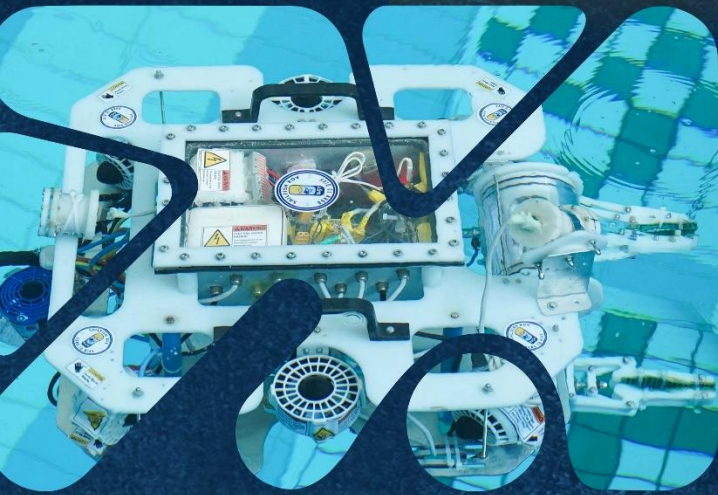


SAILFISH ROV



MEGALODON

Figure 1: MEGALDON ROV captured By Zakaria

Supervisor

Dr. Hossam Ramadan

27' Mohamed Elsayed — CEO

Mechanical

- 27' Abdelrhman Zakaria — Mechanical Head**
- 27' Abd elhamed Barka — Vice Mechanical**
- 26' Ahmed Sanad — Leader Body**
- 27' Marcos Albert — Mechanical Eng.**
- 27' Ramez Mohamed — Mechanical Eng.**
- 26' Rawan Ahmed — Mechanical Eng.**
- 27' Mohamed Abu zaid — Mechanical Eng.***
- 28' Abdalrhman Elgabry — Mechanical Eng.***
- 28' Ahmed Elkholy — Mechanical Eng.***
- 28' Hassan Muhammed — Mechanical Eng.***
- 27' Ziad Hosni — Leader Mechanism**
- 27' Mostafa Mohamed — Mechanical Eng.***
- 27' Abdala Khaled — Mechanical Eng.***
- 27' Nour Aboghaly — Mechanical Eng.***
- 27' Farah Fathy — Mechanical Eng.***
- 26' Ahmed Samir — Leader Sealing**
- 26' Abdelaziz Amir — Mechanical Eng.**
- 27' Omar Henedaq — Mechanical Eng.***
- 27' Omar Adel — Mechanical Eng.***
- 28' Hassan Maher — Mechanical Eng.***
- 28' Mostafa Mamdouh — Mechanical Eng.***

Non-Technical

- 27' Maram Ayman — Head Non-Technical**
- 27' Mariam Ahmed — Business***
- 28' Malak Mohamed — Business***
- 27' Basmala Sameh — Business***
- 28' Haneen Mohamed — Business***
- 27' Kareem Salah — Business***

Legend

- 27' Graduation Year**
- * New Member**



HIGHER TECHNOLOGICAL INSTITUTE
10th Of Ramadan City
Sharqia, Egypt

TECHNICAL REPORT 26

Software

- 26' Atif Ehab — Software Head**
- 28' Omar Hany — Software Eng.***
- 28' Toqa Mohammed — Software Eng.***
- 28' Mickael Ayman — Software Eng.***
- 28' Pavly Ihab — Software Eng.**
- 26' Jason Ehab — Software Eng.**
- 27' Reem Mohamed — Software Eng.***
- 28' Ali Mohamed — Software Eng.***
- 27' Abdullah Mohamed — Software Eng.***
- 28' Ahmed Yehia — Software Eng.***
- 28' Rawan Mahmoud — Software Eng.***

Hardware

- 26' Ebrahim Shahein — Head Hardware**
- 26' Abdllah Gamal — Hardware Eng**
- 27' Ahmed Yasser — Hardware Eng**
- 27' Amr Baligh — Hardware Eng**
- 27' Ahmed Yasser — Hardware Eng**
- 26' Ahmed Ashraf — Hardware Eng***
- 28' Ammar Abdelrhman — Hardware Eng***
- 27' Mahmoud Elsayed — Hardware Eng***
- 28' Alaa Mohamed — Hardware Eng***
- 28' Abdalrahman Mohamed — Hardware Eng***
- 28' Adham Khaled — Hardware Eng***
- 27' Kareem Sameh — Hardware Eng***

Mentors

- Ali Esam — Mechatronics Eng.**
- Mohamed Samir — Mechatronics Eng.**
- Fady Samy — Mechanical Eng.**
- Nader Elsaeed — Mechatronics Eng.**
- Mohamed Shehata — Mechanical Eng.**
- Mohamed Metwaly — Mechatronics Eng.**

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- Our Families: Their continuous support and encouragement.
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- Underwater Robotics Challenges: For providing components and funding support.



Figure 1: Acknowledgements

1. Introduction

1.1 Abstract

Sailfish ROV, based at the Higher Technological Institute in 10th of Ramadan, Egypt, and established in 2012, advances underwater engineering and collaboration skills by designing and manufacturing remotely operated vehicles (ROVs). multidisciplinary engineering team dedicated to advancing underwater robotics in alignment with Egypt's Vision 2030, promoting innovation, sustainability, and applied engineering solutions. The team follows a structured systems engineering methodology to ensure efficiency, reliability, and high-performance outcomes.

For the MATE ROV 2026 Egypt regional competition, the Company presents **MEGALODON**, an advanced upgrade of the ORCA platform, engineered to successfully meet mission tasks while maintaining full compliance with the MATE competition manual, including safety regulations, size limitations, and operational constraints.

MEGALODON features a modular aluminum frame designed for optimal strength-to-weight ratio and corrosion resistance. The system is engineered for ease of assembly, efficient maintenance, and smooth inspection, directly supporting competition requirements and minimizing potential failure points.

An AI-assisted stereo vision system is integrated to enhance mission performance through object detection, target recognition, depth estimation, and precise alignment. This enables accurate execution of vision-based tasks and improves interaction with complex underwater environments.

Task-specific mechanisms are developed using advanced **3D** modeling and simulation, ensuring precision, durability, and functional reliability. These mechanisms are optimized to meet mission objectives while strictly adhering to competition constraints and operational requirements.

The propulsion system provides full 6-degree-of-freedom maneuverability, ensuring stability, control, and accurate navigation during mission execution, supported by a responsive control system.

Safety is prioritized through proper electrical insulation, waterproof sealing, and secure system integration to mitigate risks and ensure safe operation.

With a team of **46** members, **MEGALODON** delivers a compliant, reliable, and mission-optimized ROV solution capable of achieving high performance in competitive environments.

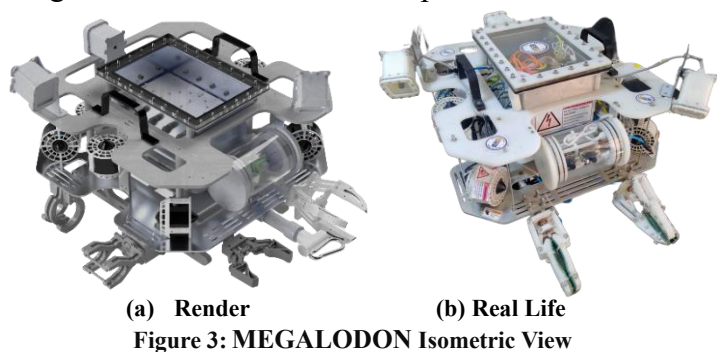


Figure 2: Sailfish ROV company members

2 Design Rationale

2.1 Design Evolution

Building on lessons learned from Orca, MEGALODON represents Sailfish ROV's most refined iteration to date. Through systematic R&D analysis of previous designs, the team identified key shortcomings and opportunities for improvement across durability, maneuverability, and imaging systems. 3D-printed mounting parts were eliminated in favor of robust alternatives, the camera enclosure was redesigned for stable positioning for new cameras, and the ROV base was rebuilt as a precision CNC-machined structure. CFD, FEA and buoyancy analyses were conducted to validate structural integrity, hydrodynamic performance and stability. This iterative, analysis-driven process culminated in a more capable, mission-ready ROV engineered to meet MATE competition demands.

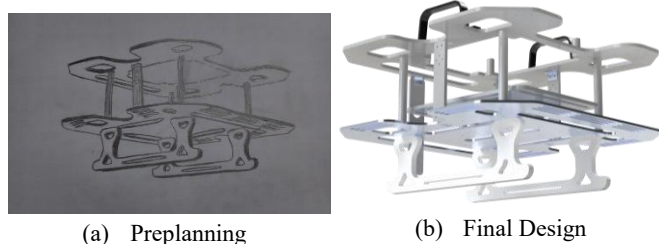


(a) Render (b) Real Life
Figure 3: MEGALODON Isometric View

2.1.1 Mechanical System Design Evolution

• Frame:

MEGALODON's frame was selected after careful preplanning and brainstorming the optimal design for the thruster's configuration. As shown in **Figure (4)**, we designed it with ease of installation and disassembly in mind. The frame consists of one aluminum plate connected by Artelon rods, resulting in a lightweight yet robust structure. This geometry offers a broader area for mounting equipment compared to alternative designs. The thrusters' mount plate, integral to the frame's geometry, enhances the propulsion system's efficiency by expanding the operating area in front of each thruster's throttle. This configuration minimizes drag force on MEGALODON and ensures maximum thrust force by eliminating obstructions within the thrusters' operational perimeter.



(a) Preplanning (b) Final Design

Figure 4: Frame Design Evolution

• Camera Housing

Rectangular housing was selected with the highest weighted score of 56/70 in the decision matrix. Its flat internal geometry maximizes usable inner space, allowing the camera to be securely mounted in a fixed orientation with ease of access for adjustment and maintenance. While the cylindrical profile offers superior hydrodynamic performance and sealing reliability through natural O-ring grooves, the rectangular housing's advantages in camera stability, inner space utilization, and ease of fixing outweigh these benefits, making it the most suitable choice for MEGALODON's camera housing design.

Table (1): Decision Matrix of Camera Housing

Shape	Camera Stability	Inner Space Utilization	Ease of Manufacturing	Hydrodynamic Drag	Ease of Fixing	Total (Out of 70)
Rectangular	9	9	8	6	9	56
Cylindrical	6	7	7	9	6	51

• Base

The CNC base was selected with the highest weighted score of 53/60. Its monolithic flat geometry ensures uniform load distribution, eliminating the localized stress concentrations inherent to cylindrical rod point-contact interfaces. CNC machining guarantees dimensional tolerances within ± 0.1 mm, applying FEA analysis to ensure the ROV loads are withstanding. The base is designed as two parallel parts oriented along the surge axis, minimizing frontal cross-sectional area and reducing drag coefficient during forward motion. Its hollowed geometry allows unobstructed water streaming through it while providing comfortable accessible space beneath the lower plate for component fixing and maintenance. Strategically integrated relief cutouts reduce net mass while preserving the plate's section modulus, optimizing the buoyancy-to-weight ratio and contributing positively to static stability.

Table (2): Decision Matrix of ROV Base

Design	Structural Rigidity	Load Distribution	Mounting Flexibility	Dimensional Accuracy	Stability	Total (Out of 60)
CNC Base	9	9	9	9	9	53
Cylindrical Rods	7	6	6	7	6	38

• Mechanisms:

The company integrated new mechanisms to solve the recent challenges including the new rotating clutch mechanism, buoy anchor mechanism and heavy hook mechanism which contribute to the versatility and performance of the ROV and increase mission success rate. The mechanisms are constructed from Artelon with an 8mm thickness. Artelon was chosen for its low density, making it lightweight compared to other materials. During the material selection process, Artelon was selected for its cost-effectiveness, high machinability, non-corrosiveness, and superior

strength, making it an ideal choice for MEGALODON's mechanisms.

• The Electronics Enclosure:

The previous cylindrical enclosure presented significant limitations in component access and maintenance efficiency, necessitating a complete redesign into a rectangular geometry. The cubic structure maximizes internal volume utilization, enabling a structured three-layer component arrangement, streamlined cable routing, and substantially reduced recalibration downtime. The rectangular profile's inherent drag penalty was directly mitigated by positioning the stereo camera housing retaining its cylindrical cross-section ($C_D \approx 0.47$) at the forward face of the enclosure. This cylindrical profile effectively reduces flow separation and frontal pressure drag during surge motion, functioning as a hydrodynamic fairing for the assembly. This combined approach successfully achieves an optimal balance between full internal accessibility and hydrodynamic efficiency without compromise.

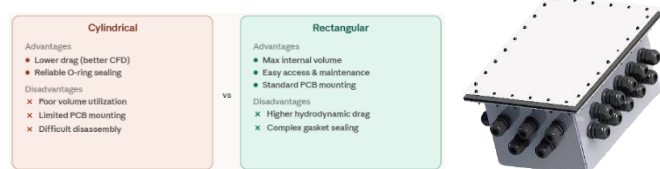


Figure 5: Electronics Enclosure

2.1.2 Electrical System Design Evolution

Previous year MEGALODON used to have a set of UVC cameras, and they served for their tasks mediocrely, then we decided to update MEGALODON's cameras system according to some parameters, into IP-cam main parameters for this switching was the processing on cameras on microprocessor as low processing on it, also the performance of this camera in low lights as it will operate underwater.

