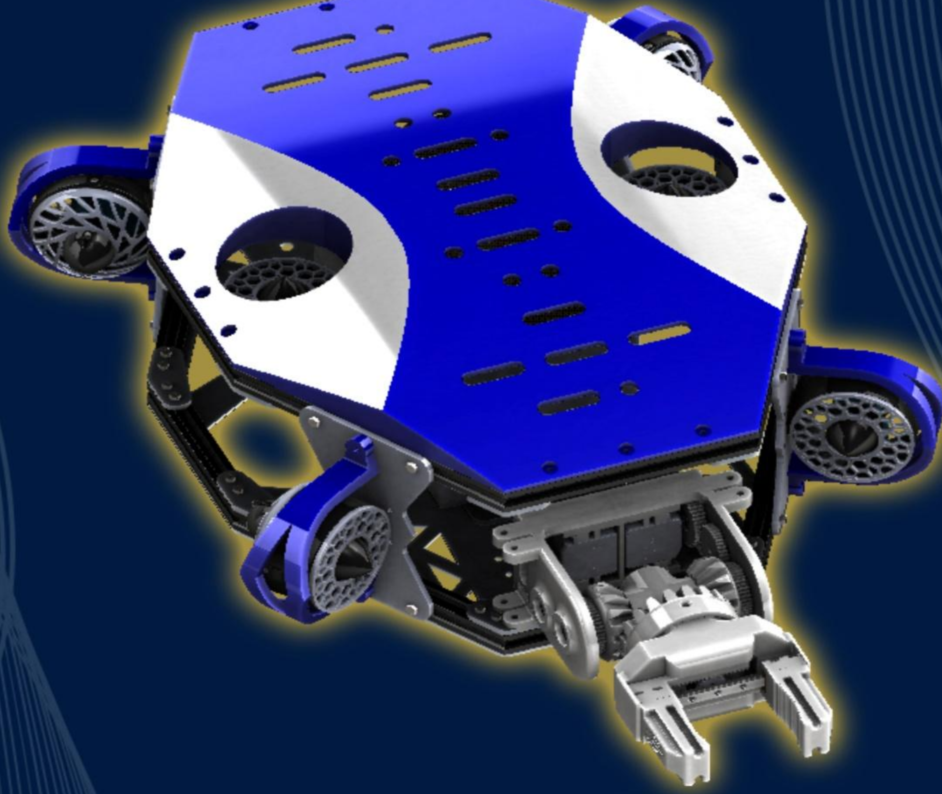


DEADPOOL

ALEXANDRIA, EGYPT 2025
TECHNICAL REPORT

Arab Academy
For Science, Technology and Maritime Transport
Regional Informatics Center

TRITON

UNDER THE SUPERVISION OF
ENG/ MUHAMMED MONGY

27' Mohamed Ehab SW. /CEO
27' Mohamed Osama SW. Leader /CTO
27' Zyad Magdy SW. /Pilot
27'Adham Waheeb SW.
27'Youssef Waleed SW.
27'Saged Khaled SW.
27'Omar Yakout SW.
27'Jana Ayman SW.
27'Salma Sherif SW.
28'Youssef Hashem SW.
29'Mokhtar Niazy SW.
27'Mohammed Shehata SW.
MENTORS : ENG/ AHMED SOBHY
ENG/ KAREEM AKRAM

27' Aly Abdelelah ME. Leader/CFO
27'Yehia Mohamed ME.
27'Omar Amin ME.
29'Alyeldin Bassam ME.
29'Amro Tarek ME.
MENTOR : ENG/ OMAR AMER

27' Abdallah Nabil EC. Leader
26'Mohamed Ashraf EC.
27'Mohamed Said EC.
27'Salma Eslam EC.
29'Mostafa Heiba EC.
MENTOR : ENG/ ABDELRAHMAN MOSTAFA
ENG/ AMR AHMED

ABSTRACT

Triton is a newly formed student-led team from the Arab Academy for Science, Technology, and Maritime Transport (AASTMT) at the Abu Qir campus in Alexandria, Egypt. Established in 2024,

AAST Triton ROVs is comprised of **22 members (Figure (1))**, our team embarked on its first journey into the world of Remotely Operated Vehicles (ROVs) with a vision to innovate, learn, and compete. We are committed to developing a high-performance ROV that meets industry and competition standards while enhancing our technical and problem-solving skills.

Our ROV, **DEADPOOL** is designed to perform a wide range of underwater tasks with precision and efficiency, from hardware optimization to software integration and mechanical innovation. Through perseverance and teamwork, we have developed an ROV that demonstrates both innovation and robustness. Our goal is to continuously improve, innovate. While this abstract provides a glimpse into our journey, the full capabilities and features of **DEADPOOL** will be explored in detail throughout this technical report.

Figure (1) Team Members 2025

ACKNOWLEDGEMENT

We would like to thank these organizations for offering us support.

- **MATE Center** – for this year competition,
- **Arab Academy For Science And Technology (AAST)** – For hosting this year regional competition.
- **AAST Regional Informatics Center** – For their continuous support for the team

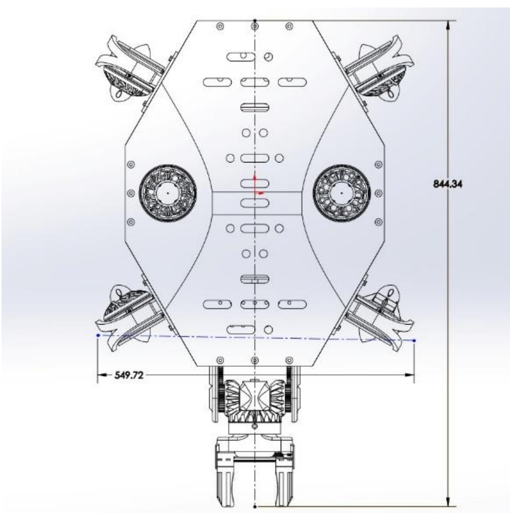
Figure (2) Supporters

TABLE OF CONTENT

1-DESIGN RATIONALE

1.1 Design Evolution

Our primary goal was to design a lightweight, compact ROV with excellent maneuverability, capable of performing efficiently in tight underwater environments. We based our development on this core principle, as this year's tasks, in our view, demanded an ROV that is both small and highly agile to navigate challenging underwater conditions effectively. Our ROV's weight is **17 KG.**



1.2 Mechanical System

1.2.1 Material Selection

Selecting the right material for our ROV frame was critical to ensuring durability, performance, and lightweight construction. After evaluating multiple options, we chose **2020 Aluminum Extrusion (Figure (3))** over alternatives like Titanium and Steel due to its optimal balance of strength, weight, and cost-effectiveness.

Aluminum offers excellent corrosion resistance due to its natural oxide layer, making it well-suited for underwater environments. It is also lighter than Steel, enhancing the ROV's maneuverability and speed. These advantages make 2020 Aluminum Extrusion the ideal material for our ROV frame, ensuring efficiency, and performance in challenging underwater conditions. Additionally, our enclosure material is Aluminum. Aluminum's **high thermal conductivity** allows efficient heat dissipation from internal components, preventing overheating and ensuring stable operation. Its ease of fabrication makes it simple to machine, customize, and repair, reducing production time and costs.

Figure (3) 2020 Aluminum Extrusion

1.2.2 Frame

Our ROV's frame **(Figure(4))** consists of three main components: **the skeleton**, **the down plate**, and the **float cover**. The skeleton is constructed using 2020 Aluminum Extrusion, ensuring modularity without the need for welding or drilling, as it is assembled with **V-slot nuts**. It measures **45 cm in length**, **60 cm in width**, and **17 cm in height**. Aluminum brackets secure the extrusions to form the **upper** and **lower** sections, while 4 larger central brackets connects them and serves as the mounting point for four thrusters. The **down** plate**(Figure (5))**, made from a **3mm Aluminum Sheet**, shares the same dimensions as the skeleton and is designed to secure the Aluminum box to the frame. It features multiple openings, allowing for easy attachment or removal of payloads, enhancing the system's modularity. **Lastly**, the float cover**(Figure (7))** matches the skeleton's dimensions and plays a crucial role in reducing drag force and improving the ROV's hydrodynamics for smoother movement in water.

1.2.3 Enclosure

Our Enclosure **(Figure (6))** is made out of Aluminum, despite the limited internal space **(22.5 × 13 × 16 mm)** of the enclosure, the components were successfully assembled. The

Aluminum's high thermal conductivity played a key role in the ROV's cooling system. Additionally, its excellent resistance to corrosion and ease of manufacturing made it an ideal choice. The head cap was made of **polycarbonate** to provide **visibility**, thanks to its transparent nature. To ensure a better seal, a **rubber gasket** was used between the polycarbonate cap and the flange layer. Through **Argon Welding** the flange sheet was permanently attached to the box, and drilling was used to create holes for the bolts.

