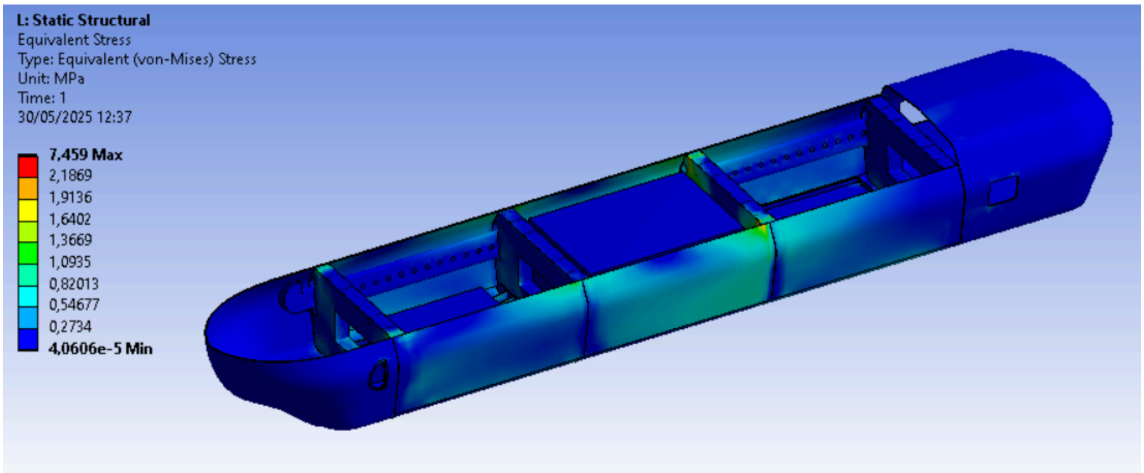

Figure 2.4.2-7: Von Mises Stresses

2.5. Definition of POD Environmental Control System (ECS)

The ECS is defined taking into account the results obtained from CFD analysis to evaluate the capacity of refrigeration of the air passing through the POD in different conditions of flight such as different heights which implies different external temperatures of the air and velocities of flight that implies the velocity of the air through the POD.

The CFD analysis provides us with the convection coefficients map along the structure. The boxes that represent the systems are modelized with the estimated heat flow dissipated for each system individually. With these values (Heat Flows and Convection coefficients) the system eventually reaches an equilibrium temperature which allows us to determine if the refrigeration is enough or if additional refrigeration modules have to be added such as cold plates or any other system. The equilibrium temperature is obtained with a static thermal model, moreover an additional transient thermal model is created to evaluate the time needed to reach the equilibrium temperature. This is also an important parameter to determine the efficiency of the refrigeration system.

2.5.1. CFD POD simulation

Once the simulation has been described, in the following paragraphs two independent cases of work are presented.

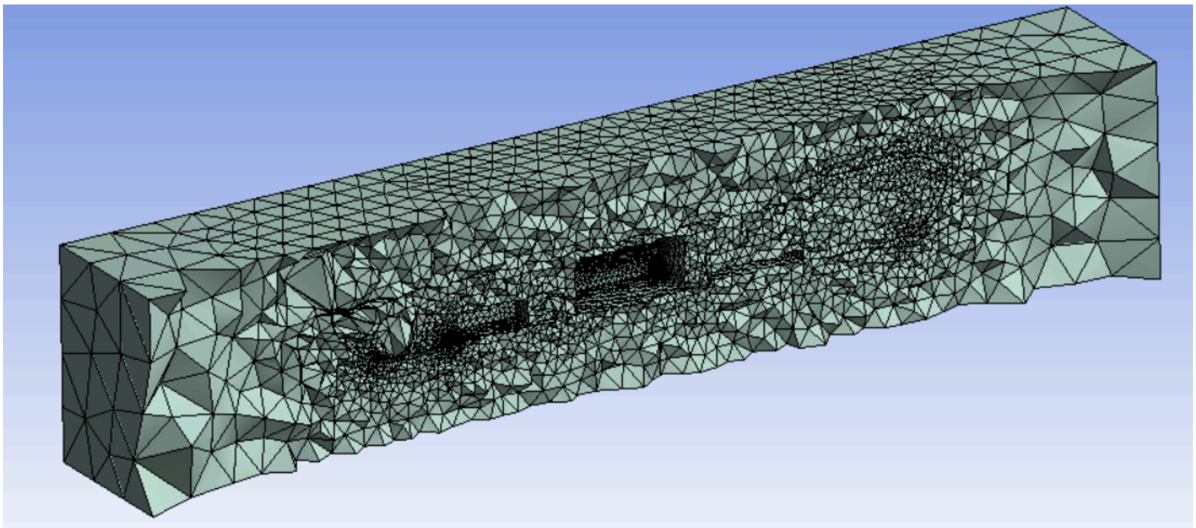

Figure 2.5.1-1: CFD Mesh

2.5.1.1. CASE 1: Airship at maximum height

The case 1 implies functioning at maximum height; the conditions of external air are:

- **Height**: 20000 m or 67098 ft
- **Pressure**: 5475 Pa or 0.55 bar
- **Temperature**: -56.5 °C or 216.53 K
- **Air density:** 0.088 kg/m3
- **Airship flight Velocity:** 10 km/h

The estimated heat dissipated for each equipment inside are:

- **DC/DC Power Source Vicor BCM4414VD1E5135C02:** 75 W
- **Antenna Integrated Radio 3227 (AIR 3227):** 300 W
- **Baseband 6648:** 100 W

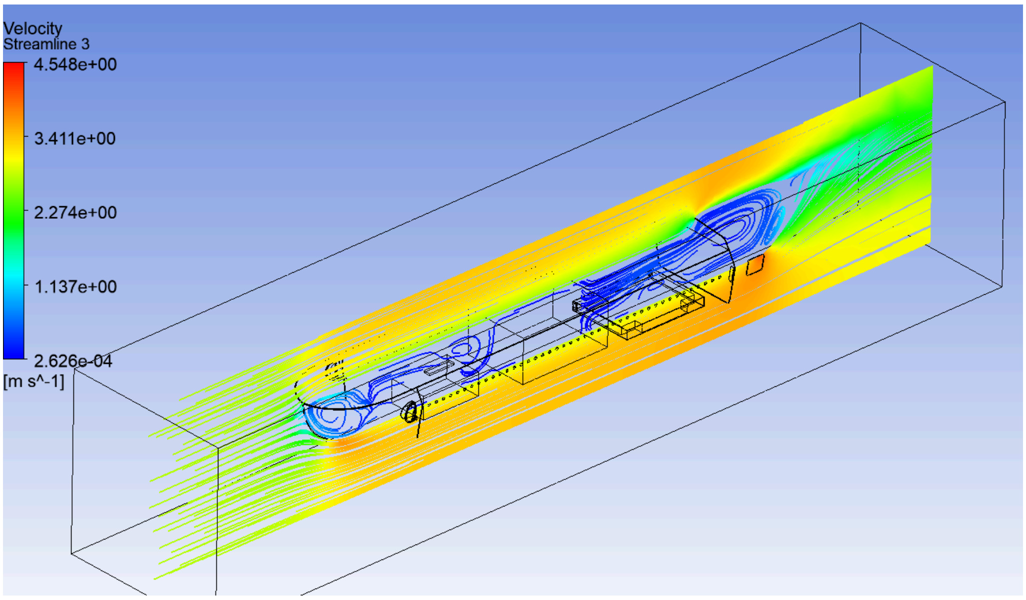

Figure 2.5.1-2: Case 1. Velocity of air (Streamline) Plane in the center of the pod