Table (3): UVC and IP Camera Specification Overview

Attribute	IP Camera	UVC Camera
Interface	Ethernet / PoE	USB
FOV	High	Medium
Processing on Pi	Very Low	Low-Medium
Low light performance	High	Medium
Cost	Medium	Medium

• Single Board Computer (SBC)

The system architecture was upgraded from Raspberry Pi 3 Model B+ to Raspberry Pi 5 to improve performance and communication efficiency in the MEGALODON ROV. The Raspberry Pi 5 acts as the main communication interface between the STM32 microcontroller and the operator's workstation via Ethernet, enabling fast and reliable real-time data

exchange. This upgrade was driven by the need for higher processing power, better networking performance, and compatibility with frameworks such as ROS2. Compared to the previous version, the Raspberry Pi 5 offers improved computational capability, true Gigabit Ethernet, and higher I/O bandwidth, resulting in lower latency, enhanced stability, and better scalability for future system expansion.

Table (4): Single Board Computer Specification Comparison

Feature	Raspberry Pi 3 Model B+	Raspberry Pi 5
CPU	Quad-core Cortex-A53 @ 1.4 GHz	Quad-core Cortex-A76 @ 2.4 GHz (Much faster)
RAM	1 GB	Up to 8 GB
Ethernet	Gigabit (limited via USB 2.0)	True Gigabit Ethernet
USB	USB 2.0	USB 3.0 + USB 2.0
GPU	Basic VideoCore IV	Much more powerful GPU
Performance	Suitable for basic tasks	High-performance, real-time capable
ROS2 Compatibility	Limited performance	Excellent support

• STM32

The STM32F103 microcontroller is responsible for precise control of thrusters and mechanical components. The selection of STM32F103 for managing these tasks is based on the trade-off analysis presented in **Table (5)**, which highlights its superior real-time performance, low power consumption, and excellent suitability for control systems that require precise and timely adjustments. These features make the STM32F103 the ideal choice for controlling the system, where real-time responsiveness and stability are crucial for effective maneuvering.

Table (5): Trade-off Analysis of STM32F103 vs. ESP32

Factors	STM32F103	ESP32	Decision
Processing Power	72 MHz ARM Cortex-M3, 32-bit	240 MHz dual-core Ten silica LX6, 32-bit	ESP32
Real-Time Performance	Excellent real-time control	Decent, but lacks deterministic real-time performance	STM32F103
Power Consumption	Very low	Higher power consumption	STM32F103
Connectivity	SPI, I2C, UART, CAN, USB, GPIO (No built-in wireless)	Built-in Wi-Fi and Bluetooth, SPI, I2C, UART, GPIO	ESP32
I/O Pins	40	34	STM32F103
Use Case	Best for real-time control, embedded systems	Ideal for IoT, wireless communication	STM32F103
Cost	Low	Moderate	STM32F103

• Stereo-vision camera

The stereo camera on Megalodon is designed to provide accurate, real-time measurements of underwater objects without relying on external references. By utilizing two IP cameras, the system mimics human binocular vision and captures depth information through stereoscopic imaging. Proper calibration of these cameras is essential to ensure precise measurement. Integrating the stereo camera marks a significant advancement for Megalodon, enabling it to perform tasks such as measuring the keel depth of the iceberg with high accuracy an essential capability for completing advanced MATE missions.

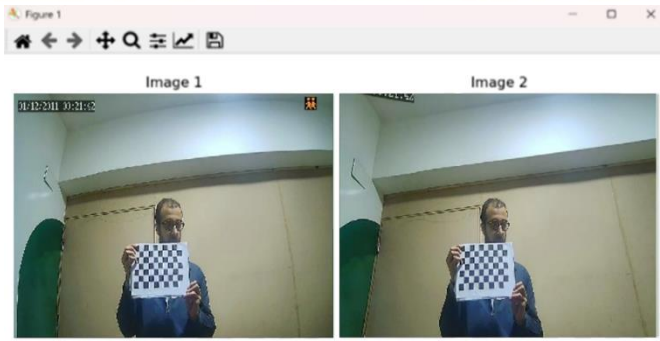


Figure 6: Stereo-vision camera

2.1.3 Software System Design Evolution

• PID Controller

This year, enhanced **MEGALODON**'s PID control by replacing last year's manually tuned gains with a calibrated IMU-based feedback loop and an autotuning method that accurately computes the optimal K_p , K_i , and K_D values across roll, pitch, and yaw. These improvements result in noticeably higher stability and smoother maneuverability under varying underwater conditions, giving the pilot more consistent, predictable control. As a result, **MEGALODON** can maintain precise positioning during demanding MATE tasks such as holding a perfectly steady hover over the coral garden in strong currents a challenge that truly highlights the power and reliability of our upgraded control system.

• ROS 2

ROS2 was adopted as the core framework for **MEGALODON** to enhance reliability, scalability, and control performance. This season, critical nodes were migrated from Python to C++, achieving lower latency, improved real-time responsiveness, and more deterministic control. The system is organized into modular ROS2 nodes handling system management, IMU acquisition, EKF state estimation, PID control, STM32 interfacing, and topside communication, enabling rapid debugging and seamless integration. Leveraging ROS2's DDS-based middleware, **MEGALODON** ensures efficient, low-latency, and reliable data exchange between all subsystems, resulting in a stable, scalable, and high-performance architecture ready for complex missions.

3 Problem Solving

• Camera Lack of Support

Previous camera housings lacked a secure internal mounting system, resulting in displacement and misalignment during operation. A custom inner fixture was designed to firmly secure the camera,

preventing rotational and translational displacement while maintaining true orientation and ensuring 100% FoV relative to the outer housing aperture for full, unobstructed visibility.

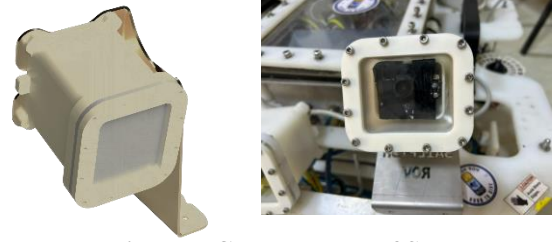


Figure 7: Camera Lack of Support

• Control Box Internal Disorganization

To improve internal organization and maintenance efficiency, a multi-layer acrylic plate system was integrated within the control box. Each layer serves as a dedicated mounting surface for a specific set of electronic components, providing structured cable routing and clear separation between power, control, and communication systems. This layered configuration significantly reduces wiring complexity, minimizes the risk of cable interference, and accelerates troubleshooting during disassembly. Acrylic was selected for the internal plates due to its low density, reducing the overall mass.



Figure 8: MEGALODON's Control Box Internal Disorganization

4 Payload and Tools

• Camera Placement

MEGALODON's vision system consists of six IP cameras. As illustrated in Figure (9), the cameras are distributed to ensure full coverage of all critical mechanisms. Each camera is connected via CAT6 cabling to a PoE switch, which provides both power and data connectivity. The PoE switch is then connected to the NVR located on the top control side, enabling centralized video recording and management. Two of the IP cameras are configured as a stereo-vision pair, serving as the primary visual interface for the pilot and supporting image processing tasks.

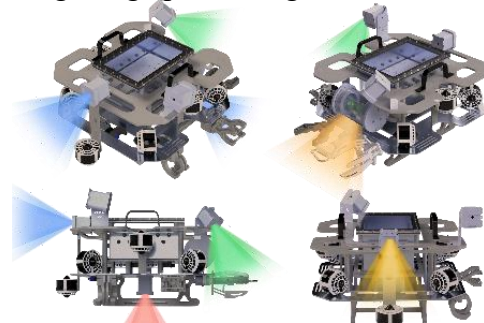


Figure 9: MEGALODON's Vision System



• Mechanisms

MEGALODON is equipped with a range of versatile mechanisms, including a two-jaw gripper and a tri-finger gripper. These mechanisms efficiently convert pneumatic power into precise movements, enabling **MEGALODON** to perform specific tasks during the competition. Pneumatic systems are particularly advantageous due to their simplicity, reliability, and cost-effectiveness. They offer high power-to-weight ratios, rapid response times, and safe operation. Furthermore, these systems are clean, versatile, and require minimal maintenance.

The mechanisms are constructed from Artelon with an 8mm thickness.

(1) Rotating Clutch Mechanism

This mechanism utilizes an enclosed DC motor to rotate a base any number of revolutions required. The clutch is designed to rotate cylindrical objects with two rolling elements allowing for an easy approach and a decent gripping of the object.

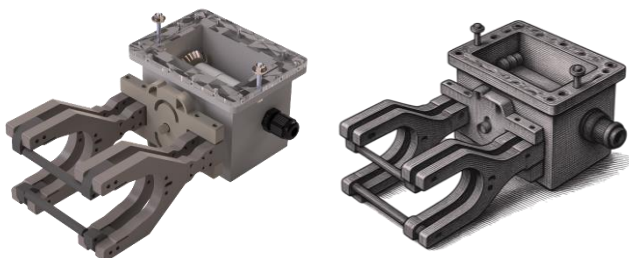


Figure 10: Rotating Clutch Mechanism

(2) Tri-Finger Gripper

This manipulator is designed for heavy-duty manipulation tasks that require a sturdy mechanism to handle or tasks that the front and side grippers can't handle. It can carry heavier weights than the front and side facing grippers but at the cost of a smaller opening the maximum task diameter is 89 mm, the minimum task diameter is 5 mm, the base width is 135 mm, the maximum width when fully open is 158 mm, and the length from the base is 170 mm.

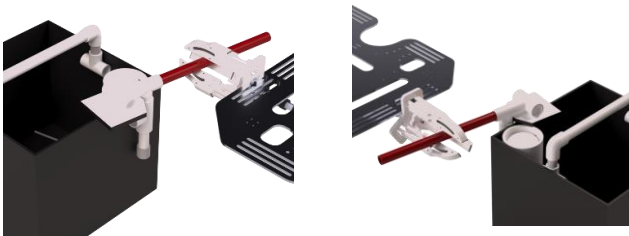


Figure 12: Tri-Finger Gripper

(3) Front-facing 2-jaw gripper

This is a general-purpose mechanism designed to manipulate most objects underwater. It is designed to have an initial parallel-motion opening with a wider arc

motion as the actuating stroke increases, this allows for large object manipulation in a compact frame. The maximum task diameter is 150 mm, the minimum task diameter is 5 mm, the base width is 90 mm, the maximum width when fully open is 175 mm, and the length from the base is 130 mm.

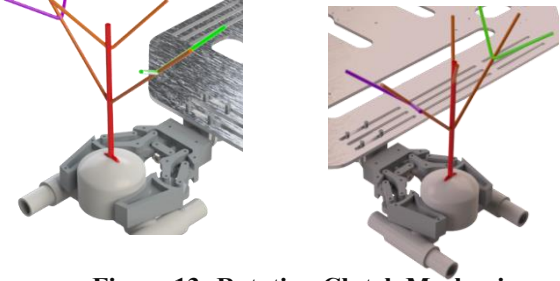


Figure 13: Rotating Clutch Mechanism

(4) Jaw Mechanism

The jaw mechanism allows for large objects precise handling. It utilizes a pneumatic piston to actuate a jaw that clamps the carried object making it easier to transport and handle.



Figure 11: Jaw Mechanism

(5) Side-Facing 2-jaw gripper

This is a general-purpose mechanism designed for the various tasks in MATE competition. It features a wide opening angle allowing it to grip large objects, and a tight grip on tiny and thin objects using the straight jaw edge. The maximum task diameter is 220 mm, the minimum task diameter is 15 mm, the base width is 85 mm, the maximum width when fully open is 265 mm, and the length from the base is 135 mm.

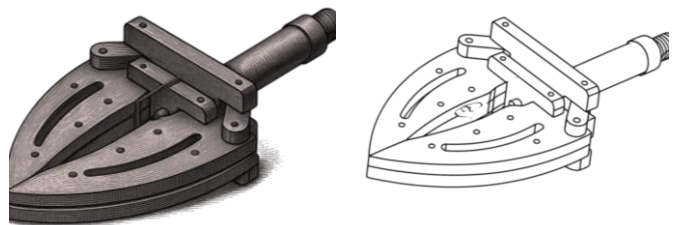


Figure 14: Rotating Clutch Mechanism

• Vertical Float

The Manta is a variable-buoyancy vertical profiling float that achieves precise depth control by modulating mass at constant volume. Two one-way pumps (17 mL/s each) fill and drain a 2.15 L contoured ballast tank, enabling a 2.5 m target depth with 30 s station-keeping.



The mechanical assembly is mounted on four 6 mm stainless-steel guide rods; electrical components reside in isolated upper sections, while cast-iron ballast plates lower the center of gravity. A 12 V AGM battery supplies power through a 3 A fused network, feeding the ESP32 via a 5 V step-down regulator and the depth sensor via a 3.3 V regulator. Closed-loop PID control uses continuous I2C depth feedback, with a water-level switch providing independent overflow protection. Telemetry is transmitted in real time using a dual-ESP32 ESP-NOW link to a surface laptop for CSV data logging. Dual pressure-relief end caps and a partitioned layout further enhance operational safety.



Figure 15: Vertical Float

• Mission Systems Strategy for MATE

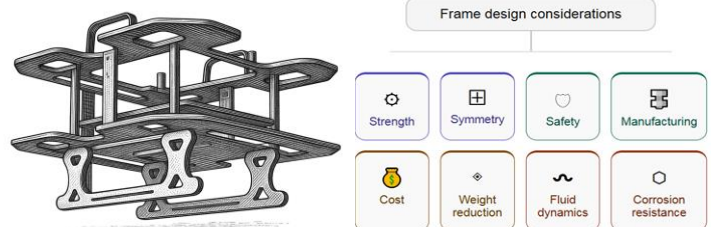
The Sailfish ROV achieved a balanced system in its payload and tool design for MATE missions. The entire team collaborated to integrate thrusters, manipulators, and cameras, aligning with the intended strategy **Appendix (E)**. This approach not only minimized costs by using fewer components but also simplified pilot control due to the reduced number of manipulators.