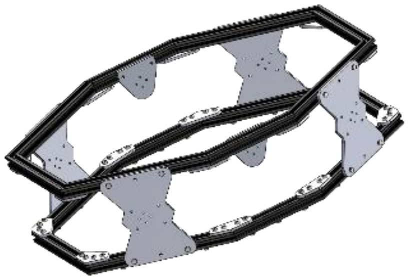


Figure (4) ROV's Frame

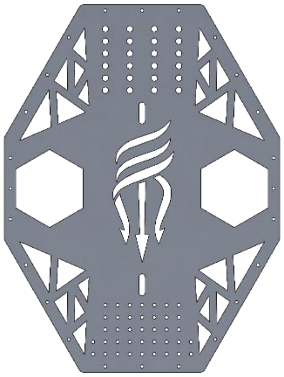


Figure (5) Down Plate

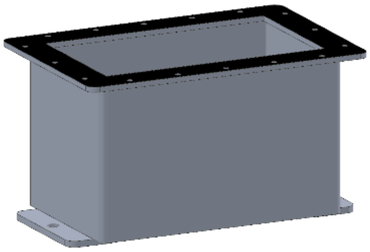


Figure (6) Enclosure

1.2.4 Mechanical Virtual Prototyping

1.2.4.1 CFD

To analyze the flow field characteristics around our ROV, A CFD was made to detect the heights pressured points. **(Figure (7))**

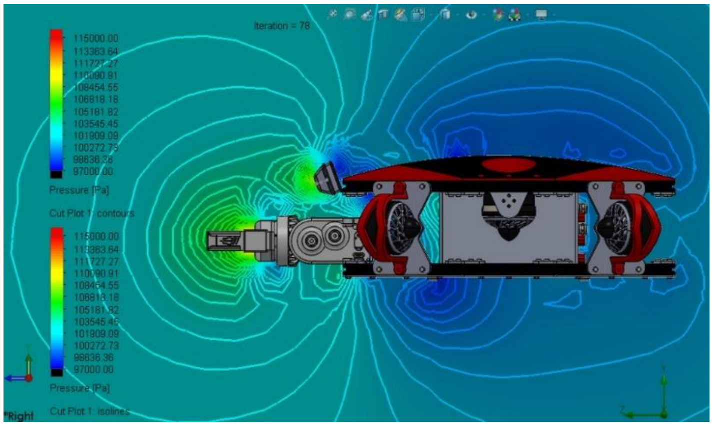


Figure (7) CFD

1.2.5 Propulsion

To meet the MATE 2025 mission requirements while maintaining a compact and efficient design, our ROV utilizes six T200 thrusters arranged to provide five degrees of freedom. Unlike larger ROVs that typically use up to eight thrusters, our smaller frame allowed us to optimize maneuverability with fewer units, contributing to reduced power consumption and simplified integration.

The four horizontal thrusters are mounted at 60-degree angles (Figure (8)), enabling precise control for yaw, lateral, and roll movement. Two vertical thrusters are mounted at 90 degrees (Figure (9)) to manage vertical translation. This configuration supports stable navigation across all mission tasks, ensuring responsive handling in confined spaces.

During development, the addition of a seventh thruster was considered to enhance range of motion. However, after evaluating power distribution limitations, the electrical sub team determined that the current six-thruster setup offered the best balance between control and electrical feasibility. This decision reflects our focus on thoughtful trade-offs between mechanical capability and system constraints.

Figure (8) 4 Thrusters 60-degree angle

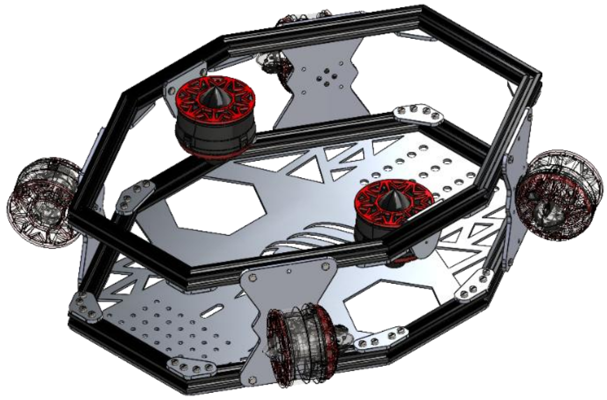


Figure (9) 2 Thrusters 90-degree angle

1.2.6 Buoyancy

Our ROV is designed to achieve **neutral buoyancy**, allowing it to remain suspended in water without sinking or floating. This balance ensures **efficient maneuverability** with **minimal energy consumption**. By carefully distributing buoyant materials and ballast weights, we optimize the ROV's stability and control. Additionally, our modular frame and strategically positioned thrusters contribute to smooth and precise movement in all directions. This enables the ROV to navigate effectively for various underwater tasks while maintaining stability in different water conditions.

1.2.7 Payloads

1.2.7.1 Gripper Mechanism

Our gripper is constructed using three servo motors, each providing 36 kgf·cm of torque. The first servo powers a rack-and-pinion mechanism (Figure (10)), where the pinion moves a rack attached to an MGN9C linear bearing on an MG9 linear rail (Figure (11)), enabling a wide and stable jaw opening. The remaining two servos control tilting and rotation. When moving in the same direction, the gripper tilts; when rotating in opposite directions, it spins clockwise or counterclockwise. A spur gear system (Figure (12)) transmits motion, while a bevel gear system (Figure (13)) ensures precise tilt and rotation.

Before finalizing this design, we explored multiple prototypes, including options with DC motors, stepper motors, and pneumatics. Each presented integration or control challenges. We ultimately selected the servo-based design for its compactness, precision, and ease of control. Its ability to tilt and rotate gives us the flexibility to complete key MATE 2025 mission tasks—such as aligning the solar panel and retrieving sacrificial anodes— which require fine orientation that we couldn't achieve using other commercial grippers such as the Blue robotics gripper which was one of the first options we had (**A detailed breakdown of build vs. buy and new vs. reused component choices can be found in Appendix 9.2**).. All components were manufactured using PETG 3D printing for accuracy and structural reliability.

	servo	DC	Stepper	Pneumatic	Blue Robotics
Cost (5)	5	5	4	3	1
Torque (5)	4	4	2	5	5
Simplicity in use (5)	3	2	3	4	5
Stability (5)	5	4	3	4	5
Range of motion (5)	5	2.5	2.5	3	2
Score (25)	22	17.5	12.5	19	18

Decision matrix for gripper mechanism

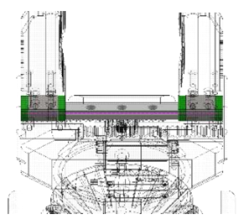
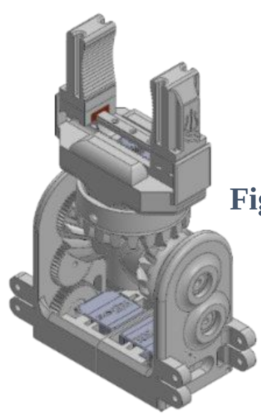


Figure (11) Linear Guide and Linear Bearing Block



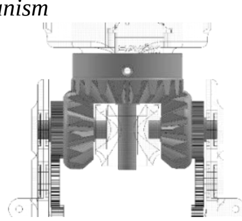


Figure (13) Bevel gear

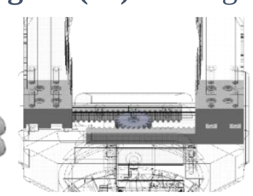


Figure (10) Rack and Pinion gear

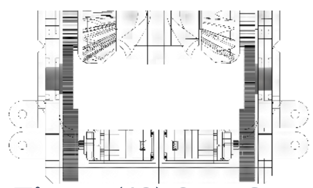


Figure (12) Spur Gear

1.2.7.2 Stereo Housing

Our software team has chosen the **OAK-D S2** stereo camera to handle computer vision tasks for this year's competition, leveraging its advanced **depth-sensing** and **AI** processing capabilities, we manufactured the stereo housing with CNC router machine using HPDE material**(Figure (14))**. An Acrylic endcap used to seal the enclosure compressing an O-ring between it and the HPDE housing for optimum sealing. The housing is specially designed for this camera to handle its cable without the need of any cutting on it.

