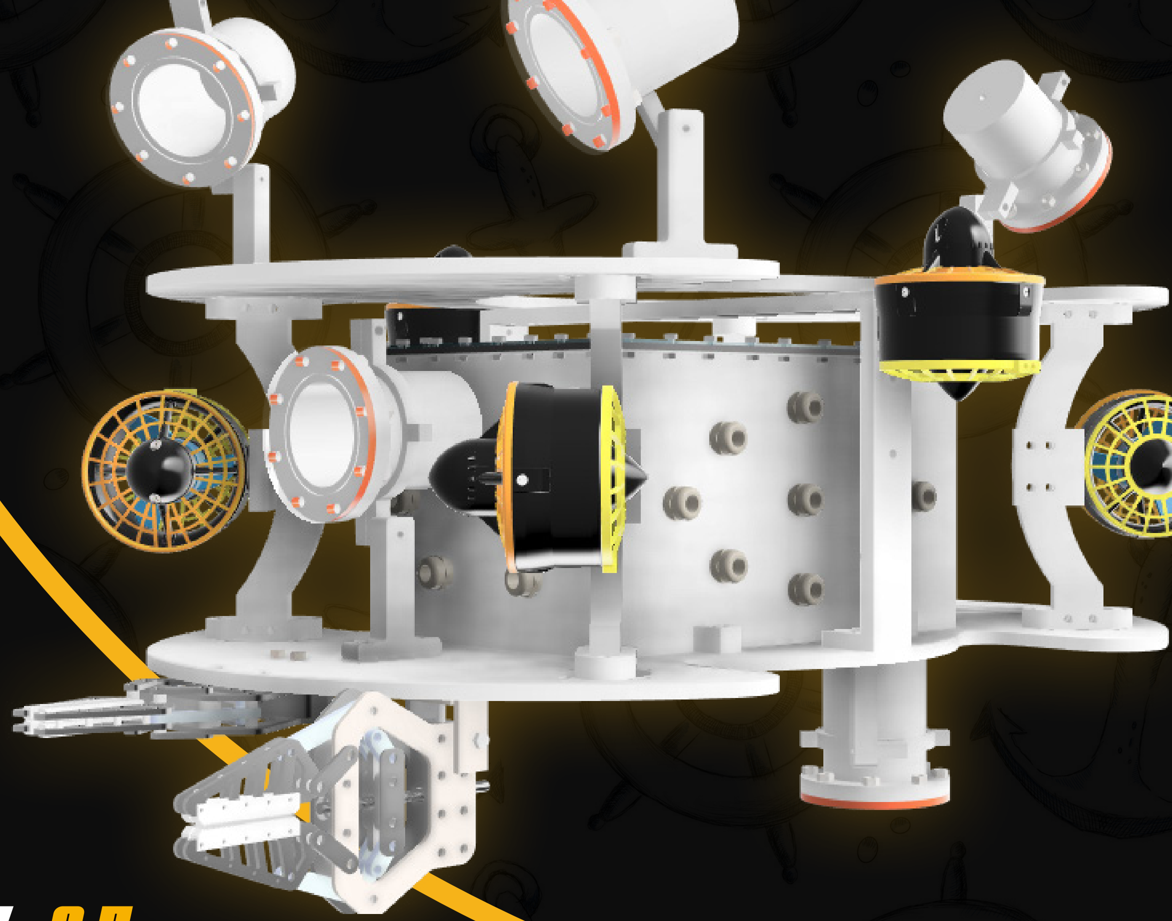
MEGALDON



MATE ROV 25
TECHNICAK DOCUMENTATION

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MATE ROV COMPETITION

iROV

ABSTRACT

Emerging from the halls of the prestigious High Obour Institute, OI ROV is an interdisciplinary team of 42 dedicated students committed to solving complex underwater challenges. Returning for their third year at the esteemed MATE ROV Competition, the team brings forward fresh perspectives and advanced engineering concepts to tackle this year's pressing marine issues. Recognizing the urgent need for sustainable solutions in a world grappling with climate change, marine debris, and ecosystem degradation, OI ROV responds with MEGALODON—a high-performance Remotely Operated Vehicle. Engineered with precision and innovation, MEGALODON features enhanced stability, six powerful T200 thrusters, and a cutting-edge imaging system, all integrated to support a wide range of mission-specific tasks. From environmental monitoring to underwater intervention, MEGALODON stands as a testament to the team's pursuit of technical excellence and environmental stewardship. This documentation captures the journey from concept to completion, highlighting the team's problem-solving strategies, design process, and testing phases, reflecting a shared vision of creating technology that serves both science and sustainability.