5 Mechanical System

5.1 Frame

The frame consists of three plates balancing structural integrity, weight distribution, and hydrodynamic efficiency. The lower plate is 5 mm aluminum 5083 (yield strength 270 MPa), selected for marine-grade corrosion resistance in compliance with MATE safety regulations, validated by decision matrix. The middle plate distributes electronics enclosure load, maintaining a Factor of Safety above 2.0 confirmed by FEA. Openings reduce mass, improve buoyancy-to-weight ratio, and minimize drag during heave while mitigating biofouling effects. The configuration is symmetric aligns the CG. The upper plate is 8 mm Artelon ($\rho = 1.081 \text{ g/cm}^3$), chosen for low density and machinability per decision matrix. Upper and lower plates are connected via cylindrical Artelon standoffs ($\text{Ø}20 \text{ mm}$), enhancing durability and mass-to-weight ratio. The control box is supported by an 8 mm Artelon sheet mounted to the lower aluminum plate,

leveraging aluminum's higher durability over the upper Artelon plate. Modularity is embedded through integrated mounting slots and standardized bolted interfaces, enabling rapid assembly and component interchangeability in line with DFMA methodology. All edges are deburred for MATE safety compliance. The frame base comprises two CNC-machined Artelon 18mm parts secured via screw and bolts avoiding direct bolt-into-Artelon threads.



(a) Render

(b) Considerations

Figure 16: MEGALODON ROV Frame

• Thrusters

MEGALODON is equipped with one T100 thruster and six T200 thrusters. Four of the T200 thrusters are calibrated at a 45-degree angle on the lower plate, while two are mounted on vertical bars made from 8mm Artelon. This thruster configuration, developed over the past year, has proven to be safer and more efficient than 3D-printed parts. The layout provides a more precise center of mass, allowing for more flexible and easier movement. The remaining T100 thruster is used for centrifugal movement and is mounted on an 8mm Artelon bar.



Figure 17: T200 Thruster

5.2 Sealing

5.2.1 Electronics Enclosure Design

• Rectangle Box

The electronics enclosure serves as the integral "brain" of the remotely operated vehicle (ROV), orchestrating all operational functions, such as controlling the thrusters, managing the gripper, and handling the camera for visual navigation. This centralized system enables flexibility in movement, allowing the ROV to maneuver in any desired direction, which is vital for effective exploration and tasks. At the heart of the vehicle lies an aluminum mold that encases the vital electronics responsible for the ROV's diverse functions.

This design protects the internal components and ensures efficient heat dissipation, which is crucial for maintaining optimal performance under challenging environmental conditions.

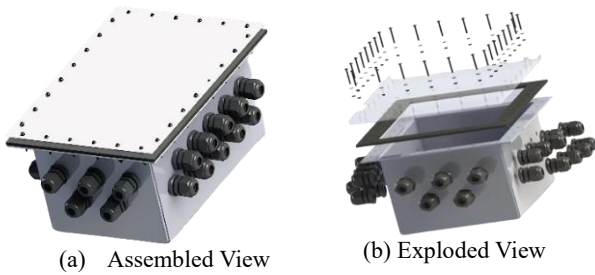


Figure 18: MEGALODON ROV Electronics Enclosure

• Gasket

The gasket, measuring 350 mm in length, 250 mm in width, and 5 mm in thickness, is within the assembly. A high-quality gasket is incorporated to ensure a watertight seal within the electronics enclosure. This gasket is secured by robust bolts and nuts, which enhance the overall sealing effectiveness and allow for reliable disassembly when maintenance or servicing is required. This ensures that the ROV remains operational in various underwater environments.

We also made 25 holes for the wires to be insulated, and here we use glands PG.7 with a diameter of 12 mm.

O-ring seals are designed to fit within a groove (referred to as a gland) between two mating surfaces. This configuration creates a secure seal that effectively prevents the passage of liquids or gases through the internal channel of the gland.

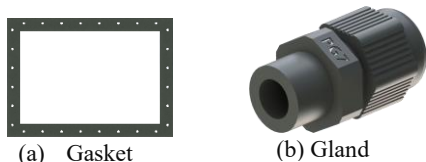


Figure 19: Sealing components For Electronics Enclosure

• Acrylic Cover

The acrylic cover, measuring 350 mm in length, 250 mm in width, and 10 mm in thickness, provides transparent protection for the electronics enclosure. This cover enables operators to visually monitor the internal components without compromising the integrity of the enclosure.

5.2.2 Camera Housing Design

• Main Camera Housing

The camera housing has been meticulously designed to be mounted at the front of the ROV, positioned ahead of the cubic electronics enclosure. This strategic

placement minimizes drag force and water resistance, thereby reducing the load on the T200 thrusters, enhancing overall efficiency, and improving maneuverability and smooth movement underwater. The housing is constructed from a transparent acrylic tube with a 113 mm diameter and 180 mm length. It is sealed using two Artelon flanges, ensuring complete waterproofing with the aid of a properly selected O-ring to protect the internal components. The design has undergone rigorous validation (CFD) analysis using ANSYS, which demonstrated excellent performance and suitability for **MEGALODON**.

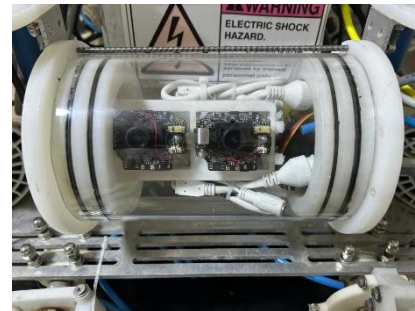


Figure 20: Main Camera Housing

• Camera Housing

The camera housing is CNC-machined from an Artelon rod (60 × 70 × 83 mm), chosen for corrosion resistance, low density, and machinability. A single open face simplifies insertion and limits sealing to one plane. Watertight integrity is achieved with a Nitrile O-ring seated in a CNC-machined groove (tolerance ± 0.05 mm, 20% compression), compressed uniformly by 12 screws through the Artelon body into stainless steel nuts eliminating direct thread-into-Artelon connections that could compromise clamping force. Four rear holes enable tool-free mounting to the ROV frame. An internal FDM-printed fixture constrains the camera against rotation and translation, maintaining orientation and 100% FoV; FDM was selected for its dimensional accuracy and cost-effectiveness, as the fixture does not require high structural stiffness. Waterproofing was validated by pressure testing to 4 m.

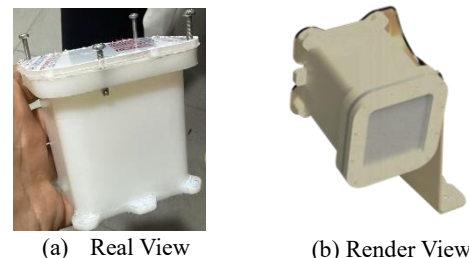


Figure 21: Camera Housing

5.3 Manufacturing Process

After thoroughly reviewing the tasks required by the vehicle, the mechanical department brainstorms different design ideas for the vehicle's frame and

thruster arrangement. Next, they present a mockup or mechanical drawing to discuss with the company's other departments and accommodate their feedback and suggested modifications. The process repeats until the design is deemed optimal by all departments. To help the company's different departments easily view the design and suggest any beneficial modifications, a computer-aided design (CAD) was created using SolidWorks and viewed at a company-wide meeting. Finally, the designs were converted into Drawing Exchange Format (DXF) and Standard Tessellation Language (STL) files to be sent to the CNC router, laser cutter, and 3D printer.



Figure 22: Mechanisms Manufacturing Process



Figure 23: Camera Housing Manufacturing Process

5.3.2 Manufacturing Process for MEGALODON Frame

The manufacturing of the **MEGALODON** frame follows a precise and structured process to ensure accuracy and durability. The process begins with the down plate, which is crafted from a 3mm-thick aluminum 5083 sheet. This sheet is carefully selected for its strength and corrosion resistance. Using a CNC laser cutting machine, the plate is cut according to the design specifications from DXF files. Once cut, it undergoes deburring to eliminate sharp edges and enhance safety. Next, the rods, made from Artelon, are prepared. These rods are cut to the required lengths using a bandsaw machine. To achieve precise diameters and smooth finishes, they are further processed on a lathe machine. If threading is necessary, additional machining is performed to ensure proper assembly compatibility.

Similarly, the top plate is fabricated from an 8mm-thick Artelon sheet. It follows the same cutting process as the down plate, utilizing a CNC laser cutting machine for precision. Once cut, the plate undergoes deburring to smooth out edges and prepare it for assembly. Before final assembly, all components undergo thorough inspection using calipers and micrometers to verify their dimensions and accuracy. Once confirmed,

The cleaned components are assembled using fasteners and threaded rods, ensuring a secure and stable frame structure.

Through this meticulous manufacturing process, the **MEGALODON** frame is built with high precision and strength, making it well-suited for underwater applications.

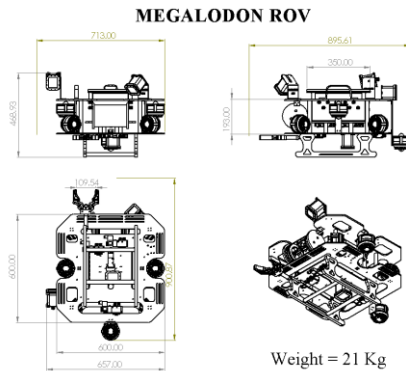


Figure 24: Mechanical Drawing of MEGALODON

5.4 Stress Analysis

Ansys CFD

Sailfish ROV performed a Finite Element Analysis (FEA) using the Static Structural module in **ANSYS**. We chose ANSYS because it provides highly accurate results compared to other software. This step was essential to test the design virtually, allowing us to validate structural integrity and avoid wasting materials or incurring unnecessary costs before the manufacturing phase. The results showed an excellent Stress Distribution across the model. To ensure the safety of the design, we calculated the Factor of Safety (F.S.) using the following

$$\text{formula: } f.s = \frac{\sigma_{\text{yield}}}{\sigma_{\text{max}}}$$

Lower Plate FEA

The lower plate (Al 5083) was analyzed in ANSYS Workbench under a 225.4 N load distributed across the enclosure contact area, with fixed constraints at all fastener points. Maximum von Mises stress was 22.33 MPa at fastener contact regions, well below the 270 MPa yield strength. The minimum Factor of Safety from ANSYS is 6.868, substantially exceeding the required 2.0 (Figure 25), confirming full structural integrity.

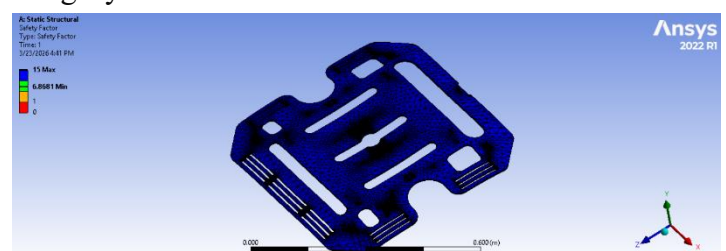


Figure 25: Lower Plate FEA



Control Box Acrylic

The acrylic cover was analyzed in ANSYS Workbench under a uniform hydrostatic pressure of 49,050 Pa (ρgh at 5 m depth), with fixed constraints at all fastener points. Maximum von Mises stress was 30.73 MPa, below the PMMA yield strength of 62.4 MPa. The minimum Factor of Safety from ANSYS is 2.029 (Figure 26), exceeding the required 2.0 and confirming structural integrity at the rated operational depth.

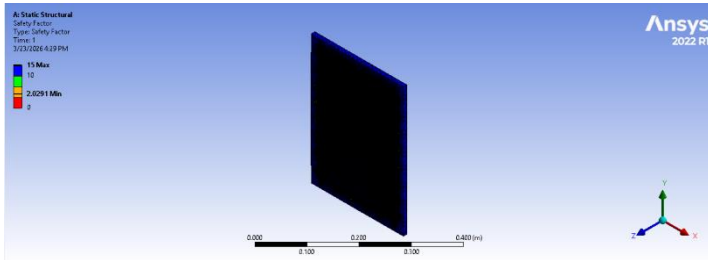


Figure 26: Acrylic cover

Control Box Aluminum

The aluminum control box (Al 1050) was analyzed in ANSYS Workbench under a uniform hydrostatic pressure of 49,050 Pa applied to the lateral and lower faces, with fixed constraints at fastener points. Maximum von Mises stress remained below the material yield strength, yielding a minimum Factor of Safety of 2.1775 (Figure 27), exceeding the required 2.0 and confirming structural integrity at the rated operational depth.

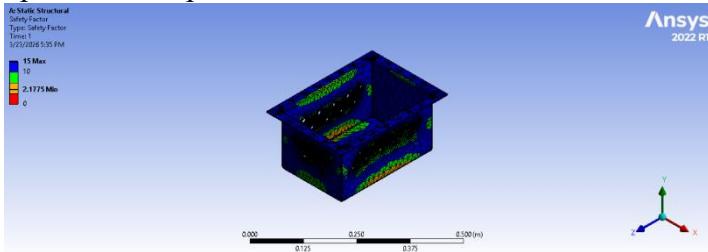


Figure 27: Control Box Aluminum

Ansyes CFD

In the **MEGALODON** application, computational fluid dynamics (CFD) is used to analyze fluid flow, heat and mass transfer, chemical reactions, and related phenomena. This involves numerically solving the governing mathematical equations including the conservation of mass, momentum, and energy while accounting for body forces. Sailfish apply CFD to calculate drag and lift forces using known pressure, velocity, and flow type data. By comparing these CFD-derived forces with the actual forces produced by the motors, we can evaluate the ROV's diving smoothness and speed, as well as

the time efficiency of task completion. The drag force equation used is:

$$F_D = \frac{1}{2} \rho V^2 C_D A$$

F_D : drag force (N)

ρ : density of fluid (kg/m³)

V : speed of the ROV relative to the fluid (m/s)

C_D : drag coefficient.