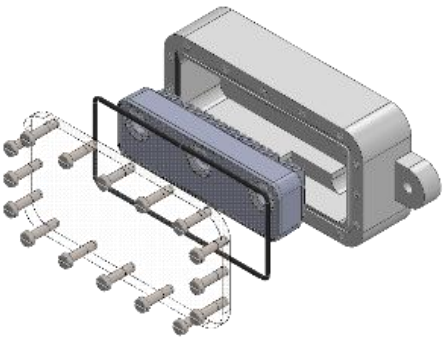


Figure (14) Stereo Camera Housing

1.2.7.3 POE housing

Our **POE** camera housing**(Figure (15))** consists of two enclosures: one housing the **camera PCB** and the other containing the **power PCB**, which supplies power to the camera. The housing is 3D-printed, ensuring modularity, a compact design, and secure attachment to the frame .

A **transparent acrylic** front panel allows clear visibility and is sealed to the housing using silicone, while the entire enclosure is further sealed with **epoxy** for waterproofing. The power enclosure accommodates multiple PCBs, serving as a **central checkpoint** for all the camera power boards, ensuring efficient power distribution and management.

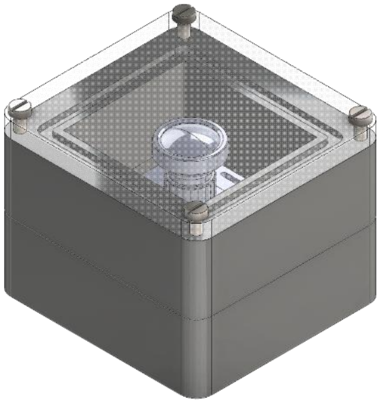


Figure (15) POE Housing

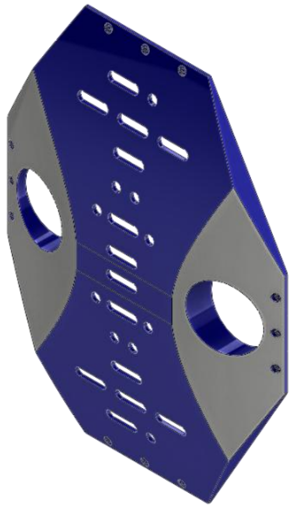


Figure (7) Float Cover

1.3 Hardware System

The modular electrical enclosure of **DEADPOOL** has been carefully designed to maximize performance, streamline functionality, and facilitate maintenance or upgrades. By dividing the enclosure into **two** distinct layers, the system ensures **superior organization** and **efficiency**.

1.3.1 Top Layer

The top layer handles advanced control operations, featuring the **Pixhawk** for mission planning and system reliability. The **Raspberry Pi 5 (8GB)** acts as the central processor, gathering data from the Pixhawk, processing it, and transmitting it to the control box. Chosen for its efficiency, lightweight design, and open-source flexibility, the Raspberry Pi 5 excels in sensor integration due to its versatile I/O capabilities.

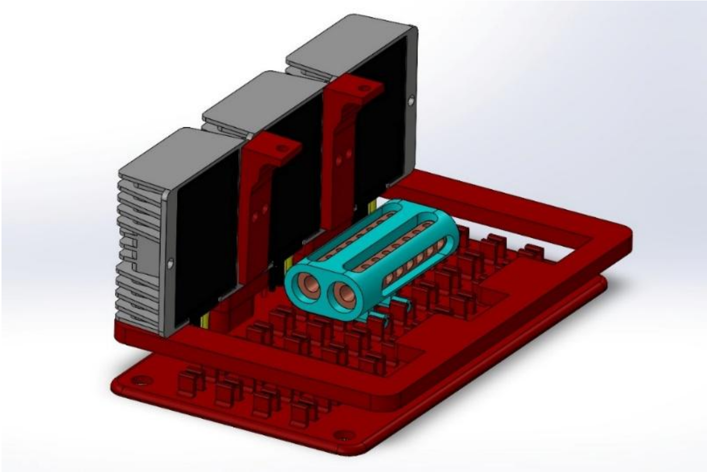


Figure (16) Bottom Layer

1.3.2 Bottom Layer

The bottom layer is dedicated to power management and is equipped with **six robust DC-DC converters**. These converters step down the **48V** input voltage to **12V (20A)**, ensuring stable power distribution to the thrusters. Additionally, **two** more **DC-DC converters (12V to 5V)** are used—one for the Raspberry Pi and the other for the servos controlling the gripper. A crucial design decision was to power the Pixhawk separately using a dedicated **power module**, as we encountered unexpected fluctuations that affected performance. Each converter is connected to a **BlueRobotics ESC** (Electronic Speed Controller), which collects signals from the Pixhawk and transmits them to the T200 thrusters. For power delivery from the tether to the converters, we custom-designed a specialized **Rosetta(OSS)**, as standard options presented space constraints within the compact enclosure. OSS is made using **two 17 mm copper rods** which are capsulated in a **3D printed PLA** cover. Each rode features **7 precisely** machined apertures for secure mounting of buck wires **(Figure (16)).**

1.3.3 Tether

Our tether **(Figure(17))** incorporates an **AWG-8 DC power cable** along with **four CAT6** Ethernet cables, all encapsulated within a **flexible meshed shield**. One of the CAT6 cables establish a connection between our Raspberry Pi and the control station and other cables are for our POE cameras. We selected the AWG-8 power cable for its **high conductivity** and **low voltage drop**, ensuring it meets the power requirements of our buck converters.

To ensure safe and reliable ROV operation, our team follows a structured tether handling procedure:

Pre-Mission: The tether is inspected for damage, securely connected, and laid out to avoid tangling.

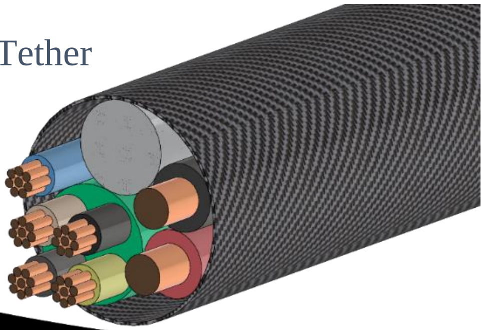
Deployment: Released in sync with ROV movement to prevent slack buildup and maintain communication.

Monitoring: A dedicated member oversees tether slack and position throughout the mission.

Adjustment: Length and tension are actively managed based on vehicle movement and environmental conditions.

Post-Mission: The tether is retrieved carefully to prevent twisting and is inspected for wear or damage before storage

Figure (17) Tether



1.3.4 Sensors

Our ROV have a **BlueRobotics Pressure sensor (Figure (19))** enables **precise depth hold** for stability, while **one BlueRobotics leakage sensor (Figure (18))** with **four probes** detect minor leaks to prevent water ingress connected to the Pixhawk for real-time monitoring and response.

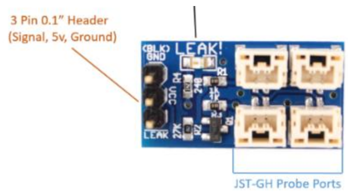


Figure (18) Leak Sensor

Figure (19) Pressure Sensor

1.3.5 Control Station

Our **Control Station (as shown in Figure (20))** consists of a **monitor**, **controller**, **NVR**, and **Laptop**, all enclosed in a **grab-and-go box** for easy deployment and quick setup. This design ensures portability, protection, and efficient organization of the components, allowing for seamless operation in various environments.

Figure (20) Control Station

1.3.6 Gripper

Figure (21) MNFLTY PCB

1.4 Software System

1.4.1 Control System

1.4.1.1 Bottom-side Software

The ROV's processing is handled by a Raspberry Pi 5. The Triton software control subteam has observed the need for an optimized and power-efficient operating system for the Raspberry Pi 5 than stock Raspberry Pi OS, which lead to the creation of **TritonOS**. **TritonOS** is a custom 64-bit build of Raspberry Pi OS with significant bloat and unneeded programs removed, in addition it is preconfigured with a **static IP address**, **administration** and **telemetry daemons**, a **MAVLink router**, **gripper control daemon** and daemons for streaming the **stereo camera** feeds to the topside.

TritonOS comes in **two** flavors, **full** and **light**; the full version features a desktop environment with custom themes and a visually appealing lightweight boot animation, while the light version is optimized for minimum resource usage and is designed for the more technically versed. All these features were created to make configuring and setting up the ROV.

1.4.1.2 Top-side Software

HydraNav is an in-house Ground Control System (GCS) developed by the control subteam to address the limitations of existing GCS software like QGroundControl, which is designed for aerial drones and lacks proper ROV compatibility. It features a flexible user input system that supports various input devices- like the DualShock 4, DualSense and 8bitdo controllers-with customizable YAML-based mappings and auto-detection for configured controllers. **HydraNav** ensures a stable connection to the ROV using **asynchronous** mechanisms, periodically sending heartbeats at ~**1Hz** while minimizing bandwidth usage without compromising responsiveness. It also supports individual **motor testing**, **autopilot parameter configuration**, and **real-time telemetry streaming** from **TritonOS**, keeping the user interface consistently updated. Additionally, it integrates remote administration capabilities, allowing operators to **monitor**, **restart essential services**, **reboot**, or **shut down** the Raspberry Pi onboard.