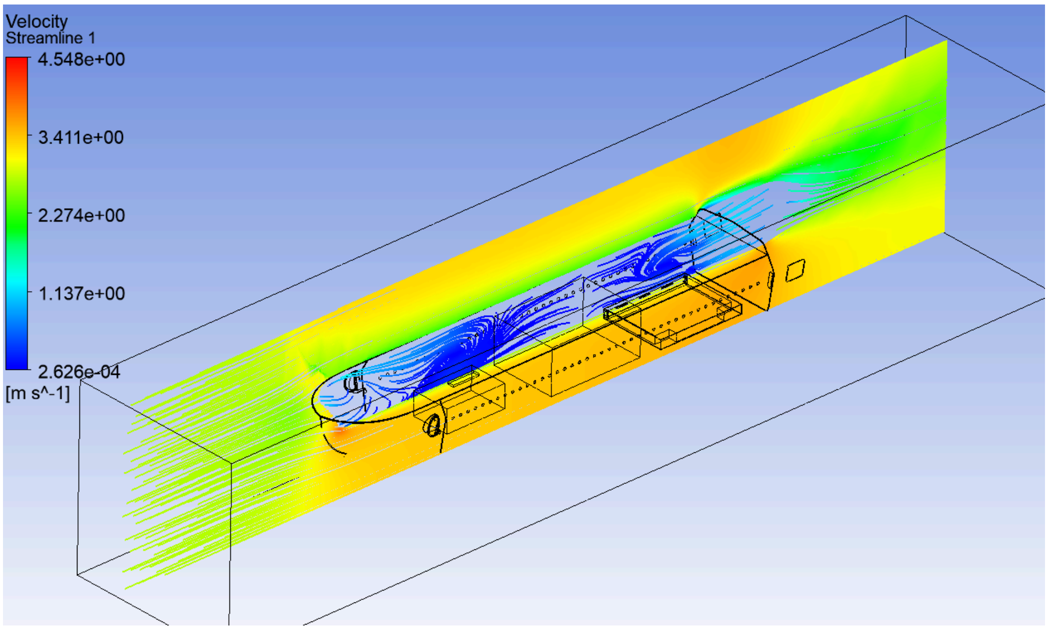

Figure 2.5.1-3: Case 1. Velocity of air (Streamline) Plane in the lateral of the pod

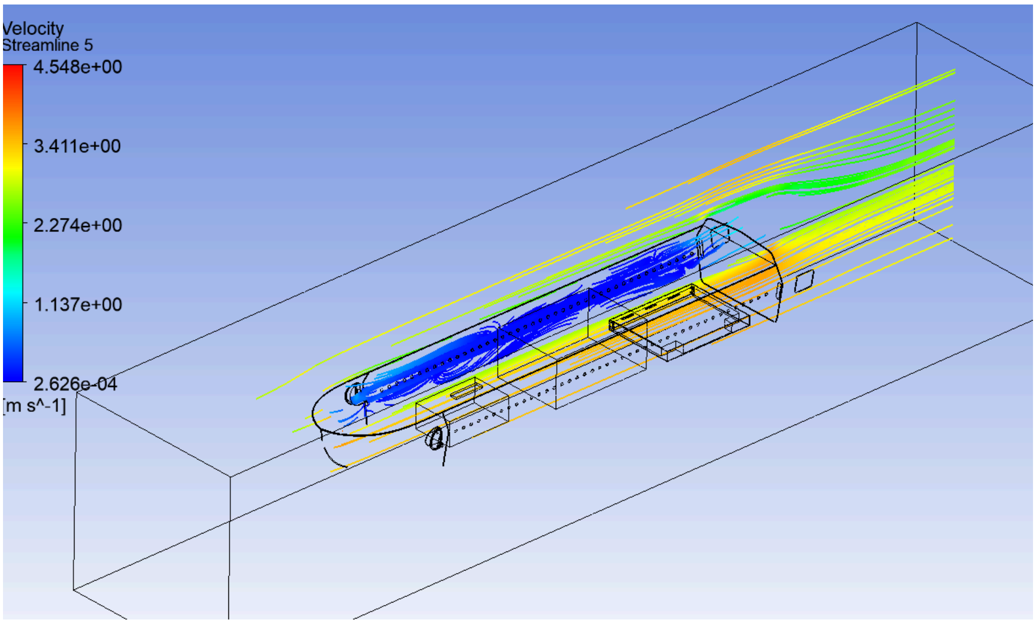

Figure 2.5.1-4: Case 1. Velocity (Streamline) Plane inside the duct

2.5.1.2. CASE 2: Airship near ground with high external temperatures (high velocity)

The case 2 implies functioning at low height, near the ground at a high temperature day and at high velocity; the conditions of external air are:

- **Height**: 0 m or 0 ft
- **Pressure**: 101325 Pa or 1 bar
- **Temperature**: 40 °C or 313.15 K
- **Air density:** 1.1272 kg/m3
- **Airship flight Velocity:** 100 km/h

The estimated heat dissipated for each equipment inside are:

- **DC/DC Power Source Vicor BCM4414VD1E5135C02:** 75 W
- **Antenna Integrated Radio 3227 (AIR 3227):** 300 W
- **Baseband 6648:** 100 W

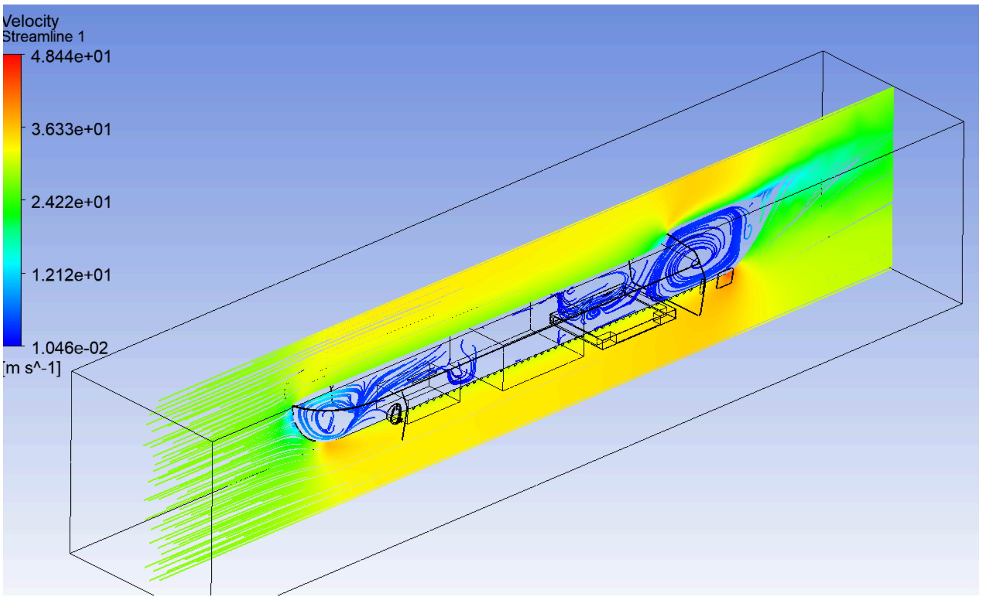

Figure 2.5.1-5: Case 2. Velocity of air (Streamline) Plane in the center of the pod