A : cross-sectional area (m²)

Cylindrical Camera Housing

Simulated at 0.5 m/s operational flow velocity, the cylindrical housing yielded a drag coefficient of 2.215 and a drag force of 1.466 N. Positioned at the forward face, its streamlined profile reduces frontal pressure drag, partially offsetting the penalty of the rectangular electronics enclosure (Figure 28).

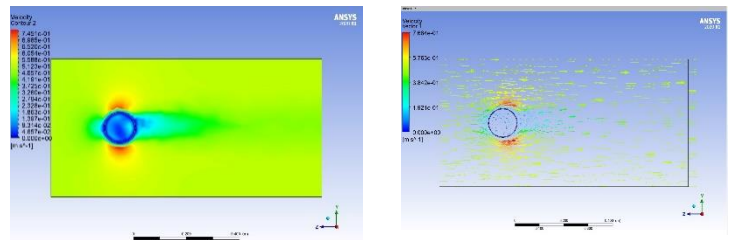


Figure 28: Pressure with Contours and Vectors of Main Camera Housing

Full ROV Assembly

A complete ROV simulation at 0.5 m/s surge velocity produced a total drag force of 17.65 N and an assembly drag coefficient of 30. These results confirm that the integrated hydrodynamic design including the cylindrical housing as a forward fairing maintains drag within the available thrust budget of the T200 thruster configuration (Figure 29).

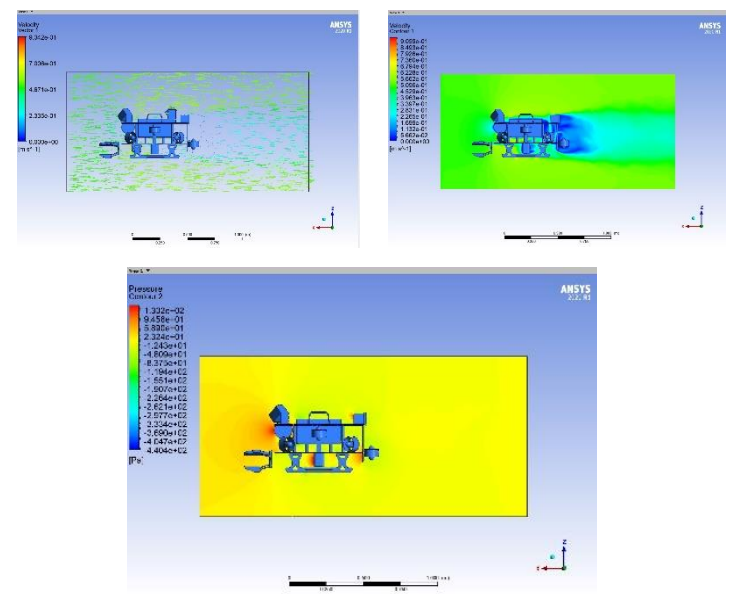


Figure 29: Pressure with Contours and Vectors

5.5 Equations of motion

The ROV's equations of motion are derived from Newton's Second Law, which states that the net force acting on a body equals its mass multiplied by its acceleration. Using the equation of motion for constant acceleration:

$$V^2 = V_0^2 + 2ad$$

The required acceleration to reach the target operational speed of 0.5 m/s over a distance of 0.1 m from rest is:

$$a = V^2 / 2d = (0.5)^2 / (2 \times 0.1) = 1.25 \text{ m/s}^2$$

Applying Newton's Second Law with the total ROV mass of 23 kg:

$$F_{\text{net}} = ma = 23 \times 1.25 = 28.75 \text{ N}$$

Accounting for the hydrodynamic drag force (YY N, derived from full-assembly CFD analysis), the total required thrust is:

$$F_{\text{thrust}} = F_{\text{net}} + F_{\text{drag}} = 28.75 + YY \text{ N}$$

This represents the minimum thrust force the thruster configuration must produce to achieve the target speed under operational drag conditions.

5.6 Mobility

Mobility, defined as the degrees of freedom for vehicle motion, is crucial for maintaining stability, with the propulsion system playing a key role. The chosen 7-thrusters vectored propulsion system is designed to ensure excellent stability, robust horizontal movement, and intuitive pilot control. Configured in this manner, the 7 thrusters grant the ROV six degrees of freedom, enabling yaw, heave, surge, roll, pitch, and sway motions.

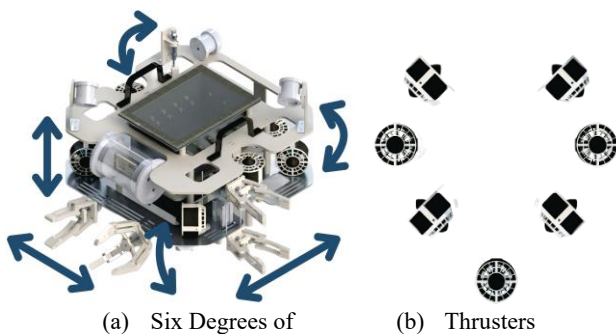


Figure 30: Six Degrees of Freedom

5.7 Buoyancy

One challenge encountered by the mechanics department was achieving smooth suspension of the vehicle in water to enhance navigation.

Additionally, obtaining neutral buoyancy Underwater posed another hurdle, aiming for a balance where the buoyancy force neither becomes excessive nor

insufficient. This balance ensures minimal effort is required for the thrusters to maneuver vertically. Consequently, maintaining the vehicle in pristine condition is imperative for executing all required tasks effectively. After compilation, the block for the ROV weighed 20 kilograms, equivalent to 198.789 N.

The weight displaced by water, causing negative buoyancy, measured 100.2 N. The variation in vertical force components tends to converge between the effect of buoyancy and the weight of the displaced water. However, the weight of the displaced water slightly outweighs buoyancy, resulting in a slight sinking of the vehicle. In response, various solutions were devised. The company opted for lightweight foam as a flotation material, chosen for its low density (30 kg/m³) and cost-effectiveness. This foam was placed in the legs and hands of the vehicle to maintain its shape and resistance at the expected depth of occupancy, as shown in [Appendices \(F\)](#).

5.8 Stability

To ensure static stability, the Center of Gravity (CG) is positioned below the Center of Buoyancy (CB) and aligned along the same vertical line at equilibrium. The restoring moment acting to return the ROV to its upright position is expressed as:

$$M_r = W \cdot BG \cdot \sin\theta$$

Where W is the ROV weight, BG is the vertical separation between CB and CG, and θ is the tilt angle. Rather than maximizing BG, the design targets an optimized BG value sufficient to passively resist unintended tilting caused by external disturbances, while remaining low enough that the two vertical T200 thrusters can overcome the restoring moment to execute controlled roll maneuvers during operation. This balance eliminates the need for excessive corrective thrust, improving overall power efficiency and maneuverability.

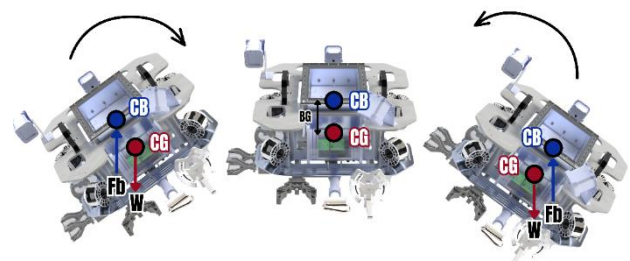


Figure 31:MEGALODON Center of Buoyancy

6 Electrical System

The hardware is divided into two main sections. The top-side control unit converts AC mains to a stable 48 V DC and feeds the vehicle through the tether. The bottom-side electronics enclosure is organized into three serviceable layers for rapid fault isolation. The lowest layer houses four primary DC-DC converters that derive and regulate the internal power rails (e.g., 12 V and 5 V) used across the vehicle.

The middle layer includes the power distribution harness, connectors, and the Electronic Speed Controllers (ESCs), which receive 12 V for the thrusters and provide clean, labeled terminations for all power cabling. The top layer integrates control and networking elements: a network switch that connects the IP cameras, a Raspberry Pi 5 Model B (8 GB RAM) for high-level control and data handling, an STM32 microcontroller for deterministic actuation of thrusters, solenoids, and the servo, and an IMU sensor (MPU-6050) interfaced to the Raspberry Pi via I²C. This architecture, used on Megalodon, separates power conversion, distribution, and control to enhance clarity, safety, and maintainability.

6.1 Top Control Unit (TCU)

Megalodon's top-side control unit is a galvanized sheet-metal enclosure, powder-coated (electrostatic) for insulation and corrosion resistance, with rounded/hemmed edges to eliminate sharp surfaces. It houses four AC-to-DC power supplies that deliver a regulated 48 V DC bus to the tether.

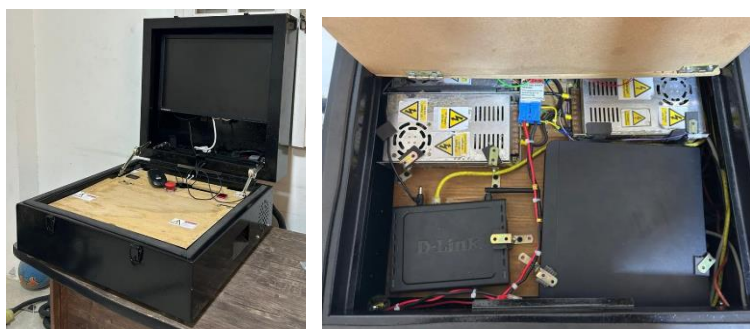


Figure 32: The Top Control Unit

For safety, the station provides two independent disconnects: a latching Emergency-Stop (E-Stop) mushroom pushbutton and a main AC circuit breaker (MCB) and uses an Anderson SB-series connector on the 48 V DC output. A Gigabit network switch interconnects the tether line, the vehicle's Raspberry Pi, and the co-pilot laptop, while an NVR records the IP-camera streams. Two panel meters monitor power: one reads the incoming AC voltage/current at the inlet,

And the other displays the 48 V DC bus voltage/current from the supplies. The station also integrates a pilot display for the ROV cameras and a protected power distribution strip for all required adapters and peripherals.

6.2 Power Distribution

Power distribution is implemented on a dedicated power distribution board using six DC-DC converters. Four independent 48 V→12 V converters generate separately fused 12 V rails for (i) the ESCs, (ii) the onboard cameras/video interfaces, (iii) the network switch/power board, and (iv) auxiliary loads; each rail is clearly labeled for fast diagnostics. A dedicated 12 V→5 V buck converter supplies the Ethernet switch. A separate 5 V buck module (USB Type-C output, Pi-rated) powers the Raspberry Pi 5 via USB-C to meet its inrush and steady-state current requirements. The STM32 control board is powered from the Raspberry Pi's 5 V header/output (with local regulation on the STM32 board to 3.3 V), keeping logic grounds common and minimizing wiring complexity. All low-voltage rails use proper fusing, polarity protection, and strain relief in line with competition safety practices. See Appendix F (Power Distribution Table) for rail assignments, current ratings, fusing, and connector details.

6.3 Switch Board

The switchboard is a reusable, drop-in module that now supports nine independent solenoid (DCV) channels. Each channel uses opto-isolated low-side switching with flyback protection and includes a status LED to indicate coil power. A protected MOSFET drive path and reverse-polarity safeguards enhance reliability, and 3.3–5 V logic compatibility enables direct control from the STM32/Raspberry Pi consistent with MATE ROV regional safety practices.

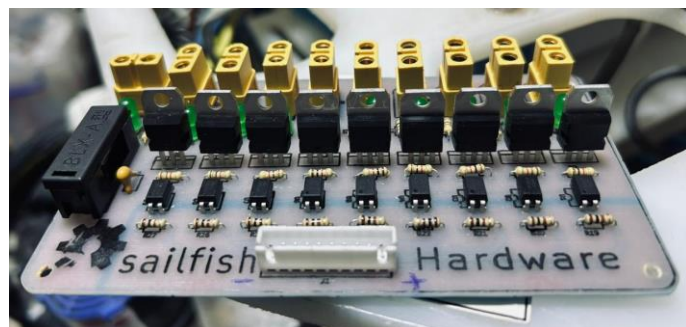


Figure 33: Switch Board

6.4 Tether

The tether comprises seven cables: two power conductors (48 V and return), three pneumatic lines (one for mechanism actuation, one for sealing tests, and one for exhaust), and two CAT6 Ethernet cables. Of the CAT6 pair, one carries vehicle communications (control/data), while the other provides a dedicated link from the bottom-side switch to the top-side NVR for the IP-camera streams. All seven lines are bundled within a rugged protective sheath that resists abrasion and provides convenient attachment points for foam floats to tune buoyancy and improve handling. The tether is secured with strain-relief terminations at both ends to prevent excessive tension from reaching internal conductors and pneumatic lines, enhancing reliability and service life.

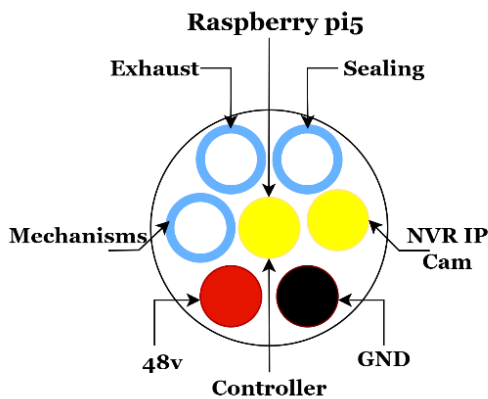


Figure 34: The Tether of MEGALODON

6.5 Tether Management Protocol

- **Pre-deployment & Transport:** Sailfish inspects the tether before each operation for wear, fraying, cuts, or connector damage.
- The tether is transported in a protected manner to prevent crushing, sharp bends, or accidental impact.
- **Deployment & Routing:** On site, the team unwinds the tether with one end routed to the ROV and the other to the electronics enclosure, avoiding twists and snags.
- Color-coded terminations are used for quick, unambiguous identification and connection.
- Foam floats are added at regular intervals (approximately every 1 m) to improve buoyancy and handling.
- **Operational Management:** Tether length is actively managed: sufficient slack is maintained to relieve strain on the ROV, while excess slack is avoided to minimize entanglement risk.