Figure (22) OAK-D S2

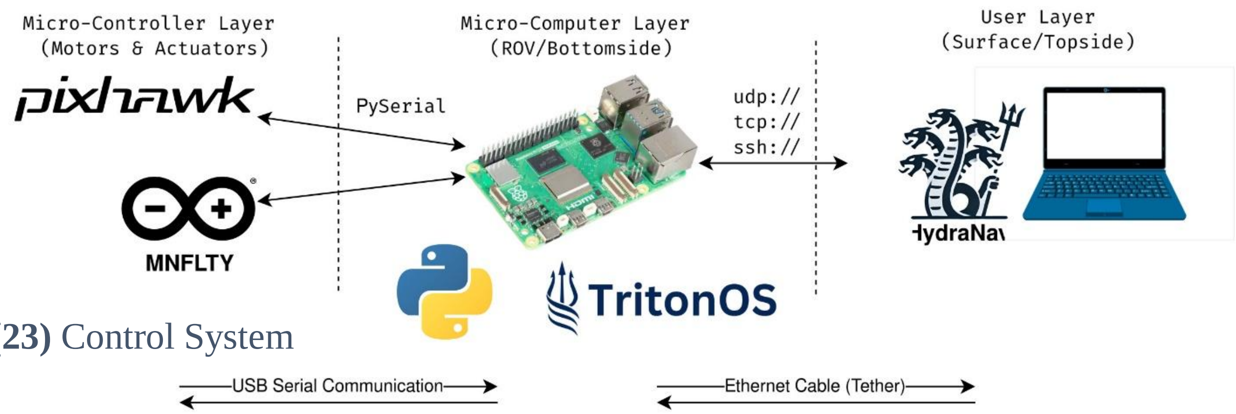


Figure (23) Control System

1.4.2 Vision System

1.4.2.1 Stereo Camera

We chose the **OAK-D S2 (Figure (22))** stereo camera because of its flexibility in different applications. The **DepthAI SDK** uses stereo vision and AI to provide **real-time depth perception** and **3D mapping**. The OAK-D also has a **built-in IMU** for motion tracking, allowing it to work with other sensors for better accuracy. With its small and lightweight design, high-resolution cameras, and built-in AI processing.

1.4.3 Streaming System

PoE cameras are **high-resolution, low-latency real-time cameras**. We modified them to be sealed for ROV mounting, capturing multiple angles to enhance navigation. They receive both **power and data through a single Ethernet cable**, simplifying wiring and ensuring stability. These cameras offer **HD or 4K resolution**, with **low-light and infrared capabilities** for clear imaging in murky conditions. Each camera has a **110° horizontal and 60° vertical**

field of view, and we are using a total of **four PoE cameras** on our ROV.

1.4.4 Measuring Length

We use the OAK-D camera for measuring the length of an object. How? The left and right **mono-camera** both take an image of the same scene but from different perspective. The camera uses these two images to calculate the disparity (shift in position of objects between the two images). Disparity measurement is converted into real world depth, from this depth values the camera generates a depth map which represents the distance of every pixel from the camera in mm. The depth map allows us to measure the length between any two selected points in the image. By selecting two points on the image we retrieve their respective depth values and compute their real world distance.

1.4.5 Automated Scripts

The system runs four Unix daemon services on a Raspberry Pi, managed by SystemD. The Telemetry Service monitors system resources and sends data via **UDP**. The MAVProxy Service relays MAVLink messages between the topside and Pixhawk.

The **MNFLTY** Bridge Service forwards commands to the MNFLTY board over serial. The Admin Service handles remote power control and service management, ensuring reliable operation.

1.4.6 360 Photosphere

The final solution involved mounting a **fisheye lens (Figure (24))**on the OAK-D S2 camera to achieve a 180-degree FOV. We captured 24 RGB frames and used stitching software to merge them with minimal distortion and a high number of control points, generating an **Equirectangular** (panoramic) image, which was then visualized as a **360°**.

Figure (24) FishEye lens

2-Safety

2.1 Safety Philosophy

At the core of our operations, Triton is committed to fostering a culture of safety that permeates every aspect of our work. We emphasize a proactive safety mindset from the **initial design** phases through fabrication, testing, and deployment of our ROV, **DEADPOOL**. This commitment is underpinned by rigorous adherence to **MATE** regulations, **continuous risk assessments**, and ongoing process improvements that prioritize the well-being of our team, equipment, and the marine environment.

Figure (25) Safety First

2.2 Personal Safety

All personnel involved in the development and operation of **DEADPOOL** must adhere to strict safety protocol.

Personal Protective Equipment (PPE): Safety glasses, gloves, masks, hearing protectors, and other required PPE are readily available and must be used during all tasks.

Workplace Organization: Daily housekeeping procedures, including end-of-day cleanups and monthly comprehensive cleaning days, ensure that workspaces remain organized and that emergency exit routes are always unobstructed.

2.3 Equipment Safety

We enforce rigorous equipment safety protocols:

Inspection & Maintenance: All tools and equipment undergo regular inspections to detect wear or defects that could pose safety hazards.

Proper Storage & Return: Borrowed items must be returned to their designated storage areas following clearly labeled instructions.

2.4 Safety Checklist

Here is our safety Checklist**(as shown in Figure(26))** that we follow to ensure the Safety of our operation.

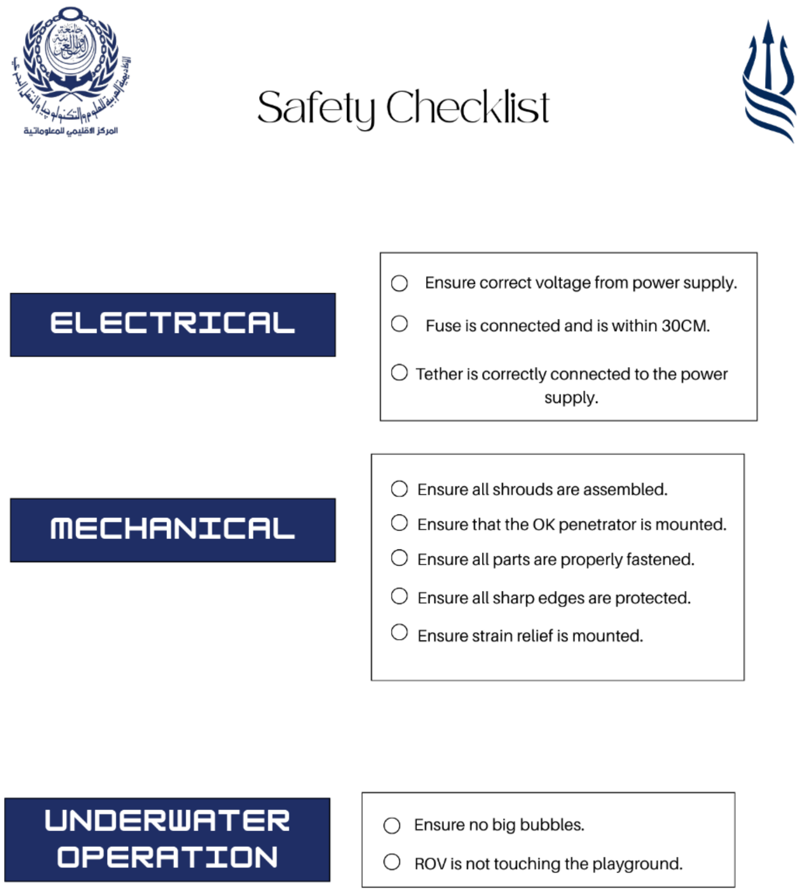


Figure (26) Safety Checklist

2.5 Safety features

2.5.1 Electrical Safety

A **fuse** is connected to our tether to ensure the safety of our system. Additionally, integrated leak sensors actively monitor for water intrusion, triggering alerts to indicate any leakage.

2.5.2 Mechanical Safety

Strain relief (Figure (27))is applied to all tethering points to ensure that the pulling load all applied to it, and protective **shrouds** enclose the thruster's intake and exhaust to prevent accidental contact.