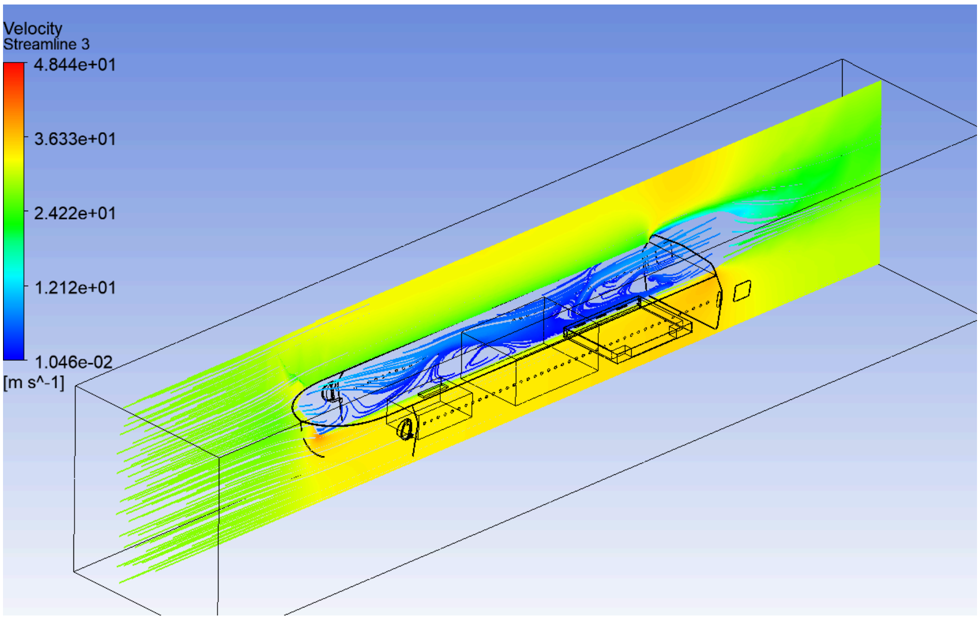

Figure 2.5.1-6: Case 2. Velocity of air (Streamline) Plane in the lateral of the pod

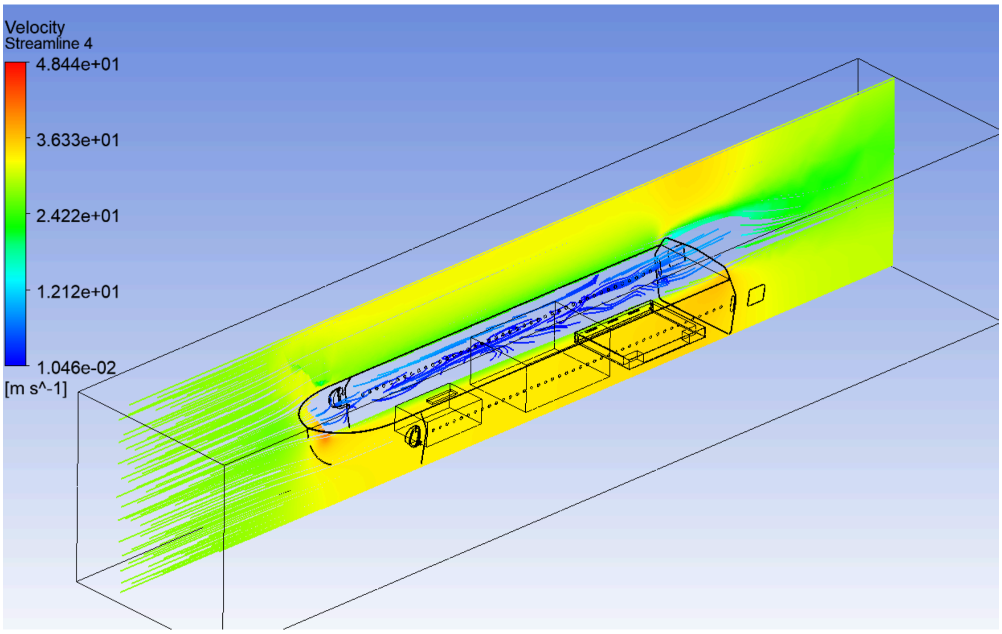

Figure 2.5.1-7: Case 2. Velocity (Streamline) Plane inside the duct

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2.5.2. ECS thermal simulation

In the following paragraphs, the results of thermal simulations are presented; The convection coefficients, the equilibrium temperature reached and some graphs of transient simulation are indicated, The transient simulations imply a lapse of time of 12 hours or 43200 seconds. The graphs presented show the evolution of the temperature reached in each equipment inside to determine the time needed to reach the equilibrium temperature and its value. Due to the fact that temperature graphs are quite asymptotic a unique value of time is indicated when the temperature is close enough to the equilibrium one; anyway a completed table of values time/temperature in each case is also presented.

2.5.2.1. CASE 1: Airship at maximum height

The convection coefficients map for the case 1 conditions is presented in the following image:

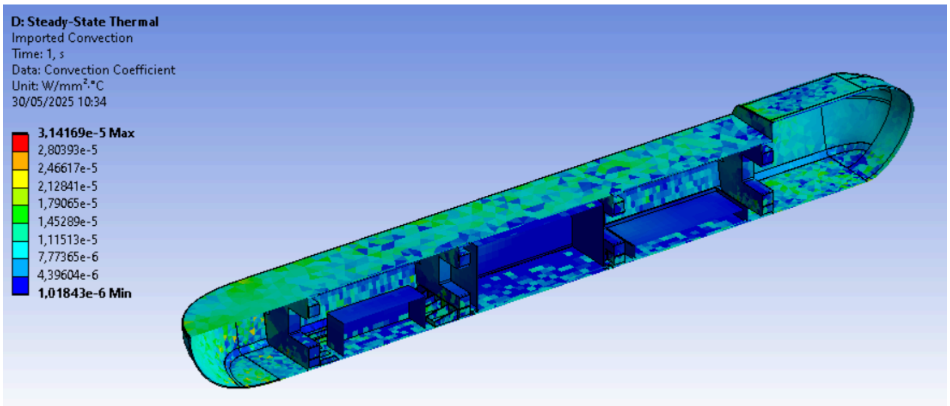

Figure 2.5.2-1: Case 1. Convection Coefficients.

With the heat flow conditions described above and considering an initial temperature of -56,5 °C at 20000 m The maximum equilibrium temperature would be of 53.8 °C located in the power source.