- **Recovery, Coiling & Storage:** Suitable coiling techniques (wide loops, no tight radii) are applied during retrieval to prevent sharp bends and stress points.
- After use, the tether is stored in wide coils to preserve structural integrity.
- **Maintenance:** Sailfish schedules regular maintenance checks, documenting findings and replacing worn sections or connectors as required.
- **Emergency Preparedness:** A backup tether is kept on-site. Personnel are trained in rapid replacement procedures to minimize downtime in case of failure.
- **Environmental Adaptation:** Prior to deployment, water currents and nearby obstacles are assessed, and tether routing/handling strategies are adjusted to ensure safe operation in varying conditions.



Figure 35: Member Demonstrating Tether Handling Protocol

7 Software System

7.1 Graphical User Interface (GUI)

The software department selected a powerful GUI framework capable of integrating multiple features while ensuring high performance. To make an informed decision, the team evaluated various options using a GUI decision matrix **Table (6)**, considering factors such as ease of development, performance, deployment complexity, learning curve, and community support. After thorough analysis, PyQt5 was chosen strategically to align with the software's development goals and future expansion plans. **MEGALODON's** GUI is developed using PyQt5 and is divided into two parts: the pilot interface and the operator interface. The pilot interface provides real-time status updates of all **MEGALODON** components, including thrusters, grippers, IMU readings, and logger messages. The operator interface is designed to assist the co-pilot in completing tasks that do not require the pilot's attention.

Table (6): Decision Matrix of GUI

	Ease of Development	Performance	Deployment Complexity	Learning Curve	Community Support	Total (out of 25)
PyQt5	5	4	5	5	5	24
Qt C++	3	5	3	3	4	18
Web Framework	4	3	4	4	4	19



Figure 36: Pilot GUI

7.2 Control System

Sailfish utilized ROS2 to fully leverage the capabilities of the Raspberry Pi 5 in **MEGALODON**'s system, which controls essential components like thrusters, solenoids, the IMU sensor, and the PID control system. ROS2's real-time communication ensures efficient data exchange, enabling smooth and responsive movement. The bottom system, running on Raspberry Pi 5, processes sensor data and sends precise control commands to the STM32 microcontroller, which directly manages the functions requested by the pilot. In addition, the bottom system continuously sends the status of all components back to the top system for display on the GUI, providing the pilot with real-time feedback on the ROV's performance. The top system, with **MEGALODON**'s GUI, allows the pilot to send commands to the ROV and monitor its status seamlessly. ROS2 acts as the communication bridge between the top and bottom systems, ensuring low-latency, reliable interaction that allows for precise, smooth maneuvering of the ROV.

7.3 3D Modelling

D Capturing images from all angles based on garden area and applying some traditional ML algorithms to enhance images. Then, upload the dataset to COLMAP (Photogrammetry Software) which applies Structure from Motion (SfM) to coral garden 3D structures from a collection of 2D images, and show targets these steps are shown in (Figure 36).

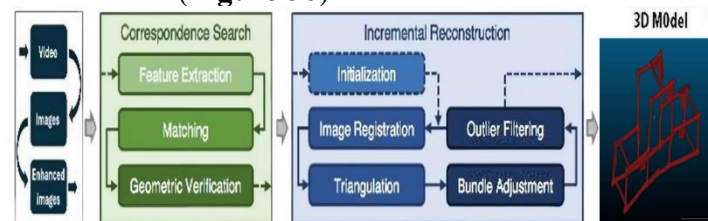


Figure 37: The steps of creating a 3D model

• Measuring the Length of Coral Garden

Measure the length of the coral garden area with image processing and use MeshLab to show a 3D model with the length and estimate the height, as shown in (Figure 37).

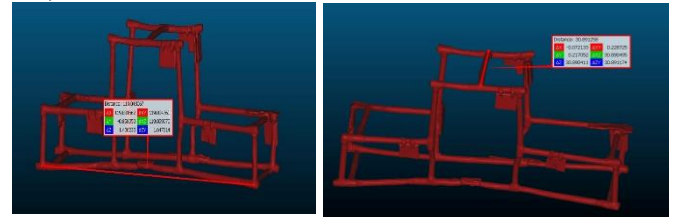


Figure 38: Coral Garden Area 3D Model

7.4 Crap Detection Model

A lightweight YOLOv8 pipeline was developed for the topside laptop and trained using a custom augmentation script that introduced rotation, scaling, and lighting variations to compensate for the limited crab dataset. A color-enhancement step was added to correct ROV camera distortion and improve detection stability. The model was trained on three crab classes and configured to highlight only the target species. It processes live video in real time, saves annotated frames, and remains reliable under changes in scale, orientation, and lighting, as shown in (Figure 39).



Figure 39: YOLOv8 detection of Green crab samples

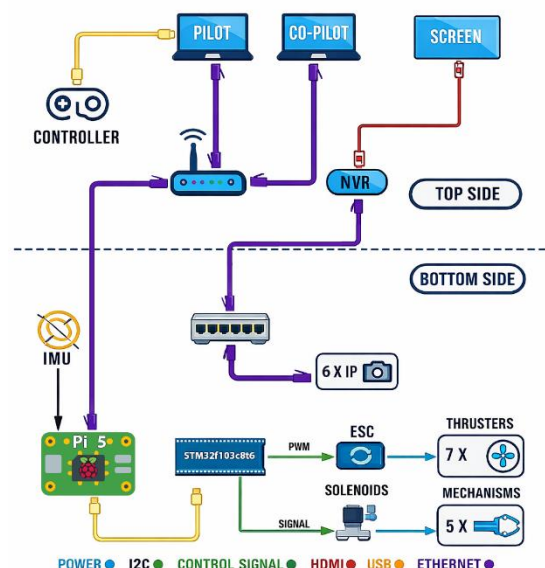


Figure 40: Control System Flow Diagram

Table (7): Mission Systems Strategy

	Subtask	Main Gripper	Tri-Finger	Rotating gripper /Clutch	Heavy Hook	Rear Gripper	Rope Container
Task 1							
1.1	Collect two basket stars	1	3	4	x	2	X
	Collect two coral species	1	3	4	x	2	X
1.2	Coral ridge photogrammetry	X	X	X	X	X	X
	Coral ridge CAD modelling	X	X	X	X	X	X
1.3	Fly a transect	X	X	X	X	X	X
Task 2							
2.1	Determine number of invasive species	X	X	X	X	X	X
	Upload the data	X	X	X	X	X	X
2.2	Track icebergs	X	X	X	X	X	X
	Turn the handle	2	1	X	X	3	X
2.3	Recover lobster pot	3	2	X	1	4	X
	Attach a recovery line	X	X	X	X	X	1
2.4	Return the line	X	X	X	X	X	1
	Recover old eDNA	2	1	X	X	3	X
2.5	Install new eDNA	2	1	X	X	3	X
	Remove biofouling	X	X	1	X	X	X
Task 3							
3.1	Install a micropile	2	1	X	X	3	X
3.2	Connect the power	1	2	X	X	3	X

8. Safety

8.1 Safety Philosophy

Sailfish ROV puts safety first and operates in strict compliance with MATE ROV Competition regulations and safety inspections. We mandate PPE, pre-dive checklists, engineered safeguards, and industry-style workmanship (no exposed conductors, clear AC/DC separation, proper strain relief), with Anderson Power pole as the main connection, a correctly sized fuse within 30 cm of the power source, and fully shrouded thrusters to IP-20 (<12.5 mm).

8.2 Safety Training

New members are required to attend safety training to gain professional experience in the use of equipment, with a particular emphasis on power tools and soldering stations. Through practical demonstrations and guidance from senior members, the goal is to develop a thorough understanding of safety protocols and hazard recognition to encourage the ability to work independently with confidence. Our company's members are always required to adhere to the PPE standards to prevent them from interacting with harmful substances such as soldering fumes or PCB acids.



Figure 41: Sailfish Member in Safety Training

8.3 Safety Features

MEGALODON's power supply unit delivers DC voltages up to 48V and includes protection against overload currents and reverse polarity. It is also equipped with a kill switch for emergency shutdowns. The SBS-50 Anderson connector is used to securely fasten power terminals, ensuring a safe and reliable connection, in compliance with MATE safety standards. Based on power consumption calculations, a 25-A fuse is added to the power cable to protect the system from overloads, and it is positioned 30 cm from the Anderson connector. To prevent slipping around the pool area, all tether cables are securely fastened and coated with polymers, enhancing safety during operation. Shrouds are used as protective enclosures for the thrusters' intake and exhaust areas, minimizing workplace injuries. Additionally, all sharp edges and corners are smoothed to reduce the risk of accidents and to improve safety.

Non-return valves are utilized in pneumatic systems to ensure unidirectional airflow in intake and exhaust lines, avoiding reverse flow that could cause system failure. By allowing air to flow in only one direction, these valves protect components such as actuators and compressors from pressure surges, contamination, or mechanical failure caused by backflow. Their use enhances the reliability and safety of MEGALODON's pneumatic systems.



Figure 42: MEGALODON Safety Features

8.4 Safety checklist and Operations

The Safety Checklist (Safety Checklist **Appendices C**) reduces errors and oversights and enhances quality and consistency by highlighting the essential steps and details that might be forgotten or overlooked. The safety checklist ensures safety during ROV construction and operation by maintaining a well-organized, ventilated workspace, secure electrical components, and protective measures.

9 Testing and Troubleshooting

During the current year, as part of the team-building process, the team focused on training members in the procedures shown in **Figure (39)** to address any problems we might encounter, particularly during MATE mission training. We divided the testing strategy into two main categories: dry tests and pool tests. Each category involves conducting multiple tests to ensure MEGALODON is functioning properly, helping us implement an effective troubleshooting strategy.

In the dry testing phase, we check for electrical, performance, and full system issues. During pool testing, we check for leakage (with MEGALODON turned off for safety reasons), followed by assessments of buoyancy, stability, and full system performance.

9.1 Electrical

We made a flow chart to figure out if there are any issues with the electrical system, we are using a multimeter to test the electronic components while following the flow chart.

9.2 Performance test

In this test, we check the ROV functions, using the pilot's laptop GUI system we check the status of the components while utilizing the logger to identify if there are any communication losses.

9.3 Leakage and stability test

In this test, we need to make sure there are no problems with the sealing. We use a compressor to blow air into the ROV underwater, and bubbles indicate leakage. Then, we check the ROV's buoyancy to make it neutrally buoyant. We use lead weights and foam to adjust it.

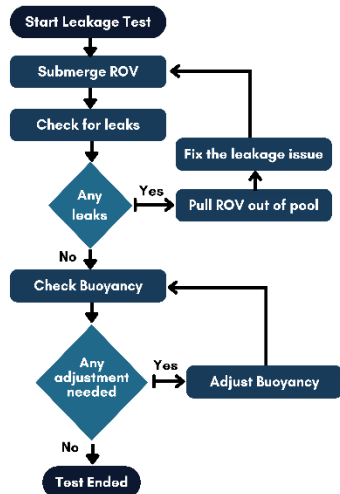


Figure 43: The flow chart of Leakage Test

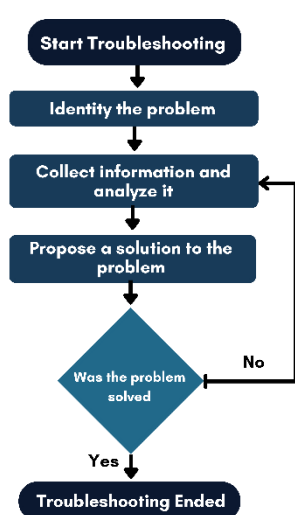


Figure 44: The flow chart of Troubleshooting

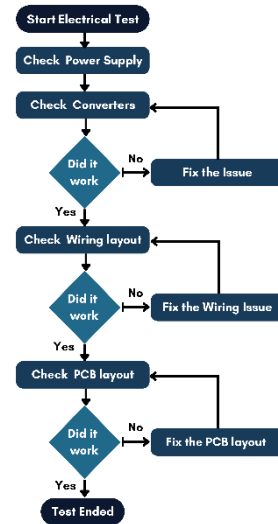


Figure 45: The flow chart of Electrical Test

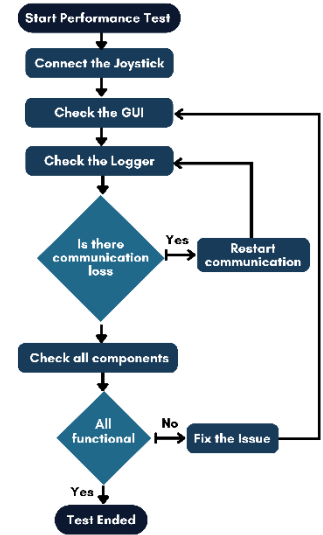


Figure 46: The flow chart of Performance Test



Figure 47: Full System Test

10 Logistics

10.1 Company History

The Sailfish ROV Company is the first ROV Company in Egypt. The team was founded in 2012 at a higher technological institute in 10th of Ramadan City, where a small group of motivated students came together with a shared interest in building Remotely Operated Vehicles (ROVs) and exploring the fields of marine and robotics engineering. Since its establishment, Sailfish has evolved from a small student initiative into a competitive engineering team recognized both nationally and internationally. The team focuses on the design, development, and operation of MEGALODON that's capable of performing complex tasks in marine environments. Over the years, the team has participated in numerous national and international competitions, gaining hands-on experience and achieving notable

results. Sailfish's achievements reflect commitment to innovation, engineering excellence, and collaboration. The team continues to push the boundaries of underwater robotics while proudly representing Egypt in major robotics competitions. It has also received several awards and recognition in engineering, robotics, and innovation. Included:

- 4th place in MATE ROV competition 2025.
- 1st place in Afro-Asian competition, 2025.
- 3rd place in global robotics challenges 2025 and qualified for finals in Saudi Arabia.
- 1st place in global robotics challenges in Saudi Arabia 2025.
- First place in underwater competition (ROV) in 2024.