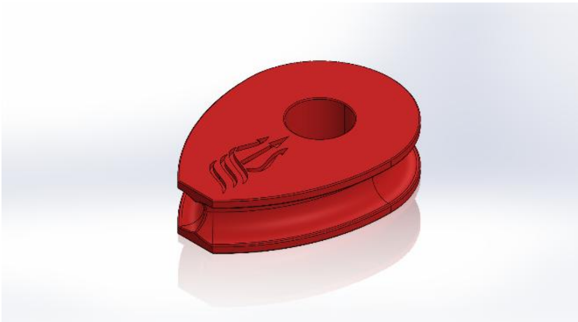


Figure (27) Strain-Relief

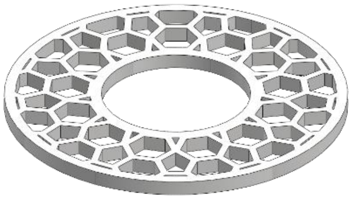


Figure (28) Upward Shroud

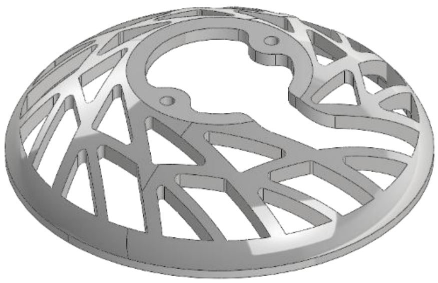


Figure (29) Backward Shroud

3-Logistics

3.1 Project Management

3.1.1 Team Structure

Our team operates under a structured leadership model with a CEO, CTO, and CFO overseeing key areas of operation. We are divided into three main sub-teams—Mechanical, Software, and Electrical—each led by a team leader who manages task delegation, progress tracking, and quality control, while coordinating with upper management. Our workflow includes daily stand-up meetings where long-term goals are broken into specific tasks and deadlines. Team members receive daily responsibilities and report progress to their team leader, ensuring consistent coordination and efficient execution.

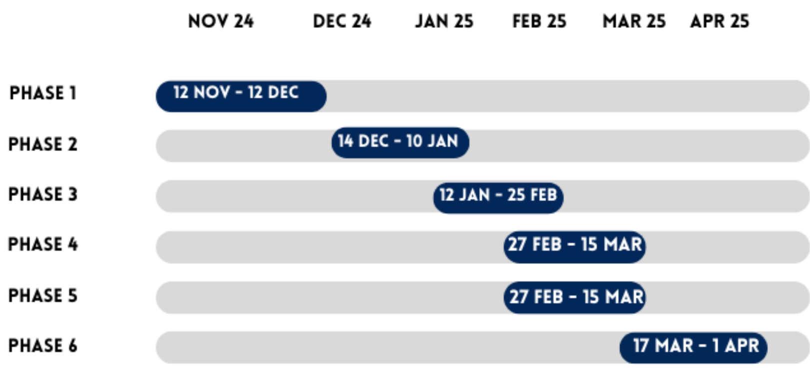


Figure (30) Schedule

3.1.2 Schedule

Phase 1: Training and Workshops – Conducting intensive workshops to ensure the team understands ROV concepts, operations, and core engineering principles.

Phase 2: Research and Development (R&D) – Analyzing designs and creating a detailed plan for the Mechanical, Electrical, and Software systems.

Phase 3: Implementation and Testing – Implementing the R&D plans and conducting tests to validate system performance and efficiency.

Phase 4: Vertical Profiling Float Development – Running parallel to later phases, this involves scheduling and implementing the Vertical Profiling Float.

Phase 5: Documentation and Presentation Planning – Preparing accurate and well-structured technical and project-related documents.

Phase 6: Tasks Strategy for the Competition & Troubleshooting – Developing strategies and plans for executing the competition's tasks.

3.1.3 Resources Used

We utilized various resources and software to enhance productivity, streamline project management, and ensure seamless collaboration among all sub-teams, keeping everyone informed about each other's work.

1- **Discord**: **(as shown in Figure(31))**We used Discord for real-time communication, facilitating our weekly meetings.

2- **GitHub**: We used GitHub for version control and software reliability.

3-**Google drive:** Used in sharing administrative files and documents

3.2 Budget Allocation

Our team operates on a **bootstrapping** model, structuring the season into four funding rounds. In each round, we assess financial requirements, allocate contributions among team members, and collectively secure the necessary capital. The budget statement will be included on the final page of the report.

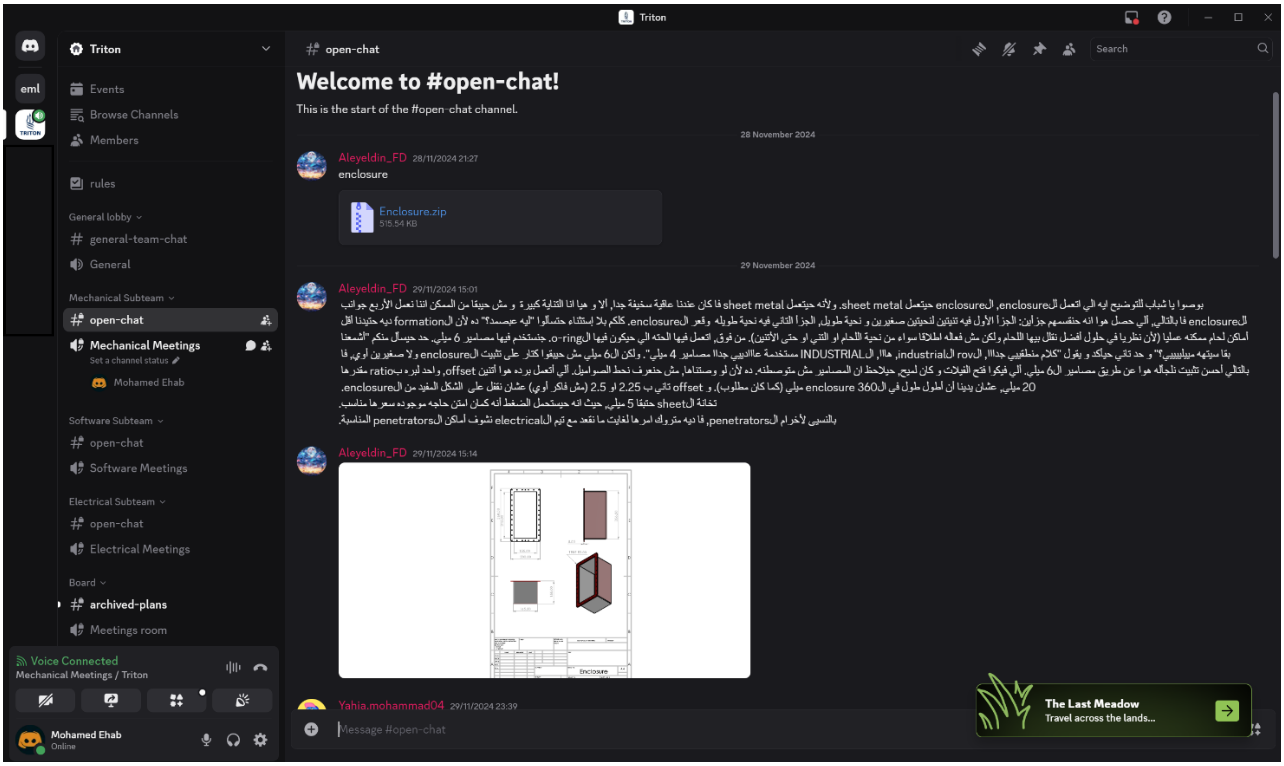


Figure (31) Our Discord Server

4- Testing, Troubleshooting & Innovation

4.1 Mechanical

4.1.1 Sealing

To ensure the protection of electrical components from leakage, both **dry** and **water** sealing tests were conducted. The dry tests included a vacuum test, which simulated underwater conditions by creating a pressure difference inside the enclosure, with a pressure gauge detecting any leaks through pressure drops. Another dry test involved pressurizing the enclosure with **visible smoke** to identify potential leaks. For the water tests, the ROV was submerged for **30 minutes**, exceeding the typical competition demonstration time, and was also tested at a depth of **4.5 meters** to evaluate its sealing effectiveness.

4.1.2 Frame Assembly

We faced some issues in frame cutting caused motor misalignment and **CAD** assembly errors, which were resolved using specially cut **CNC** machining plate to accurately align the dimensions of the ROV to it. Another issue we faced was incorrectly cutting the Aluminum 2020 Extrusion required custom **3D-printed fillers**. The enclosure also posed challenges, Limited visibility in the aluminum enclosure prompted redesign with an acrylic window, but due to brittleness and leakage risks of the acrylic material , the team choose to switched to polycarbonate sheet for better durability and resistance to cracking .

4.2 Electrical

4.2.1 Space inside the enclosure

We faced a lot of issues inside the enclosure due to the constraints in space and difficulty in distributing the input power, so we made a custom Rosetta (OSS) **(Figure (32))**which is made using two 17mm in diameter and 75mm in length copper rods which are capsulated in a 3D printed PLA cover to isolate each terminal away from each other. Each rod features 7 precisely machined apertures for secure mounting of buck converter wires with its own screw.