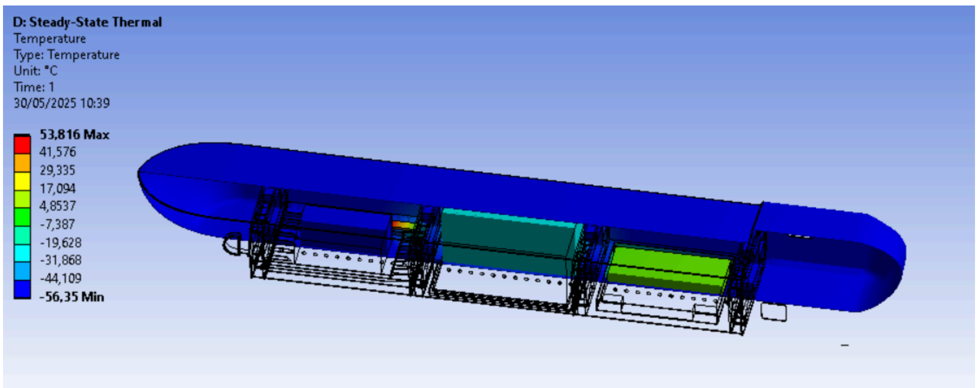

Figure 2.5.2-2: Case 1. Global Temperature Map

The local equilibrium temperature in each of the equipments would be:

- Power source: 53.8 °C

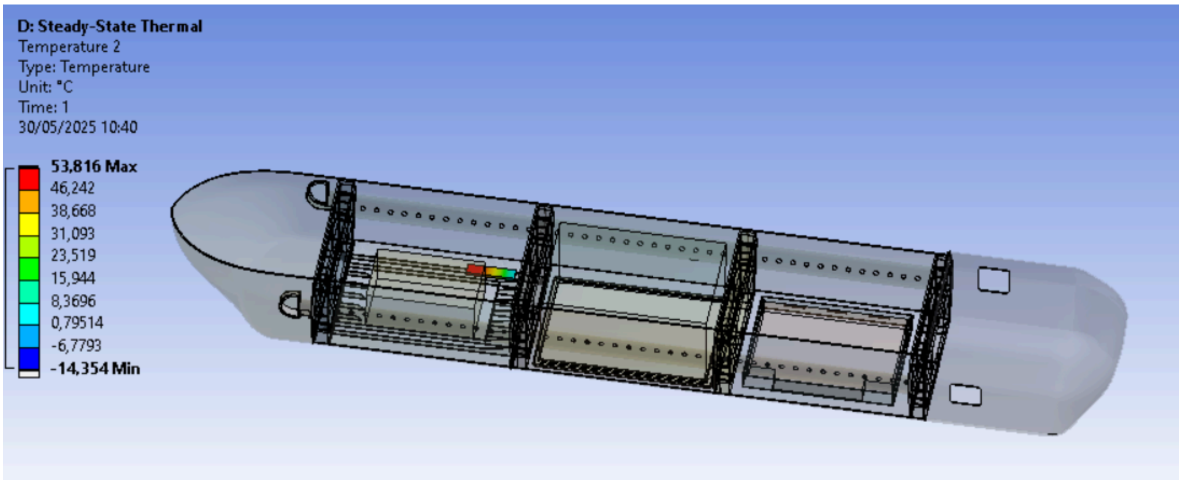

Figure 2.5.2-3: Case 1.Temperature Map (power source)

- Antenna AIR 3227: -24.6 °C

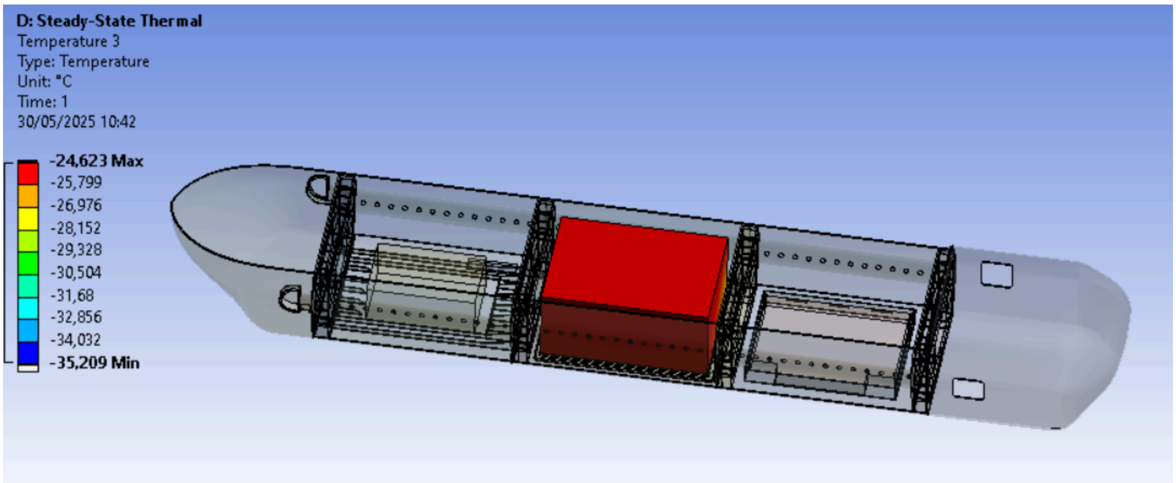

Figure 2.5.2-4: Case 1. Temperature Map (Antenna)

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- Baseband 6648: 6.91 °C

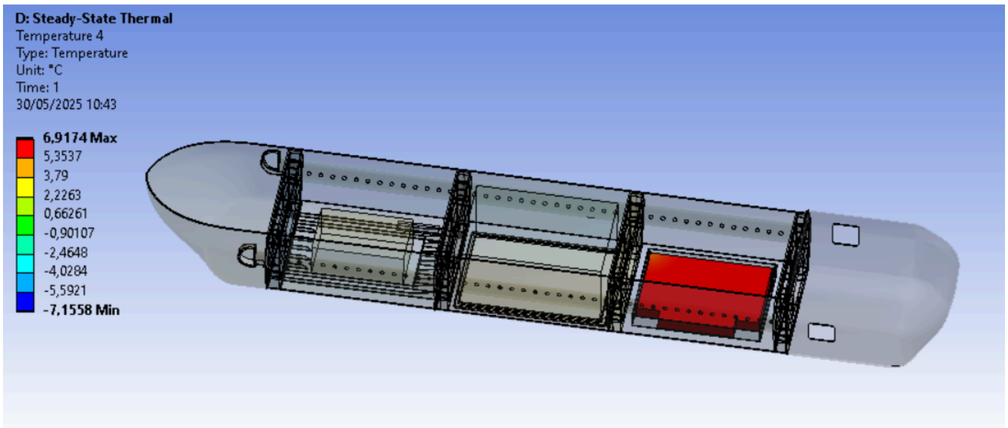

Figure 2.5.2-5: Case 1 Temperature Map (Baseband)