10.2 Company Structure

The Sailfish company consists of **46** members. The team structure splits into technical and non-technical departments. The technical departments are hardware, software, and mechanical.

1. Hardware department: ensure durability, hydrodynamics, and compatibility with other systems.
2. The software department develops navigation, control systems, and autonomous features.
3. The mechanical department: handles structural engineering and system assembly.
4. The non-technical department includes media marketing, public relations, business plan, and human resources.
 - The media marketing department manages social media, blogs, and event coverage.
 - The public relations department builds partnerships with school research institutions and government entities.
 - The business plan department develops long-term goals and growth strategies for the company.
 - The human resources department recruits skilled professionals to join the team.

The CEO and the four heads, technical and non-technical heads, oversee strategies, growth, and overall alignment. As shown in [Figure\(55\)](#).

10.3 Project Management

10.3.1 Project Scheduling

The Sailfish ROV project is organized into six main stages, with each stage covering specific tasks within a defined timeline.

1. Planning (22 Jul – 10 Oct 2025): This stage focuses on research and development, team building, and sponsorship activities.

2. Design (11 Oct – 29 Dec 2025): During this phase, the body, electrical system, control system, and mechanical design are completed.

3. Building (20 Nov 2025 – 27 Jan 2026): The ROV is fabricated, and the main components are assembled.

4. Testing (12 Dec 2025 – 18 Apr 2026): The system is tested, including software testing and troubleshooting.

5. Final Setup (12 Jan – 26 Mar 2026): Integration of the software system is completed, and documentation is prepared.

6. Review (25 Feb – 18 Apr 2026): Final training and system evaluation are conducted to ensure readiness.

As shown in Project Gantt Chart in [Appendices \(A\)](#).

10.3.2 Workspace Management

At Sailfish ROV, effective workspace management is crucial for keeping collaboration organized and ensuring projects progress consistently. The team follows a structured workflow that promotes clear communication, efficient task assignment, and ongoing progress tracking.

Meeting Structure: The team holds three levels of meetings.

Sub team meetings: occur once or twice a week to check on technical progress, assign tasks, and tackle specific challenges.

Leadership meetings: take place monthly with the team leader and sub-team leaders to review progress and keep everything on track with the project timeline.

General meetings: happen when major updates or team-wide coordination are necessary.

Task Management: Project tasks are organized using Click Up. Each task has a description, assigned member, deadline, and relevant attachments. Tasks progress through three stages: To Do, In Progress, and Completed. This setup lets leaders track progress and clarify responsibility. This season, we continued using Click Up due to its ease of use and effective task organization, as our previous experience showed it to be efficient in managing workflow and tracking progress within the team.

Communication Protocol: The team maintains clear communication channels between members and leaders to minimize delays and quickly tackle challenges.



New members receive onboarding guidance that explains the team's workflow, tools, responsibilities, and expectations. Sailfish's high operational efficiency is ensured through strategic management of its resources, which include human, physical, and financial resources. The framework focuses on resolving operational issues and identifying financial discrepancies. This includes optimizing shared working spaces, managing the distribution of commonly used equipment, procuring consumables, and regularly monitoring budget utilization.

10.4 Shared Files and Libraries

- Design and development area: Equipped with high-performance computers and engineering software such as SolidWorks to support CAD modeling, simulation, and system design.
- Workshop and fabrication zone: A fully equipped space for assembling, machining, and maintaining ROV components, ensuring efficient hands-on work and prototyping.
- Testing and validation area: A water facility used for evaluating ROV performance, allowing the team to conduct trials under realistic operating conditions.
- Organization and inventory system: Tools, spare parts, and materials are systematically stored and tracked to ensure easy access.
- Safety protocols: Strict safety guidelines are enforced across all zones, with regular inspections and oversight by a workshop supervisor to maintain a safe working environment.

This structured workspace enables the team to operate efficiently while maintaining high standards of organization, safety, and engineering quality.

10.5 Shared Files and Libraries

To achieve sustainable performance, Sailfish ROV implemented a unified digital operations system to eliminate communication failures and document sprawl.

Primary repository: Google Drive is the single source of truth; files are stored in defined directories with role-based access to protect engineering designs and other assets.

Communication: Google Meet and Microsoft Teams are the approved platforms for weekly progress reviews and interdepartmental updates; decisions and action items are recorded and archived on Drive.

Work management: ClickUp is the system of record for task prioritization, assignments, deadlines, and progress tracking across the season.

Software lifecycle: GitHub is the controlled environment for source code, issues, pull requests, and version control.

This ecosystem ensures transparent workflows, efficient project management, and predictable, organized delivery.

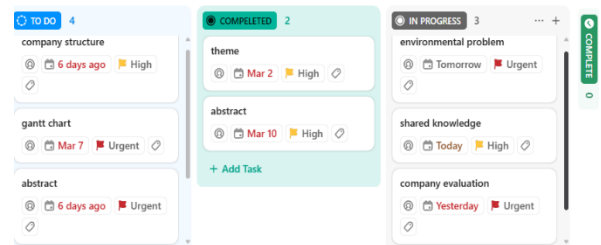


Figure 48: Tasks management of non-technical team

11. Budget of Accounting

In previous seasons, limited seed funding constrained manufacturing and budgeting. To address this, the team adopted an evidence-based seasonal budget that combines historical spending with forecasts for upcoming needs. This season, we strengthened financial controls and prioritized the reuse of qualified components: carry-over parts were inspected, tested, and integrated into the current ROV, **MEGALODON**, only when they met all technical specifications. This preserved reliability and performance, reduced waste, and allowed us to redirect funds to critical upgrades. While the fair-market value of all resources was **\$4,103.41**, our actual spending was **\$1,876.94**, funded mainly by team contributions and our university achieving substantial savings without compromising quality. These measures ensured full technical compliance and cost efficiency for the Egypt regional competition., see [Appendixes \(D\)](#).

12 Conclusion

12.1 Future Improvements

To enable precise depth control, Sailfish ROV's will add a pressure-depth sensor and refine filtering for better estimation. We will improve stability and maneuverability by increasing vertical thrusters from two to four and optimizing propulsion layout and control gains. Upgrading structural materials for stiffness and durability, and adding converters to the power system, will allow the T200 thrusters to operate at maximum strength.

12.2 Lessons learned

The Sailfish ROV project provided hands-on learning across all teams, strengthening both individual skills and overall team performance.

- **Mechanical:** Deeper understanding of material selection, manufacturability constraints, and the trade-offs between design and real-world implementation. Integration highlighted the value of iterative prototyping and continuous testing.
- **Software:** Practical experience building stable, responsive control systems; handling real-time data; ensuring reliable software-hardware communication; and writing performance-oriented, well-structured code. System testing reinforced disciplined debugging practices.
- **Hardware:** Greater focus on system reliability and component compatibility. Troubleshooting improved analytical and problem-solving skills, underscoring the importance of circuit protection, organized wiring, and balanced component choices (performance, cost, availability).
- **Non-Technical:**
 - Human Resources (HR): Structured recruitment, clear internal communication, and effective leadership to support healthy team dynamics.
 - Business Planning: Aligning technical capabilities with sustainability goals; financial planning and strategy to support growth.
 - Public Relations (PR): How strategic communication shapes external perception and partnership opportunities; stronger coordination and negotiation across stakeholders.
 - Media: Building a coherent brand identity and presenting technical achievements clearly to diverse audiences and platforms.

General: The project reinforced collaboration, adaptability, and disciplined project management as foundations for reliable field performance.

13. Appendices

A Project Gantt Chart

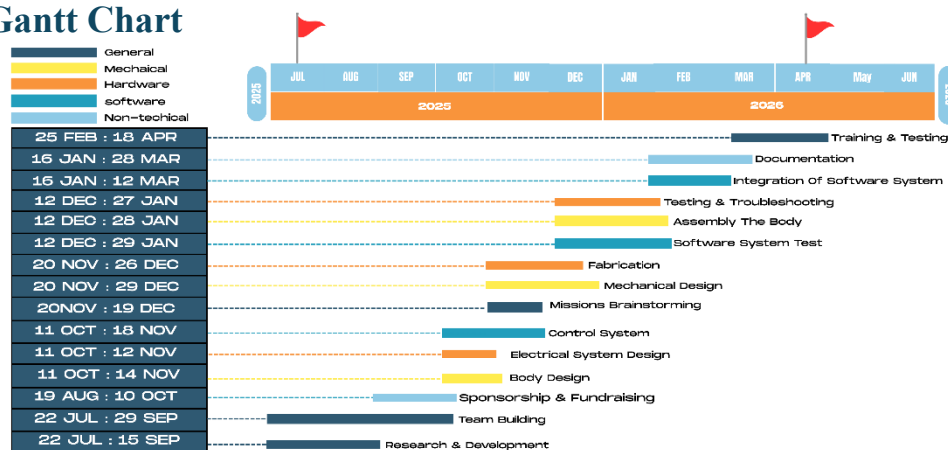


Figure 51: Project Gantt Chart

12.3 References

- [MATE ROV Competition Manual 2026](#)
- Blue Robotics' [T100](#). and [T200](#) Thrusters Documentation.
- [Nave, Rod. "Buoyancy." Hyper Physics. Georgia State University.](#)
- [Blue Robotics](#)
- Texas Instrument [TPS54561](#) buck
- [Motion Tracking Sensor \(IMU\) MPU-6050](#)
- [OpenCV Python Documentation](#)
- [STM32](#)
- [Raspberry Pi 3B+](#)
- [ROS 2](#)
- [Instant Neural Graphics Primitives](#)
- [PPA standards](#)

B Safety Checklist

Environment and Personnel	The products
☐ The workspace is well-ventilated to release soldering fumes. ☐ The workspace is well-organized to promote safety. ☐ Firefighting counter measurements are readily available. ☐ A regular inspection and test of the equipment. ☐ All first aid essentials are available. ☐ PPE is available to ensure personal safety.	☐ No exposed wiring. ☐ All connections are well-soldered and suitable connectors are used. ☐ All electrical components are well-sealed. ☐ The fuse is located 30 cm from the Anderson power pole connector. ☐ Glands are applied to tether all wires out of or from the ROV. ☐ Propellers are covered from all sides by a shroud following the IP-20 standard. ☐ The ROV does not have any sharp edges. ☐ Warning labels are mounted to all components of the ROV system that may pose potential hazards.

Figure 49: Safety Checklist for Construction

Pre-launch	Power-up	Launching in water
☐ Only the company members are responsible for setting up the ROV. ☐ The setting-up team follows safety rules, following the PPE standards. ☐ Working members beside the pool wear life jackets and aqua shoes to protect them from slipping. ☐ The ROV's components are securely fastened. ☐ All screws, nuts, and caps are securely installed. ☐ Anti-corrosion spray is applied to corrosion-prone parts. ☐ Tether strain relief is connected to the control station.	☐ The power supplying 48V nominal. ☐ Check the tones of ESCs. ☐ Verify that all cameras are streaming. ☐ Verify communication between TCU and SBC. ☐ Test all components using joystick.	☐ Conduct a leakage test underwater and check for bubbles. ☐ A buoyancy test ensuring that the ROV floats neutrally underwater.

During the operation

- ◻ The GUI displays the state of each component (thrusters, mechanisms, IMU sensor).
- ◻ Check GUI Logger for communication loss.
- ◻ Keep distance between the ROV and the shipwreck (historical site).