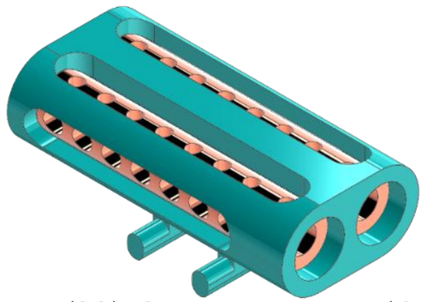


Figure (32) Custom Rosetta (OSS)

4.2.2 Powering tests

During system testing, we encountered issues with thruster signal which effects the movement due to inadequate power supply to the **Pixhawk**, which was initially powered via micro-USB from the Raspberry Pi, this setup proved insufficient, so we attempted to power the **Pixhawk** through the servo rail, but it also failed. To resolve the issue, we implemented a dedicated **power module** connected to the **Pixhawk**, ensuring a stable and adequate power supply.

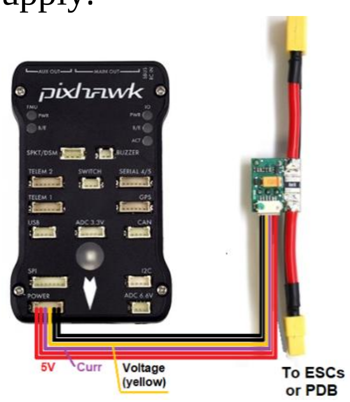


Figure (33) Power Module with Pixhawk

4.2.3 ESC Problem

We initially used **four HolyBro ESCs** and **two BlueRobotics ESCs** to control our six T200 thrusters, which performed well in initial tests. However, during water testing, the HolyBro ESCs encountered errors, causing them to lock up and prevent the thrusters from moving. To resolve this issue, we replaced all ESCs with BlueRobotics ESCs, which successfully restored proper thruster functionality.

4.3 Software

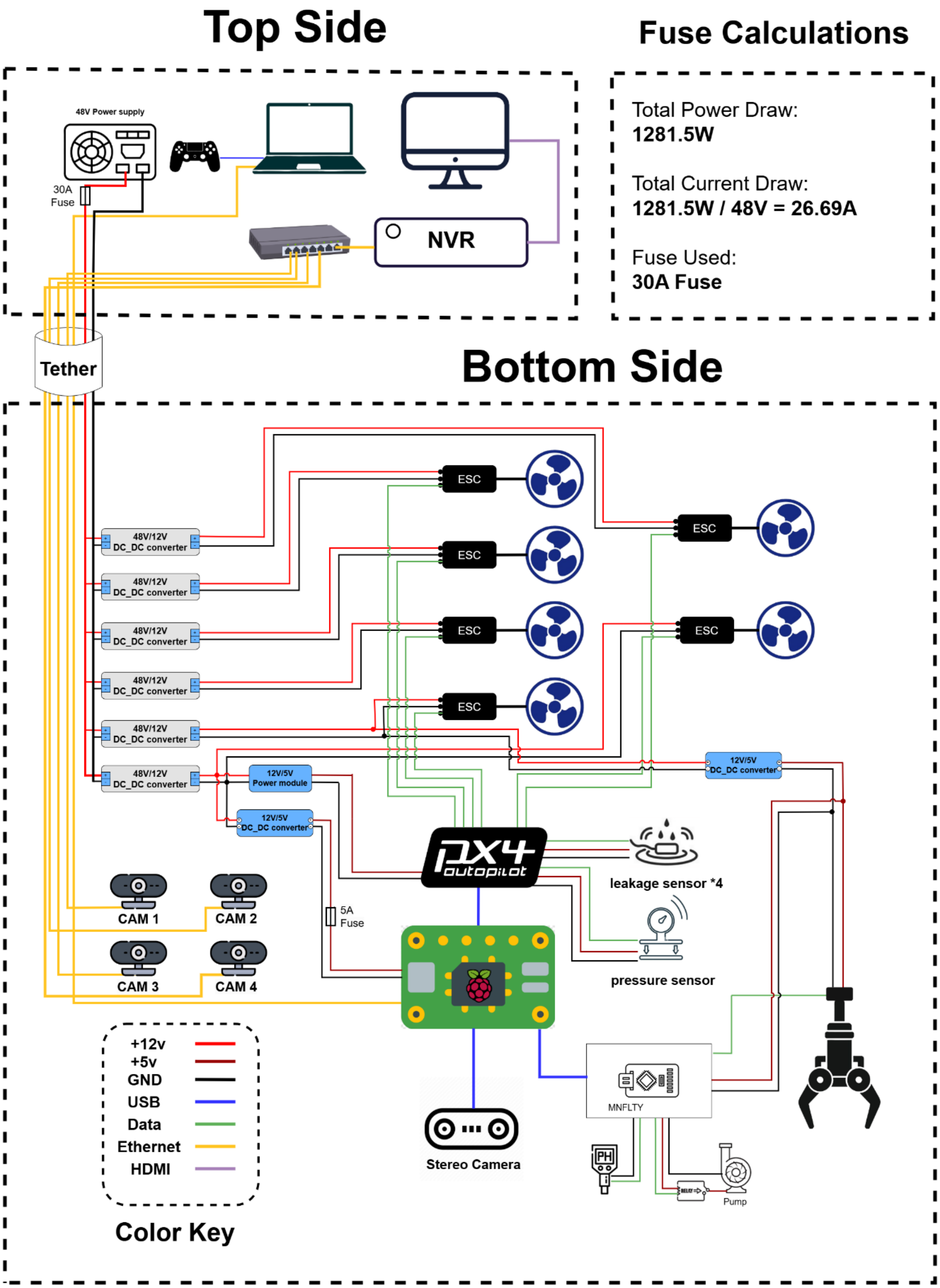
4.3.1 Control

HydraNav is a modular control software with a decoupled hybrid architecture, allowing modules to be loaded, unloaded, restarted, and monitored during runtime. This enables independent unit testing of each module. It also features a multi-level logging system that saves logs, formats them for standard output, and displays them in the GUI.

TritonOS is an operating system with built-in services (Admin, Telemetry, MNFLTY Bridge, and MavProxy), each with multi-level logging accessible via journaling. The Admin service can monitor, restart, or stop other services and manage Raspberry Pi power. All services were individually tested before integration.

SEE APPENDIX 9.6 FOR TROUBLESHOOTING CHECK-LIST

5-SID



Fuse Calculations

Total Power Draw:
1281.5W

Total Current Draw:
1281.5W / 48V = 26.69A

Fuse Used:
30A Fuse

6- Future Plans

Our future plans for the ROV include designing a custom PCB that will house all critical components, such as the ESCs, power management circuitry, and additional electronics, ensuring a more compact and organized design inside the enclosure. By manufacturing a custom PCB, we aim to streamline the assembly process, reduce wiring complexity, and enhance the ROV's durability and reliability. Additionally, we are focusing on implementing autonomous navigation capabilities that will allow the ROV to navigate through obstacles and underwater environments without manual intervention. Utilizing advanced sensors and machine learning techniques, we will enable real-time obstacle detection and avoidance, improving the ROV's ability to operate efficiently in complex underwater scenarios and reducing the reliance on constant manual control.

7- Lessons Learned

Our ROV team learned key lessons in effective communication and power management. To enhance communication, we implemented daily stand-up meetings, ensuring alignment and quick problem-solving. In terms of power management, we focused on optimizing our system for efficiency and reliability, addressing challenges related to power distribution and consumption to ensure longer operation times and prevent overheating or overcurrent issues. These improvements have significantly boosted our team's performance.

8- References

[1] OpenCV, "Tutorial Root," *OpenCV Documentation*, 2025. [Online]. Available: https://docs.opencv.org/4.x/d9/df8/tutorial_root.html. [Accessed: 1-Apr-2025].

[2] Ardusub, "PyMAVLink Documentation," *ArduSub Developers*, 2025. [Online]. Available: https://www.ardusub.com/developers/pymavlink.html. [Accessed: 1-Apr-2025].