CASE 1	Global	Power Source	Antenna	Baseband
Time (s)	Max Temp (°C)	Max Temp (°C)	Max Temp (°C)	Max Temp (°C)
100	-21,867	-21,867	-55,897	-55,896
200	1,3034	1,3034	-55,578	-55,336
505,03	32,181	32,181	-54,728	-53,664
1852,7	46,757	46,757	-51,943	-46,985
3852,7	48,693	48,693	-48,166	-38,466
5852,7	49,497	49,497	-44,907	-31,295
7852,7	50,128	50,128	-42,098	-25,257
9852,7	50,655	50,655	-39,677	-20,173
11853	51,102	51,102	-37,591	-15,892
13853	51,482	51,482	-35,794	-12,288
15853	51,808	51,808	-34,245	-9,2535
17853	52,088	52,088	-32,912	-6,6983
19853	52,328	52,328	-31,763	-4,5468
21853	52,534	52,534	-30,773	-2,7354
23853	52,712	52,712	-29,921	-1,2101
25853	52,865	52,865	-29,186	7,41E-02
27853	52,997	52,997	-28,554	1,1554
29853	53,111	53,111	-28,009	2,0659
31853	53,209	53,209	-27,54	2,8325
33853	53,293	53,293	-27,135	3,4779
35853	53,366	53,366	-26,787	4,0214
37853	53,428	53,428	-26,487	4,479
39853	53,482	53,482	-26,229	4,8643
41853	53,528	53,528	-26,006	5,1887
43200	53,556	53,556	-25,873	5,3791

Table 2.5.2-1: Case 1. Transient temperature values

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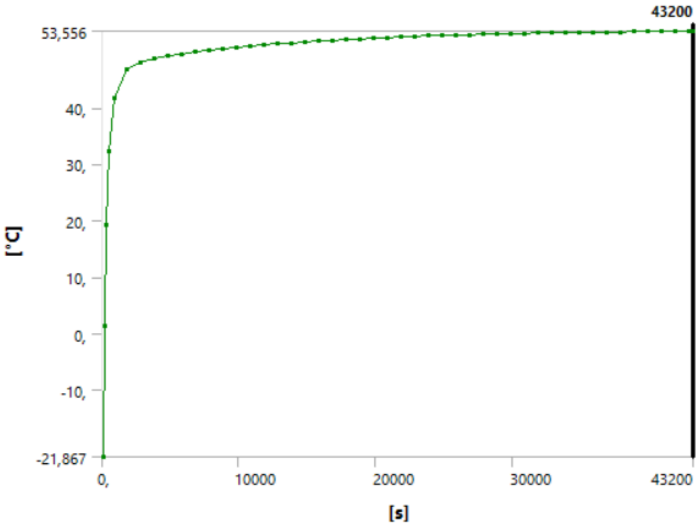

Figure 2.5.2-6: Case 1. Global Transient temperature graph

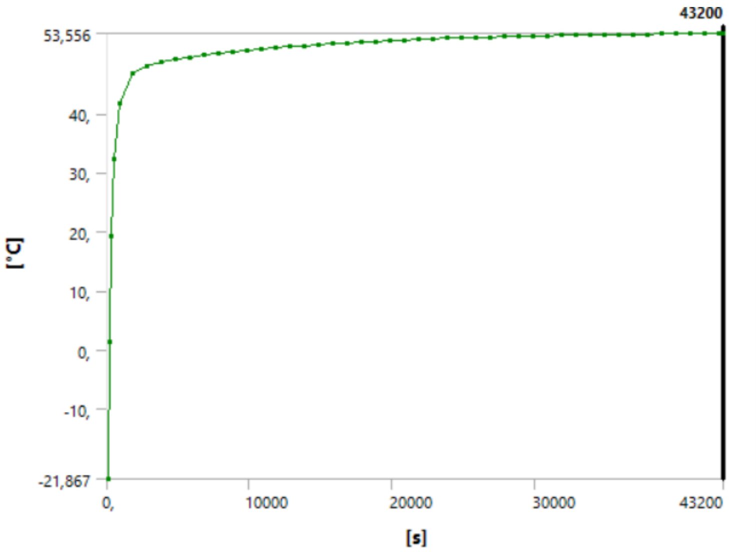

Figure 2.5.2-7: Case 1. Power source transient temperature graph

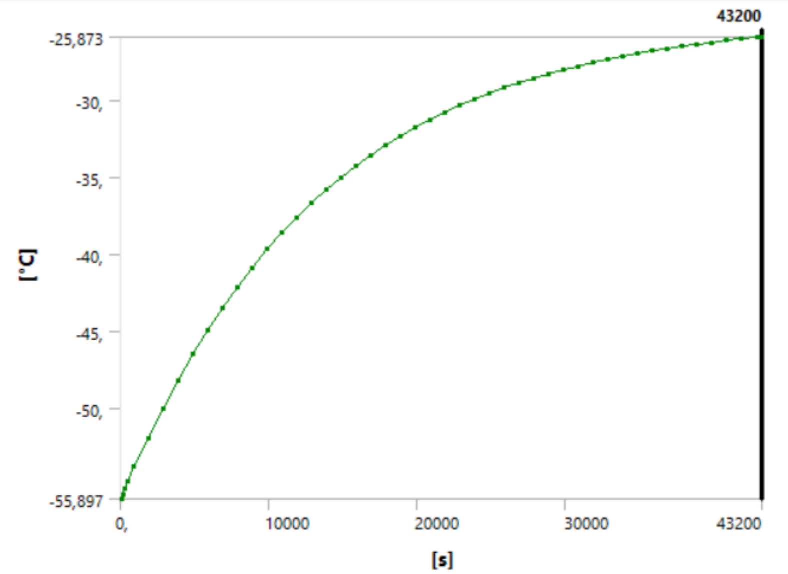

Figure 2.5.2-8: Case 1. Antenna transient temperature graph

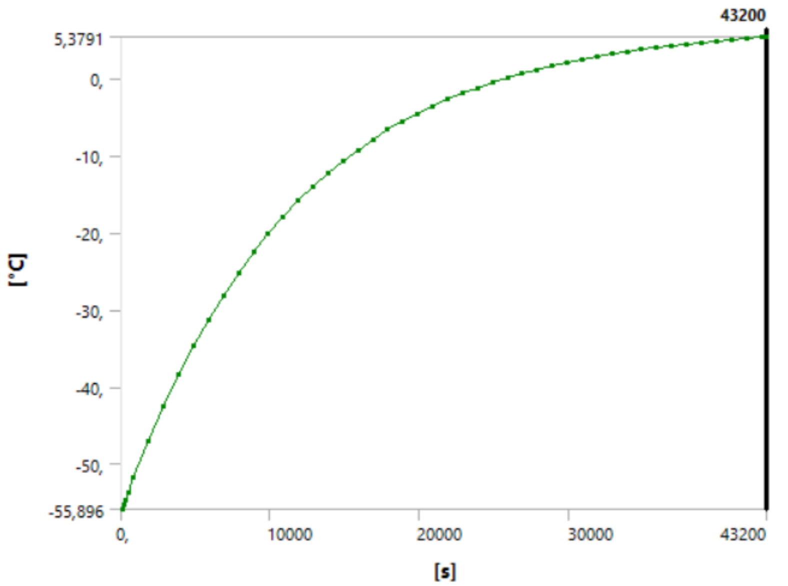

Figure 2.5.2-9: Case 1. Baseband transient temperature graph

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2.5.2.2. CASE 2: Airship near ground with high external temperatures (high velocity)

The convection coefficients map for the case 2 conditions is presented in the following image:

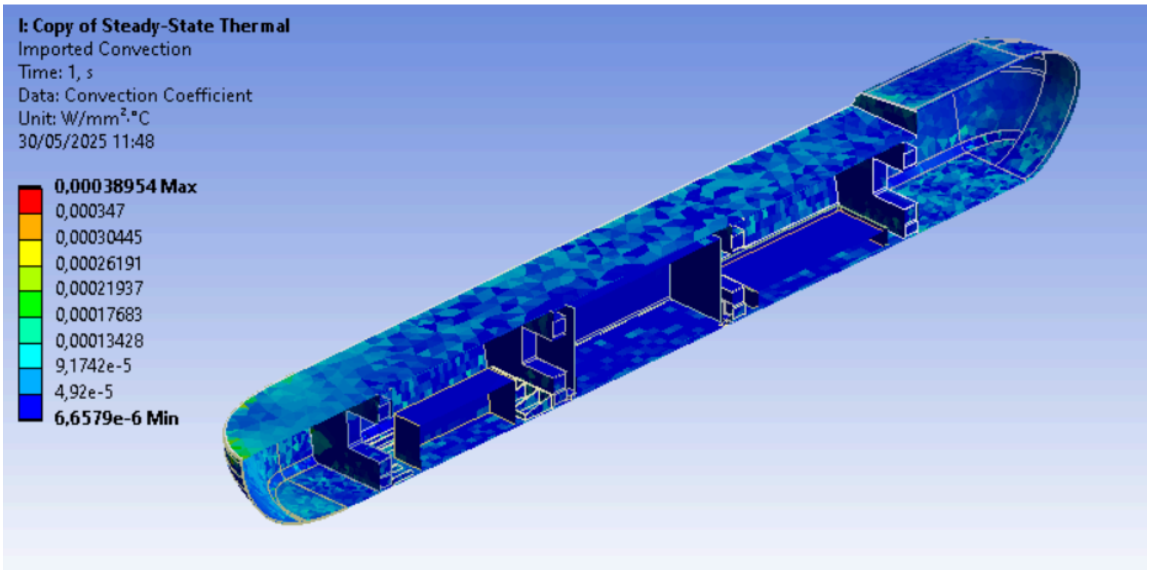

Figure 2.5.2-10: Case 2. Convection Coefficients.

With the heat flow conditions described above and considering an initial temperature of 40 °C at 0 m height. The maximum equilibrium temperature would be 96.8 °C located in the power source.

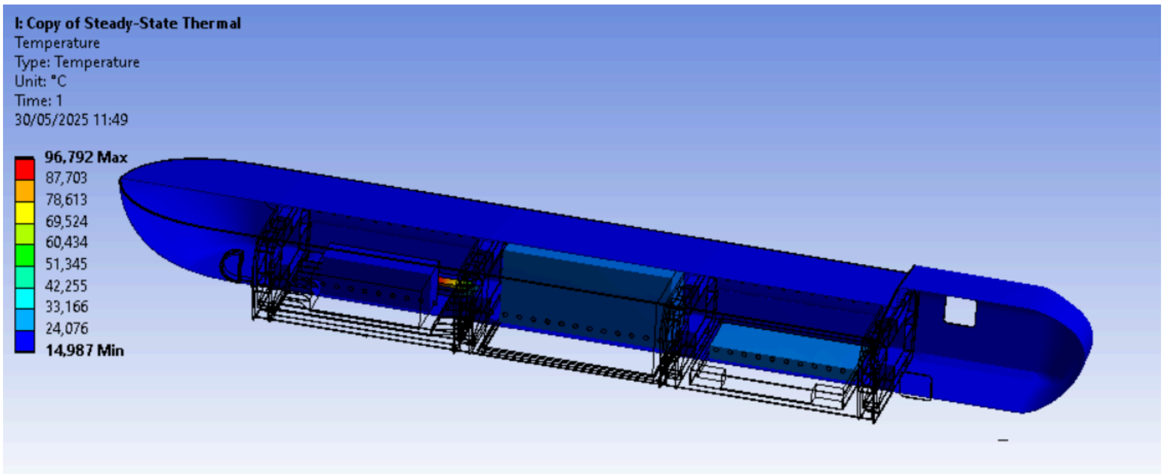

Figure 2.5.2-11: Case 2. Global Temperature Map

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The local equilibrium temperature in each of the equipments would be:

- Power source: 96.8 °C

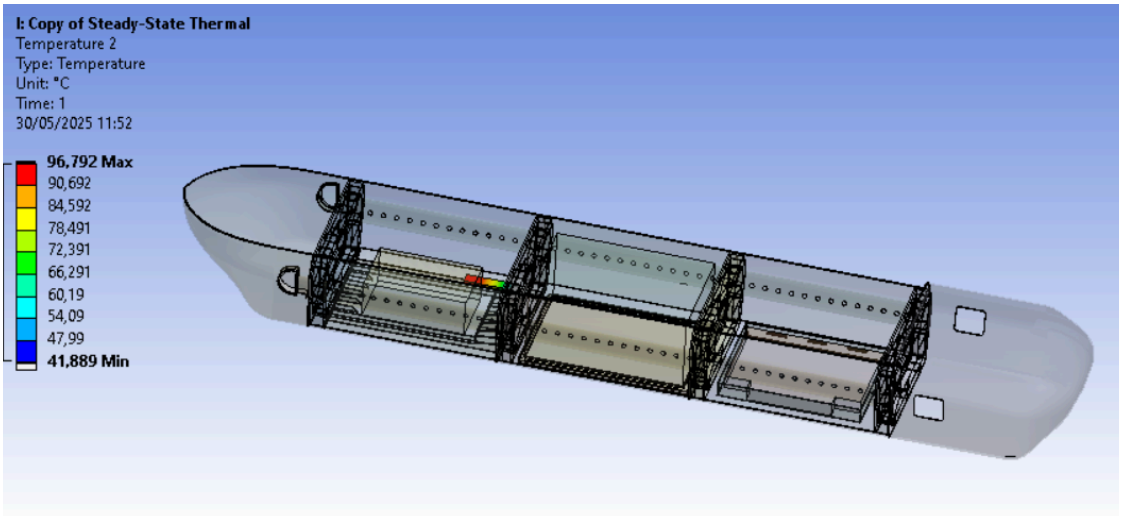

Figure 2.5.2-12: Case 2.Temperature Map (power source)

- Antenna AIR 3227: 25.87 °C

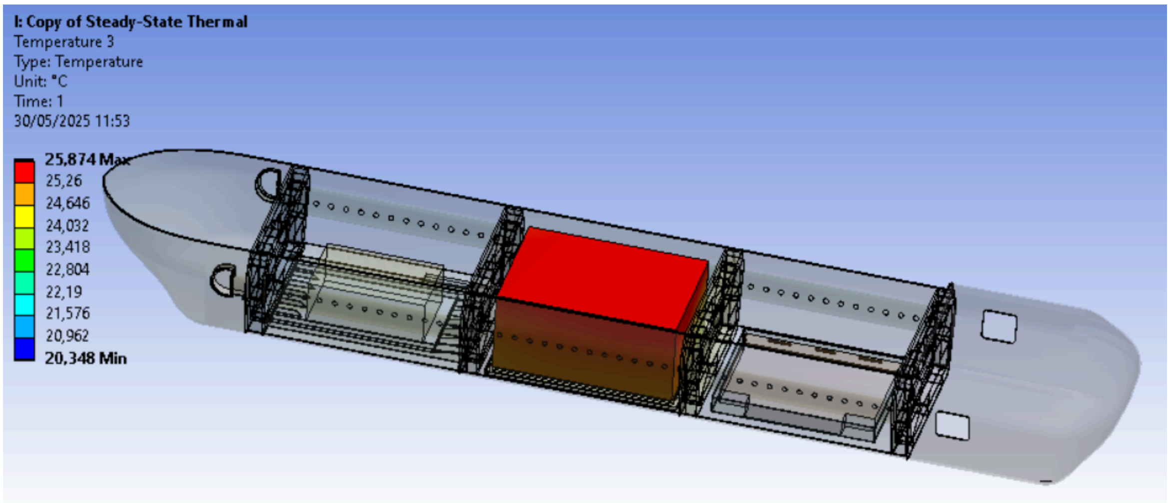

Figure 2.5.2-13: Case 2. Temperature Map (Antenna)