Figure 50: Safety Checklist for Operation

C



D

Figure 53: Budget planning

TECHNICAL REPORT



	Project cost							
		Date	Items	Type	Description	Amount (USD)		
Income	1	3/10/2025	HTI fund	Cash - Donated	University fund	\$450.00		
	2	3/7/2025 to 20/4/2026	Employee contribution	-	Monthly Team members contributions	\$67.00		
Mechanical (categories)		Date	Items	Type	Description	Amount (USD)	Running balance(USD)	Market fair value (USD)
							\$2,393.94	
	1	3/12/2025	PVC pipes, PVC Connectors, Spray Colors, Ropes, Corrugated Sheets	Purchased	Play ground	\$48.81	\$2,345.13	\$55.95
	2	3/12/2025	Buoyancy Foam, Weights, Velcro	Purchased	using for Diverse	\$11.40	\$2,333.73	\$20.00
	3	3/12/2025	Screws (Stainless), Counter Nuts, L-Fixations (Aluminum)	Purchased	Using for securing components.	\$40.00	\$2,293.73	\$35.00
	4	15/3/2025	Shrouds, Caps, Fuses, Non-Return Valve	Reused	using for Safety Equipment	\$29.50	\$2,293.73	\$29.50
	5	25/12/2024	Artelon (Sheet,Rod), Aluminum Sheet (5083.1050), Acrylic (Sheet,Tube)	Reused	using for vehicle Frame	\$130.00	\$2,293.73	\$130.00
	6	25/12/2025	Arltone Road (Cameras Housing)	Purchased	using for Cameras Housing	\$2.87	\$2,290.86	\$3.50
	7	30/12/2025	Acrylic(camera housing)	Purchased	using for Cameras Housing	\$7.65	\$2,283.21	\$10.00
			Pneumatic					
	1	7/1/2025	DCVs, Pistons, Fittings	Reused	using for Pneumatic System	\$91.00	\$2,283.21	\$91.00
	2	3/7/2025	Compressor	Reused	compressed and storage air	\$68.91	\$2,283.21	\$68.91
			Sealing					
	1	2/1/2026	Metal Glands, Epoxy, Gasket	Purchased	using for Sealing	\$26.90	\$2,256.31	\$23.00
	2	2/1/2026	O-Rings	Purchased	using for Sealing	\$5.00	\$2,251.31	\$7.36
			Manufacturing					
	1	5/1/2026	CNC Routing, Laser Cutting, 3D Printing	Purchased	Manufacturing for vehciel	\$25.00	\$2,226.31	\$25.80
	2	5/1/2026	cnc milling	Purchased	camera housing for vehciel	\$76.56	\$2,149.75	\$77.12
	3	10/1/2026	Welding control box	partly donated	Manufacturing by Morcos Company	\$20.00	\$2,129.75	\$20.00
	Total						\$583.60	
Electrical Categories)			Bottom side					
	1	18/1/2026	2*PCB (main board and mechanisms board)	Purchased	Provides structure support for electronic components	\$24.89	\$2,104.86	\$27.00
	2	18/1/2026	2*DC-DC step down voltage conv eror 5A (24V to 12V to fixed output 5V/5A)	Purchased	Transform a DC voltage source into a different DC voltage level	\$5.74	\$2,099.12	\$7.81
	3	20/10/2024	4 Dc converter reused	Re-used	Transform a DC voltage source into a different DC voltage level	\$53.60	\$2,099.12	\$55.00
	4	20/10/2024	Ethernet Cable(CAT6) (re used)	Re-used	Using for transfer data	\$24.00	\$2,099.12	\$75.00
	5	18/1/2026	2 IP Cameras reused	Re-used	Used to captures and transmits video data over a network	\$34.64	\$2,099.12	\$35.00
	5	20/1/2026	4 IPcameras purchased	Purchased	Used to captures and transmits video data over a network	\$45.94	\$2,053.18	\$50.00
	7	20/10/2026	Switch POE purchased	Purchased	Transmits data and electrical power over a single Ethernet cable	\$21.79	\$2,031.39	\$44.02
	8	25/10/2026	Raspberry pi 5 -8 GB	Purchased	Designed for demanding tasks like robotics, and desktop computing	\$124.34	\$1,907.05	\$171.32
	9	8/12/2023	6*T200, 6 ESCs	Re-used	Thrusters	\$856.80	\$1,907.05	\$856.80
	9	8/12/2023	1*T100, 1ESCs	Re-used	Thrusters	\$82.80	\$1,907.05	\$82.80
	10	2/2/2026	Servo Motor	Purchased	Motor	\$42.85	\$1,864.20	\$45.00
	11	2/2/2026	MPU 6050, BMP 180	Purchased	using fo data collection and environmental monitoring.	\$5.90	\$1,858.30	\$6.00
			Top side					
	1	5/2/2026	NVR	Purchased	Record, store, and manage video footages from IP	\$47.85	\$1,810.05	\$50.00
	2	2/2/2023	4*power supply 12V -30A (re used)	Re-used	Using To providing electrical power	\$16.80	\$1,810.05	\$20.00
	3	10/2/2026	Monitor	Purchased	Camera display screen	\$44.02	\$1,766.48	\$45.00
	4	10/2/2026	power strip	Purchased	collect electrical device	\$19.14	\$1,747.34	\$20.00
	Total						\$1,451.10	
General (categories)			Vertical float					
	1	21/11/2025	Artylon	Purchased	material float	\$9.57	\$1,737.77	\$9.80
	2	21/11/2025	Manufacturing vertical caps	Purchased	cnc Lathe	\$34.45	\$1,703.32	\$35.00
	3	21/11/2025	Balancing weight plate	Purchased	cnc laser	\$9.57	\$1,693.75	\$10.00
	4	21/11/2025	Acrylic tube	Purchased	material tube	\$76.56	\$1,617.19	\$76.14
	5	21/11/2025	oring gland	Purchased	sealing	\$1.91	\$4,615.28	\$2.45
	6	10/10/2025	lead screw and screw nut	Purchased	secure	\$4.78	\$1,610.50	\$7.17
	7	11/11/2025	pneumatic tube and connectors	Purchased	connection flow system	\$4.78	\$1,605.72	\$5.00
	8	11/11/2025	floating board	Purchased	new technology	\$9.57	\$1,596.15	\$9.50
	9	28/11/2025	electrical wires	Purchased	connect component with pcb and battery	\$1.91	\$1,594.24	\$2.00
	10	12/12/2026	2*pumps	Purchased	inlet and outlet flow	\$8.61	\$1,585.63	\$9.00
	11	12/12/2025	battery	Purchased	feeding system	\$11.48	\$1,574.15	\$12.00
	12	20/12/2025	depth sensor	Purchased	measure depth vertical	\$19.14	\$1,555.01	\$20.00
	13	20/12/2025	level sensor	Purchased	safety	\$1.91	\$1,553.10	\$3.00
	14	20/12/2025	2*esp 32	Purchased	controlling for vertical float	\$15.31	\$1,537.79	\$15.00
			Station manufacturing					
	1	5/3/2026	1.5mm sheet metal	Purchased	thickness sheet	\$28.71	\$1,509.08	\$29.00
	2	5/3/2026	Welding	Purchased	welding parts of station	\$9.57	\$1,489.94	\$10.00
	3	5/3/2026	Bending	Purchased	Bending sheet metal	\$9.57	\$1,480.37	\$10.00
	4	5/3/2026	Laser cutting	Purchased	cutting sheet metal	\$9.57	\$1,470.80	\$10.00
5	5/3/2026	Painting	Purchased	protection from electrostatics	\$9.57	\$1,461.23	\$10.00	
6	5/3/2026	Hinge	Purchased		\$5.74	\$1,455.49	\$5.46	
7	5/3/2026	Monitor holder	Purchased	Accessories	\$5.74	\$1,449.75	\$7.30	
8	6/3/2026	Handle	Purchased		\$1.91	\$1,447.84	\$3.60	
9	10/3/2026	New wood plate	Purchased		\$11.49	\$1,436.35	\$12.00	
11	10/3/2026	Power strip	Purchased	connector	\$34.64	\$1,401.71	\$35.00	
12	10/3/2026	Fan,voltmeter,Ametec,cabels	Purchased	cooling station	\$20.10	\$1,381.61	\$25.45	
13	10/3/2026	socket	Purchased	Inlet power to system	\$0.96	\$1,380.65	\$1.00	
14	10/3/2026	3D parts	Purchased	Fasteners	\$3.83	\$1,376.82	\$4.00	
		Indirect cost						
1	1/3/2026	Work space fees	Purchased	Work shop	\$28.71	\$1,348.11	\$28.71	
2	10/3/2026	Pool fees	Purchased	Training & testing	\$38.29	\$1,309.82	\$38.29	
3	3/7/2026	T- shirts	Purchased	Company staff T-shirt	\$7.27	\$1,302.55	\$7.27	
4	29/3/2026	MATE, MATE Egypt, Fluid Power Quiz	Purchased	registration fees	\$750.86	\$551.69	\$750.86	
5	10/4/2026	Brochures, Business Cards, Poster, Banners, Technical Report, Flyers, Safety Documentation,Member IDs	Purchased	Printables	\$95.71	\$455.98	\$95.71	
		Equipments						
1	5/4/2025	25 Litre Compressor Unit	Reused	compressor	\$100.00	\$455.98	\$100.00	
2	2/2/2023	4* 12V-30A	Reused	Power supply	\$28.00	\$455.98	\$28.00	
3	5/9/2023	Drill -Screwdrivers -Sandpaper -Pliers -Wrenches -Hacksaw -Files	Reused	Mechanical tools	\$120.00	\$455.98	\$120.00	
4	13/8/2023	Soldering Iron Station -Flux -Solder Wire -AVO Meter (Multimeter) -Wire Stripper -Heat Gun	Reused	Electrical tools	\$73.00	\$455.98	\$73.00	
Total						\$1,602.38		\$1,620.71
					Total raised	\$4,103.41		
					total spent	\$1,876.94		
					Final balance	\$455.98		

		Cost (USD)
Travel Expenses	Team transportation to Alex. per member	\$9.82
	Accommodation in Alex. per member for 6 days	\$13.82
	Total expenses per Member	\$23.64
	Total expenses for 40 Member	\$945.60
	ROV Shipping	\$49.57
	Total Travel Expenses in Egypt	\$995.17

Figure 54:Sailfish Travel Expenses in Egypt

F Buoyancy & Power Distribution Table

Table (8): Buoyancy Effects

No.	Part Name (Click to open cad)	Numbers of part	Mass of One Part (grams)	Total Mass (grams)	Total Mass out Water (Kg)	Volume of One Part (mm3)	Total Volume (mm3)	Total Volume (m3)	Total Weight Outside (N)	Buoyant Force (N)	Total Weight Inside (N)
									Wo = mg	Fb = ρVg	Wi = Wo - Fb
1	Lower Plate	1	3279.62	3279.62	3.27962	1232940.77	1232940.77	0.001232941	32.16208547	12.0910186	20.07106687
2	Two Plates Rod Support	4	70.57	282.28	0.28228	54286.72	217146.88	0.000217147	2.768221162	2.129483451	0.638737711
3	Upper Control Box Rod Support	4	13.72	54.88	0.05488	10555.75	42223	0.000042223	0.538188952	0.414066183	0.124122769
4	Control Box Base Plate	1	750.42	750.42	0.75042	754191.8	754191.8	0.000754192	7.359106293	7.396095015	-0.036988722
5	Lower Control Box Rod Support	4	21.56	86.24	0.08624	16587.61	66350.44	6.63504E-05	0.845725496	0.650675542	0.195049954
6	PG7 control box	31	6.1	189.1	0.1891	3543	109833	0.000109833	1.854437515	1.077093789	0.777343726
7	Leg	2	355.32	710.64	0.71064	323015.45	646030.9	0.000646031	6.968997756	6.335398925	0.633598831
8	Electronics Enclosure	1	7061.22449	7061.22449	7.06122449	11175000	11175000	0.011175	69.24695714	109.5893138	-40.34235661
9	Rod Leg Connector	2	80	160	0.16	79521.56	159043.12	0.000159043	1.569064	1.559680213	0.009383787
10	upper plate	1	1746.39	1746.39	1.74639	1343374.23	1343374.23	0.001343374	17.12623549	13.17400089	3.952234601
11	up&down Thruster Connectors	2	49.52	99.04	0.09904	49771.68	99543.36	9.95434E-05	0.971250616	0.976186891	-0.004936275
12	Horse Thruster Connector	1	57.85	57.85	0.05785	58143.81	58143.81	5.81438E-05	0.567314703	0.570195994	-0.002881292
13	3 Jaw	1	302.842639	302.842639	0.302842639	302.842639	302.842639	3.02843E-07	2.969871766	0.002969872	2.966901894
14	2 Jaw	1	175.39	175.39	0.17539	157686.51	157686.51	0.000157687	1.719988344	1.546376413	0.17361193
15	Valves	5	1700	8500	8.5	91426.54	457132.7	0.000457133	83.356525	4.482940392	78.87358461
16	Stereo Camera	1	1129.92	1129.92	1.12992	2036571.429	2036571.429	0.002036571	11.08072997	19.9719432	-8.891213232
17	Hand	2	80.64	161.28	0.16128	38940.02	77880.04	7.788E-05	1.581616512	0.763742294	0.817874218
18	L Part	6	60	360	0.36	2179.47	13076.82	1.30768E-05	3.530394	0.128239797	3.402154203
19	Camera	4	202.58	810.32	0.81032	177701.92	710807.68	0.000710808	7.946524628	6.970642135	0.975882493
20	Thrusters	7	355	2485	2.485	187312.63	1311188.41	0.001311188	24.36952525	12.85836582	11.51115943
21	45 Camera Stand	1	211.18	211.18	0.21118	26397.29	26397.29	2.63973E-05	2.070968347	0.258868984	1.812099363
22	360 Camera Stand	1	271.2	271.2	0.2712	33899.89	33899.89	3.38999E-05	2.65956348	0.332444356	2.327119124
23	Rotating Clutch mechanism	1	262.64	262.64	0.26264	232102.7	232102.7	0.000232103	2.575618556	2.276149943	0.299468613
24	Buoy attachment mechanism	1	383.02	383.02	0.38302	150308.3	150308.3	0.000150308	3.756143083	1.47402089	2.282122193
25	Main gripper	1	120.71	120.71	0.12071	126783.66	126783.66	0.000126784	1.183760722	1.243322979	-0.059562258
26	Tri-finger gripper	1	227.093582	227.093582	0.227093582	238543.679	238543.679	0.000238544	2.227027276	2.33931437	-0.112287094
27	Piston	2	190	380	0.38	30902.85	61805.7	6.18057E-05	3.726527	0.606106868	3.120420132
28	Heavy hook mechanism	1	432.373887	432.373887	0.432373887	263612.8943	263612.8943	0.000263613	4.240139379	2.585159389	1.65497999
29	Heavy hook mechanism Piston	1	282.2	282.2	0.2822	105870.22	105870.22	0.00010587	2.76743663	1.038232193	1.729204437
30	gripper4			0	0		0	0	0	0	0
31	DC Motor Enclosure	1	123.05	123.05	0.12305	280000	280000	0.00028	1.206708283	2.745862	-1.539153718
32	Hex Screws	160	0.5	80	0.08	493.0743	78891.888	7.88919E-05	0.784532	0.773665133	0.010866867
33	Nuts	160	0.2	32	0.032	37.537	6005.92	6.00592E-06	0.3138128	0.058897955	0.254914845
34	Cup Nuts	60	0.8	48	0.048	206.939	12416.34	1.24163E-05	0.4707192	0.121762701	0.348956499
Totals				18633.50011	18.63350011		22272689.88	0.02227269	306.0449976	218.4204742	87.62452339