9- Appendix

9.1 Power Calculation

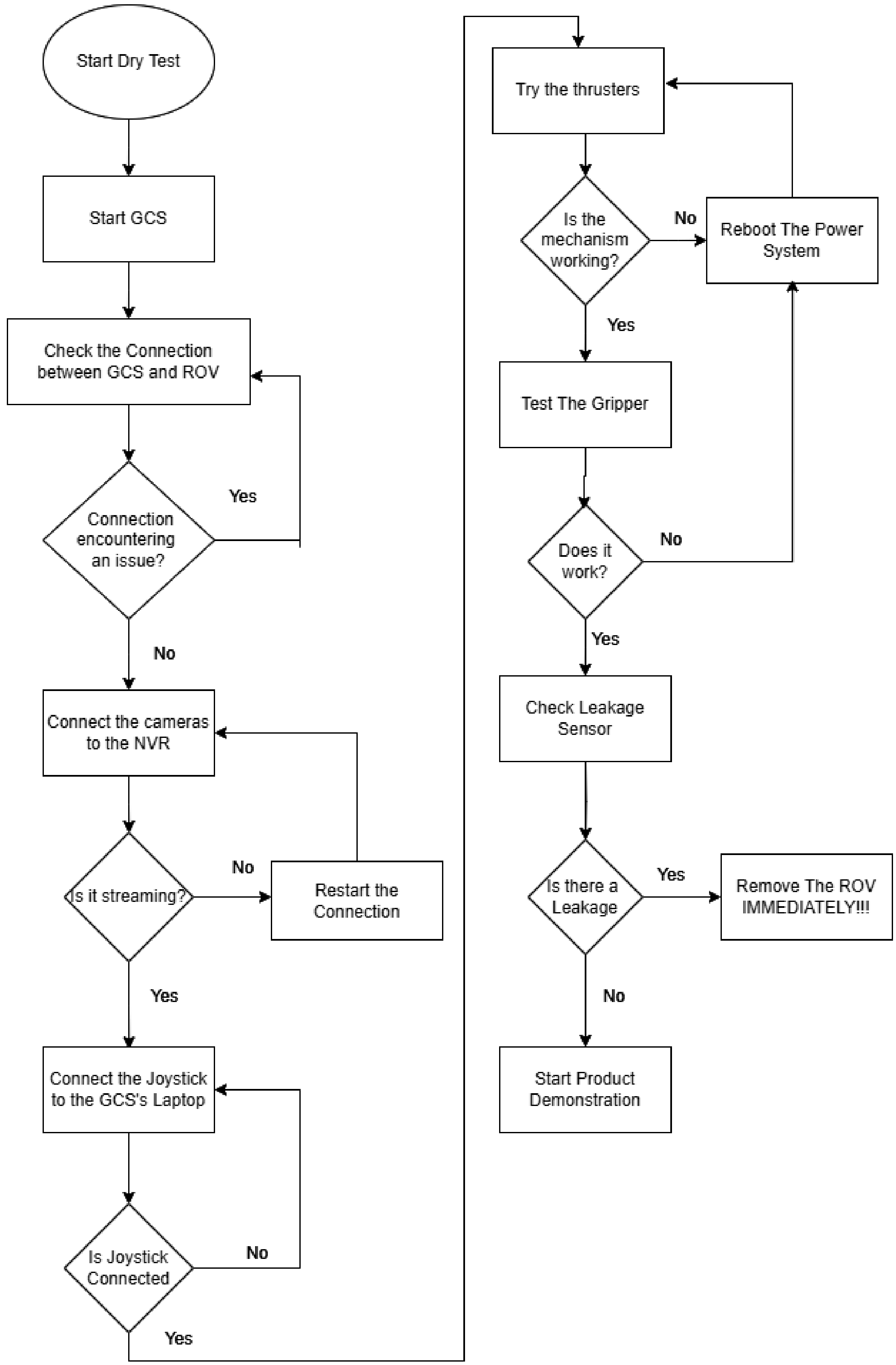
Component	Model	Qty	Voltage (V)	Max Current (A)	Config Current (A)	Max Power per Unit (W)	Config Max Power per Unit (W)	Total Max Power (W)	Total Config Power (W)
Motors	Blue Robotics T200 Thrusters	6	12	17	15	204	192	1224	1152
ESC	Blue Robotics basic Esc	6	12	0.5	0.5	6	6	36	36
Stereo Camera	OAK-D s2	1	5	1	1	5	5	5	5
Controller	Pixhawk 2.4.8	1	5	0.5	0.5	2.5	2.5	2.5	2.5
Processing unit	Raspberry-Pi 5 8gb	1	5	5.5	5.5	27.5	27.5	27.5	27.5
Gripper	Savöx 1230SG	1	5	5	5	25	25	25	25
Arm Mechanism	Ram FB5311M	2	5	2	2	10	10	20	20
Pump Mechanism	Micro Water Pump 310T	1	5	1.2	1.2	6	6	6	6
Camera mechanism	MG996R Servo Motor Tower Pro	1	5	1.5	1.5	7.5	7.5	7.5	7.5
Total Power								1353.5	1281.5
Total Power Consumption = 1281.5W Current Drawn = 26.69 A Fuse used = 30A									

9.2 build vs. buy / new vs. reused

Throughout our development process, we evaluated whether to build, buy, reuse, or modify components based on their performance, cost, and suitability for the MATE 2025 Explorer Class missions.

Component	Built / Bought	New/Used	Justification
Gripper	Built	New	Custom 3 DOF design enables precision needed for tasks
Thrusters	Donated	Used	Met performance needs; reused to reduce cost and waste
Control PCB	Built	New	Tailored for power routing
BlueRobotics Sensors	Bought	New	Precise readings of pressure and leakage
Camera Housing	Built	New	No-off- the-shelf options can fit what we needed