- Baseband 6648: 26.6 °C

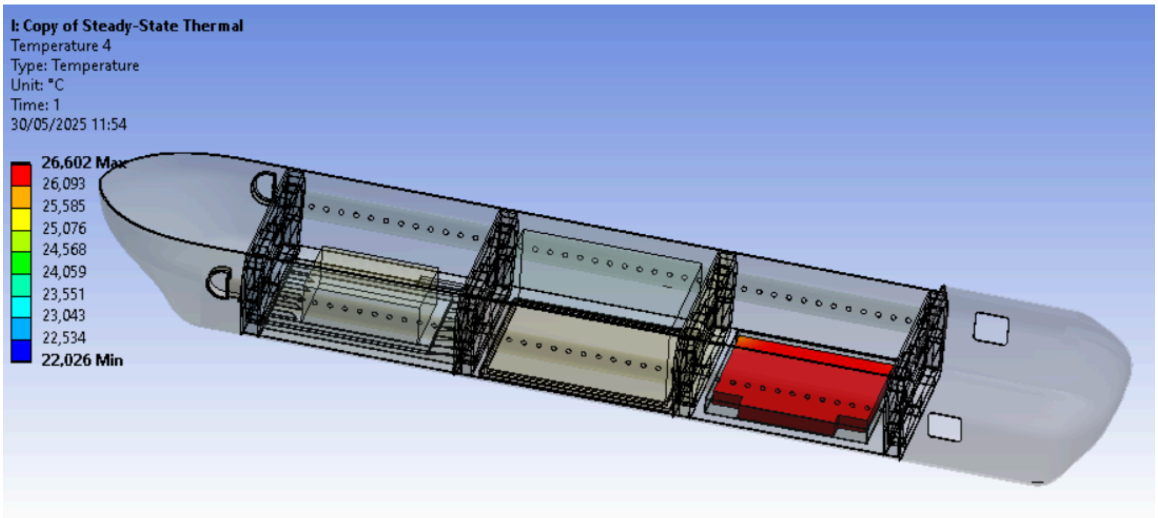

Figure 2.5.2-14: Case 2. Temperature Map (baseband)

CASE 2	Global	Power Source	Antenna	Baseband
Time (s)	Max Temp (ºC)	Max Temp (ºC)	Max Temp (ºC)	Max Temp (ºC)
100	66,795	66,795	40,273	39,523
200	81,65	81,65	40,191	38,966
500	93,993	93,993	39,469	37,387
2400	97,591	97,591	35,057	31,521
4400	97,171	97,171	31,898	28,764
6400	96,997	96,997	29,823	27,552
8400	96,916	96,916	28,463	27,02
10400	96,871	96,871	27,571	26,785
12400	96,843	96,843	26,986	26,683
14400	96,825	96,825	26,603	26,637
16400	96,814	96,814	26,352	26,617
18400	96,806	96,806	26,187	26,609
20400	96,802	96,802	26,079	26,605
22400	96,798	96,798	26,009	26,603
24400	96,796	96,796	25,962	26,602
26400	96,795	96,795	25,932	26,602
28400	96,794	96,794	25,912	26,602
30400	96,793	96,793	25,899	26,602
32400	96,793	96,793	25,89	26,602
34400	96,793	96,793	25,885	26,602
36400	96,793	96,793	25,881	26,602
38400	96,792	96,792	25,879	26,602
40400	96,792	96,792	25,877	26,602
43200	96,792	96,792	25,876	26,602

Table 2.5.2-2: Case 2. Transient temperature values

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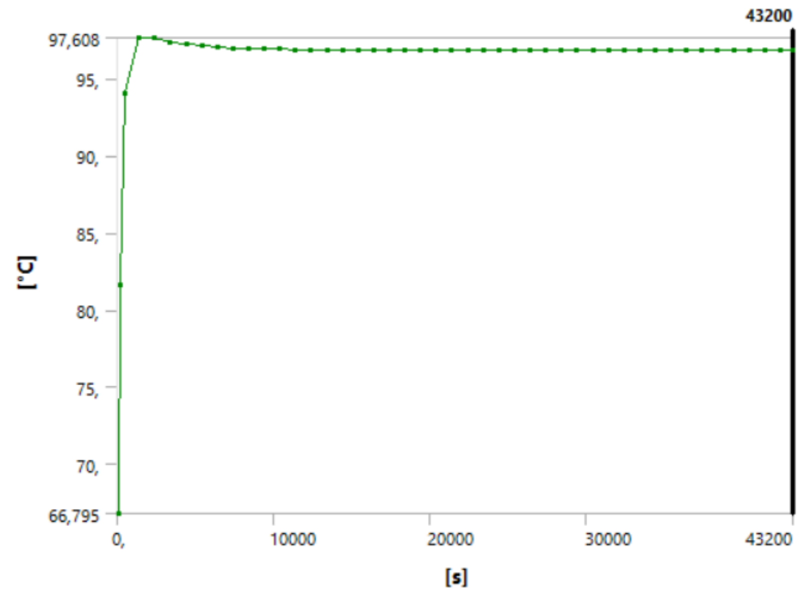