Table (9): Power Distribution

Component	Quantity	Voltage (v)	Nominal Current (A)	Max Current (A)	Nominal power/ component (W)	Max Power/ component (W)	Nominal Total power (w)	Max Total power (W)
T200 thruster	6	12	6	13	72	156	432	936
T100 thruster	1	12	0	6	0	72	0	72
ESCs	7	12	0.3	0.5	3.6	6	25.2	42
DCV (solenoid)	4	12	0	0.4	0	4.8	0	19.2
DC (Motor)	1	12	0.25	1	3	12	3	12
IP Camera	6	12	0.5	1.5	6	18	36	108
USB Hub	1	12	0.5	2	6	24	6	24
STM	1	5	0.0127	0.0127	0.0635	0.0635	0.0635	0.0635
Raspberry Pi	1	5	3	5	15	25	15	25
servo motor	1	4.8	0.8	1.8	3.84	8.64	3.84	8.64
LM2596S	2	12	2	3	24	36	48	72
IMU Sensor	1	5	0.0039	0.0039	0.0195	0.0195	0.0195	0.0195
Total							569.123	1318.923
Total power consumption= 1318.923w MAX Current drawn from MATE Power Supply=27.47756A								



G Sailfish Company Structure

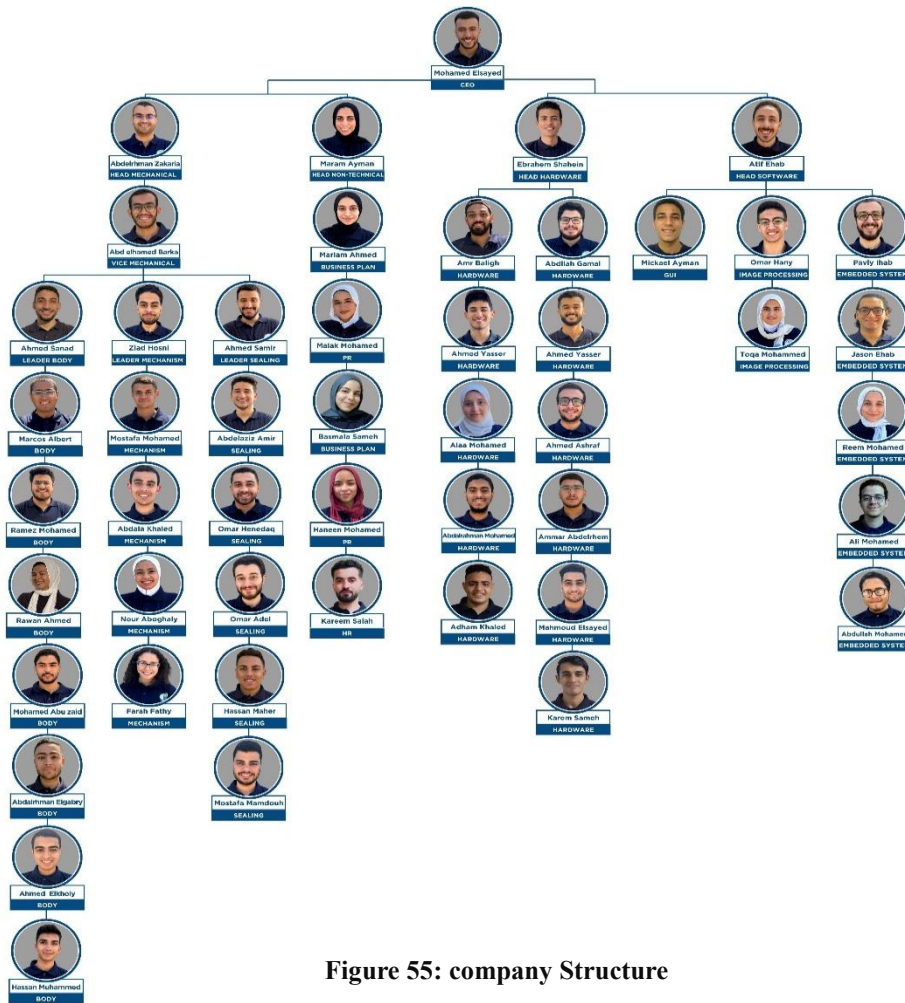


Figure 55: company Structure

H SIDs

• Software SID

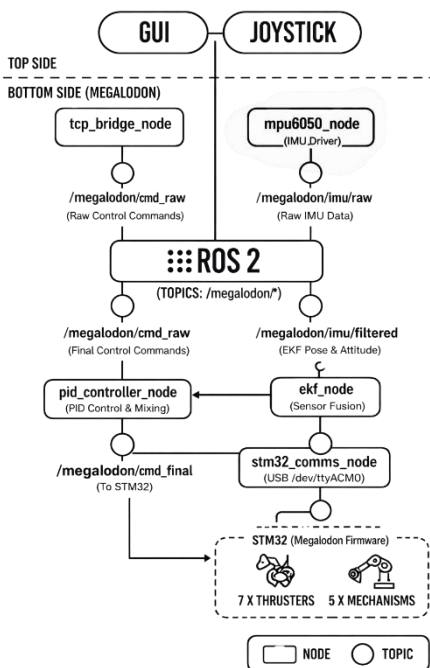


Figure 56: Software SID

• Vertical SID

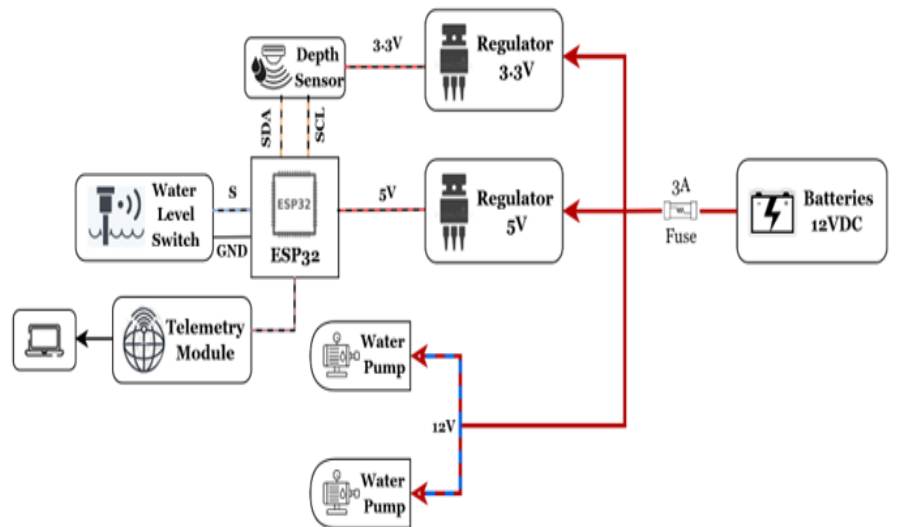


Figure 57: Vertical float SID



Hardware SID

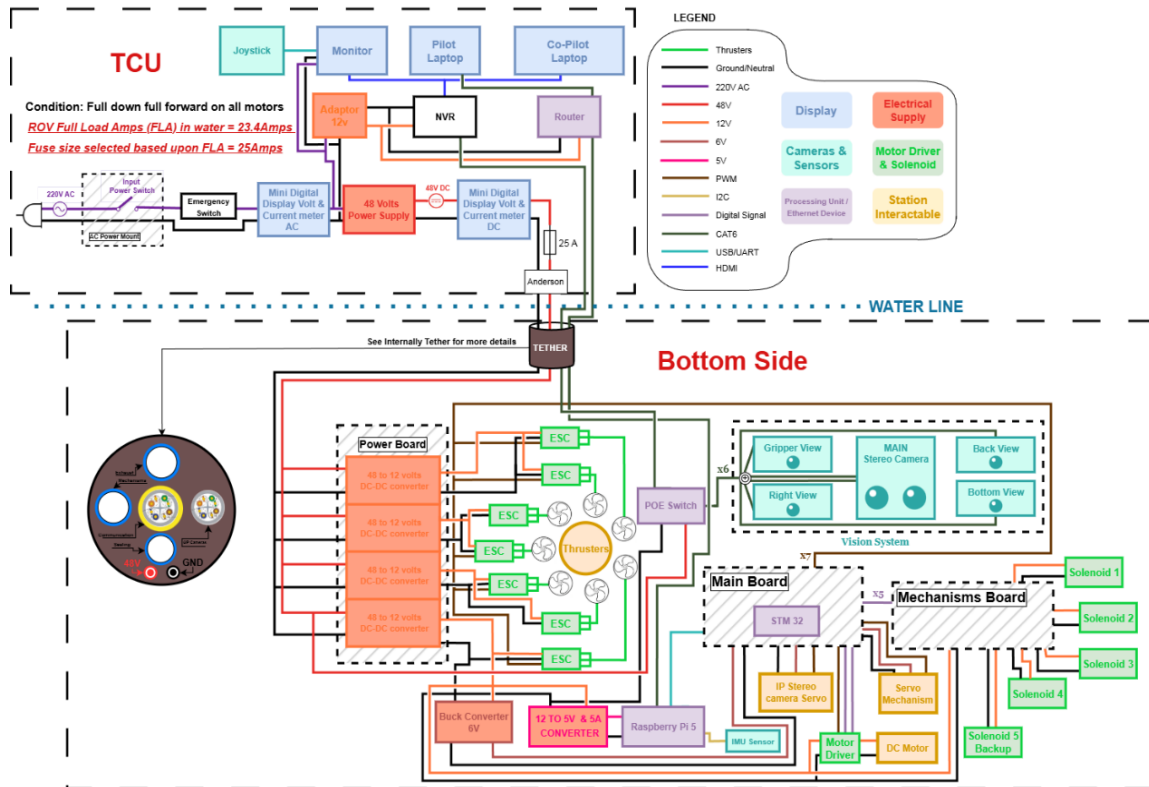


Figure 58: Hardware SID

Pneumatic SID

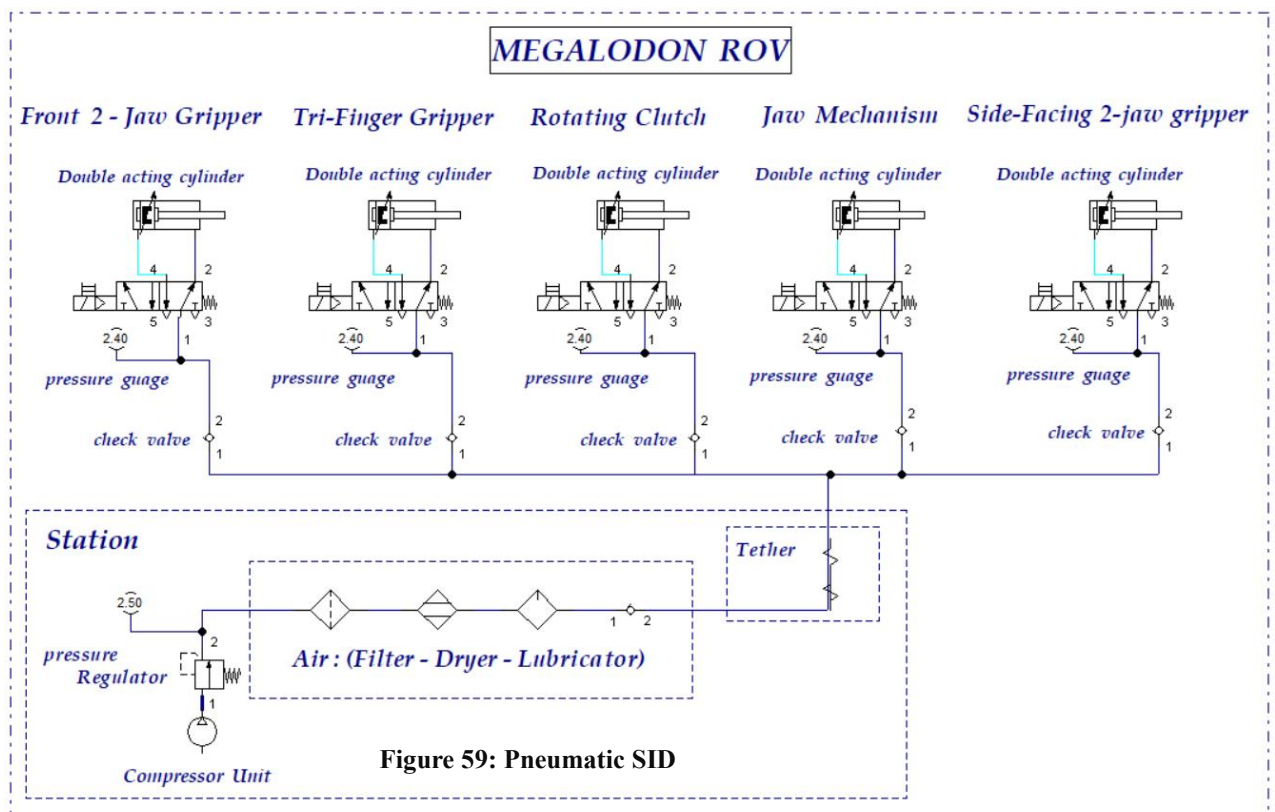


Figure 59: Pneumatic SID