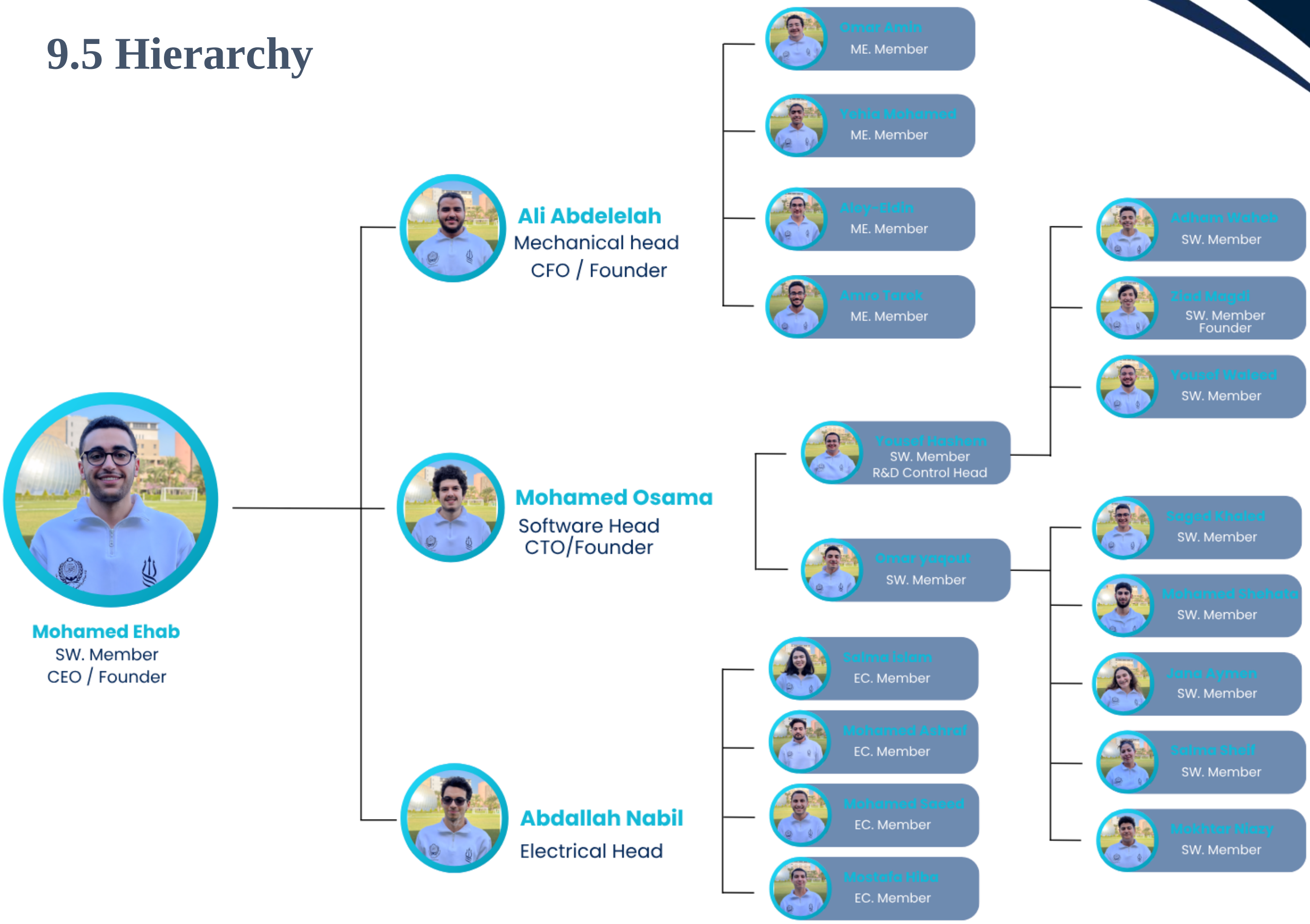
9.3 System Flowchart



9.4 Budget Sheet

Department	Type	category	Expenses	Description	Cost (USD)	Cost (LE)	Amount	Total Cost (USD)	Total Cost (LE)	Running balance (USD)	Running balance (LE)
General	Cash Raised	-	Phase 1 (Members Training)	-	20	1,000	35	700	35000	700	35000
General	Cash Raised	-	Phase 2	-	50	2,500	27	1350	67500	2050	102500
General	Cash Raised	-	Phase 3	-	50	2,500	25	1250	62500	3300	165000
General	Cash Raised	-	Phase 4	-	40	2,000	25	1000	50000	4300	215000
General	Purchased	-	MATE Regional Entry Fee	-	260	13,000	1	260	13000	4040	202000
General	Purchased	-	MATE International Entry Fee	-	400	20,000	1	400	20000	4440	182000
Mechanical	Purchased	Raw Material	2020 V-Slot Aluminum Profile Extrusion	The main building unit of the frame skeleton	3.7	185	5	18.5	925	4421.5	181075
Mechanical	Purchased	Raw Material	3mm Aluminium sheet	Used to fix the main enclosure to the ROV	12	600	1	12	600	4409.5	180475
Mechanical	Purchased	Raw Material	5mm Aluminium sheet	Enclosure flange + Corners fixation brackets	20	1,000	1	20	1000	4389.5	179475
Mechanical	Purchased	Raw Material	PETG Filament	3D printing all the gripper parts + Float cover for the ROV	18	900	4	72	3600	4317.5	175875
Mechanical	Purchased	Raw Material	EPDM rubber	To fabricate the the enclosure gasket	2	100	1	2	100	4315.5	175775
Mechanical	Purchased	Machining & Manufacturing	Fiber laser	Aluminium cutting	25.9	1,295	1	25.9	1295	4289.6	174480
Mechanical	Purchased	Machining & Manufacturing	Metal cutting	V-Slot Aluminium Profile angle cutting	3.7	185	1	3.7	185	4285.9	174295
Mechanical	Purchased	Machining & Manufacturing	Argon welding	Welding the Aluminium box	30	1,500	1	30	1500	4255.9	172795
Mechanical	Purchased	Machining & Manufacturing	CO2 laser	Polycarbonate end cap + Enclosure gasket	6	300	1	6	300	4249.9	172495
Mechanical	Purchased	Machining & Manufacturing	3D Printing	-	97	4,850	1	97	4850	4152.9	167645
Mechanical	Purchased	Machining & Manufacturing	CNC Machining	Stereo camera Housing	12	600	1	12	600	4140.9	167045
Mechanical	Purchased	Miscellaneous	Tools	Screwdrivers + Drill bits + Manual saw bit + Pliers + Coupling	112.6	5,630	1	112.6	5630	4028.3	161415
Mechanical	Purchased	Miscellaneous	Sealing Components	PU50 + Epoxy + O-rings + Mineral oil	45.3	2,265	1	45.3	2265	3983	159150
Mechanical	Purchased	Miscellaneous	Fasteners	Bolts + Nuts + Washers	84.6	4,230	1	84.6	4230	3898.4	154920
Mechanical	Purchased	Miscellaneous	Floats	-	0.5	25	9	4.5	225	3893.9	154695
Mechanical	Purchased	Non-ROV Device	Acrylic tube	1 meter tube	70	3,500	1	70	3500	3823.9	151195
Mechanical	Purchased	Non-ROV Device	HDPE	For manufacturing the Float End caps & Syringe	17.5	875	1	17.5	875	3806.4	150320
Mechanical	Purchased	Non-ROV Device	Alkaline battery	For the non-ROV device operating	58	2,900	1	58	2900	3748.4	147420
Mechanical	Purchased	Non-ROV Device	Weights	-	14.4	720	1	14.4	720	3734	146700
Mechanical	Purchased	R&D	-	trying different types of welding ,purchasing materials to test its strength, purchasing spare part for the emergency situations , trying new type of sealing materials	300	15,000	1	300	15000	3434	131700
Electrical	Donated	Electro-Mechanical systems	BlueRobotics T200 thrusters	The ROV's main moving component	460	23,000	6	2760	138000	3434	131700
Electrical	Donated	Electro-Mechanical systems	BlueRobotics ESC	-	38	1,900	6	228	11400	3434	131700
Electrical	Donated	Power Conversion	Power Module 5.3V BEC APM Pixhawk Flight Controller	From 12v to 5v buck converter 15A	14	700	1	14	700	3434	131700
Electrical	Purchased + Donated	Protection	Fuses + Fuse holder	-	10	500	1	10	500	3424	131200
Electrical	Purchased	Power Conversion	DC-DC step down	from 48v to 12v buck converter 20A	31.2	1,560	6	187.2	9360	3236.8	121840
Electrical	Purchased	Power Conversion	DC-DC step down	From 12v to 5v buck converter 12A	6.1	305	1	6.1	305	3230.7	121535
Electrical	Purchased	Power Conversion	DC-DC step down	From 12v to 5v buck converter 15A	10	500	1	10	500	3220.7	121035
Electrical	Purchased	Power Input	AC-DC power supply	From 220v AC to 12v 30A power supply	11.9	595	4	47.6	2380	3173.1	118655
Electrical	Purchased	Wiring	Copper rod + Copper bolts + Machining	To make special made connector to connect the power supply output and the buck converters input	14.2	710	1	14.2	710	3158.9	117945
Electrical	Purchased	Wiring	Ethernet cable	CAT 6 + RJ45	0.69	34.5	123	84.87	4243.5	3074.03	113701.5
Electrical	Purchased	Wiring	Power cable	-	0.76	38	50	38	1900	3036.03	111801.5
Electrical	Purchased	Wiring	Anderson SB50BLUE Blue 50A Anderson Connector	-	13.5	675	1	13.5	675	3022.53	111126.5
Electrical	Purchased	Protection	Tether shield	To protect the tether from any scratches	0.45	22.5	45	20.25	1012.5	3002.28	110114
Electrical	Purchased	Miscellaneous	Heat shrinks +Special connectors + Wires + Electronics	-	129.95	6497.5	1	129.95	6497.5	2872.33	103616.5
Electrical	Purchased	R&D	-	Spare Parts	240	12,000	1	240	12000	2632.33	91616.5
Software	Donated	Sensors	SOS Leak Sensor	For the safety of the system in case of any leakage	32	1,600	1	32	1600	2632.33	91616.5
Software	Purchased	Vision System	OAK-D S2	To accomplish most of the vision tasks	272	13,600	1	272	13600	2,360	78,017
Software	Purchased	Vision System	NVR + Hard disk	For the ROV main streaming	70.3	3,515	1	70.3	3515	2,290	74,502
Software	Purchased	Vision System	Switch	-	16.6	830	2	33.2	1660	2,257	72,842
Software	Purchased	Vision System	IP-Cameras	-	17.2	860	2	34.4	1720	2,222	71,122
Software	Purchased	Vision System	Wide angle IP-Cameras	For the ROV main streaming	35.4	1,770	2	70.8	3540	2,152	
Software	Purchased	Microprocessor	Raspberry Pi 5	The Microprocessor Of Our ROV	131.4	6,570	1	131.4	6570	2,020	
	Purchased	Flight Controller	Pixhawk PX4 Flight Controller	Our Flight Controller Which We Use To Control Our Thrusters	100	5,000	1	100	5000		
		Sensors	Depth/Pressure Sensor (R1 Version)	To Maintain Depth Underwater	30	1,500	1	30			
			-	Spare Parts	400	20,000	1				

9.5 Hierarchy



9.6 Troubleshooting Checklist

MECHANICAL:
Check penetrators, gasket, enclosure, outer wiring; foam test with vacuum pump.

ELECTRICAL:
Check power-tether link, restart power, inspect RPi & Pixhawk lights, signals, wiring, rosetta, buck converters, ESCs.

CONTROL (SOFTWARE):
Check ethernet, RPi voltage/system, Pixhawk ports, proxy, reboot; for gripper: check Hydranav logs, PCB logs, Arduino, PCB power, PWM (oscilloscope), servo sealing.

VISION (SOFTWARE):
Check device cables & packages; for length: verify ROV-object distance, camera angle, environment; for photosphere: check image overlap % & lighting.