Figure 2.5.2-15: Case 2. Global Transient temperature graph

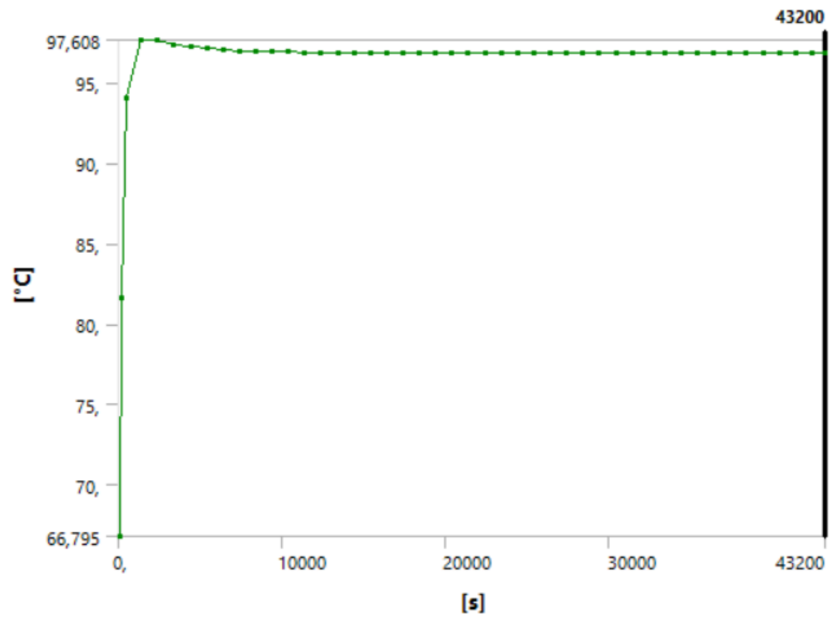

Figure 2.5.2-16: Case 2. Power source transient temperature graph

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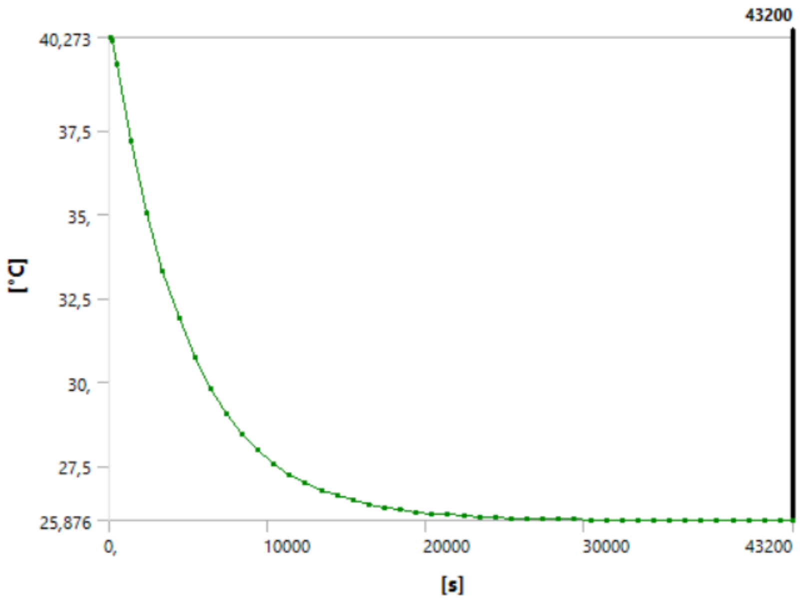

Figure 2.5.2-17: Case 2. Antenna transient temperature graph

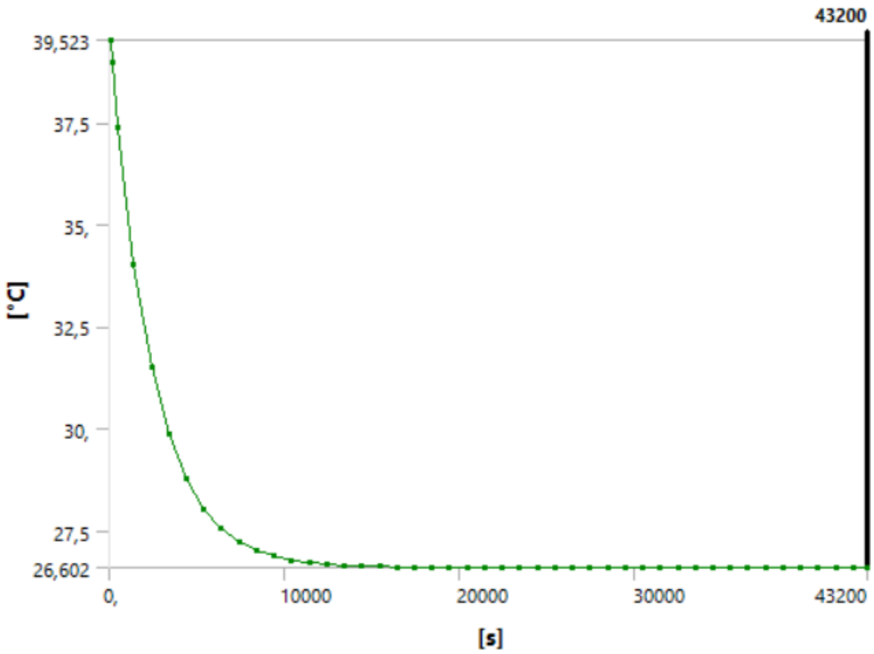

Figure 2.5.2-18: Case 2. Baseband transient temperature graph

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3. Summary and conclusions

3.1. Summary

This document details the preliminary design of a specialized POD intended for integration with High-Altitude Platform Station (HAPS) aircraft. The POD is designed to house and support the operation of 5G and 6G telecommunications systems, enabling expanded connectivity in remote or challenging environments.

The design process encompassed several critical areas:

- **Aerodynamic Profile**: The POD features a streamlined, elongated form with a constant rectangular cross-section and carefully contoured ends to minimize drag and ensure stable integration with the aircraft's wing.
- **Structural Design:** The POD's structure utilizes a combination of external skin, transverse frames, and longitudinal stiffeners to achieve a robust yet lightweight construction capable of withstanding flight loads. Specialized frames are incorporated for secure attachment to the aircraft's wing.
- **Equipment Integration**: The design accommodates the integration of key 5G/6G equipment, including baseband units and antennas, with considerations for power supply and cabling.
- **Environmental Control System (ECS)**: An air-cooling system, leveraging both free and forced convection, is designed to maintain optimal operating temperatures for the internal equipment.
- **Finite Element Method (FEM) Analysis**: A comprehensive structural analysis was conducted, incorporating external pressure data derived from the CFD models, to evaluate the POD's performance under a critical load condition and confirm its structural integrity.

3.2. Conclusions

This preliminary design provides a solid foundation for the development of a functional 5G/6G telecommunications POD for HAPS aircraft. The design effectively addresses key considerations such as aerodynamic efficiency, structural integrity, equipment integration, and thermal management. Further development will focus on:

- Detailed design and optimization of the ECS.
- Refinement of the structural design based on FEM analysis results.
- Integration of specific communication interfaces with the host aircraft.
- Detailed design of equipment anchoring and cabling systems.
- Material selection and manufacturing process definition.

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This design represents a significant step towards enabling the deployment of next-generation communication networks in areas where traditional infrastructure is limited.

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4. References

ERICSSON, Antenna Integrated Radio Unit Description, 2020. [Online]. Available: https://es.scribd.com/document/770814842/AIR-3227-01

ERICCSON, Baseband Description, 2022. [Online]. Available: https://es.scribd.com/document/730003635/Baseband-ConnectionsBaseband-6648

VICOR, BCM in VIA Package Bus Converter. 2020. [Online]. Available: https://www.vicorpower.com/documents/datasheets/ds_BCM4414xD1E5135yzz.pdf

C. A. Balanis, Antenna Theory:Analysis and Design, Wiley, 2016.

R. Mark Rennie et al.: Aerodynamic Design of an Aircraft-Mounted Pod for Improved Aero-Optic Performance, 2014

Megson, T.H.G.: Aircraft Structures for Engineering Students, 2021.

R. Mark Rennie et al.: Aerodynamic Design of an Aircraft-Mounted Pod for Improved Aero-Optic Performance, 2014.

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