(Figure 1). OIROV Team Members 2025

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ACKNOWLEDGEMENT

Our team would have not been founded nor able to overcome the challenges it faced without the help of these organizations and individuals:

- **Obour institute for computer science -** for funding our company in all previous years, as well as funding our new vehicle MEGALODON and supporting us.
- **MATE Center** for sponsoring this year's competition and for their generous awards.
- **Arab Academy for Science and (AAST)** for hosting and organizing the regional Technology competition.
- **Prof. Dr. Abdullah EL-Dahshan, Eng. Waleed EL-Dahshan, Prof. Ehab Ashour Farag, and Dr. Ibrahim Abdullatif** have all provided invaluable technical and non-technical support, for which I am sincerely grateful.
- **A.T.E.C** for being our strategic partner and continuously supporting our vision.
- **JLCPCB** – for their valuable technical support and contribution to our electronic development efforts.
- **Makers Electronics** for importing electronic parts from USA .
  SolidWorks, Altium, Ansys for providing the team members with access to their products.
- **Our Families and friends** - Their unwavering encouragement and support.

1- DESIGN RATIONALE

1.1- DESIGN EVOLUTION

Emerging from the halls of the prestigious High Obour Institute, OI ROV is an interdisciplinary team of 42 dedicated students committed to solving complex underwater challenges. Returning for their third year at the esteemed MATE ROV Competition, the team brings forward fresh perspectives and advanced engineering concepts to tackle this year's pressing marine issues. Recognizing the urgent need for sustainable solutions in a world grappling with climate change, marine debris, and ecosystem degradation, OI ROV responds with MEGALODON—a high-performance Remotely Operated Vehicle. Engineered with precision and innovation, MEGALODON features enhanced stability, six powerful T200 thrusters, and a cutting-edge imaging system, all integrated to support a wide range of mission-specific tasks. From environmental monitoring to underwater intervention, MEGALODON stands as a testament to the team's pursuit of technical excellence and environmental stewardship. This documentation captures the journey from concept to completion, highlighting the team's problem-solving strategies, design process, and testing phases, reflecting a shared vision of creating technology that serves both science and sustainability.

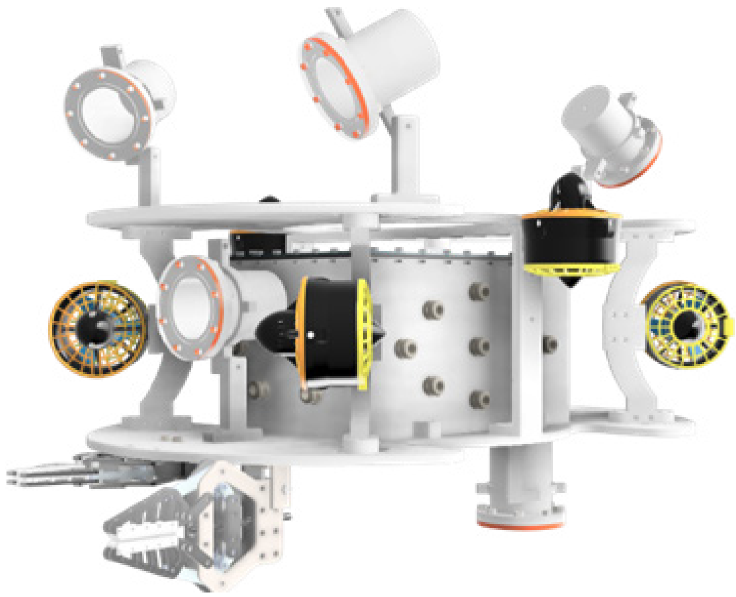

Figure (2). ROV Rendered Model

1.1.1- MECHANICAL SYSTEM DESIGN EVOLUTION

FRAME

This year's ROV frame was engineered using 10mm-thick ARTELON (HDPE), selected for its excellent balance of strength, machinability, and buoyancy. Its density, closely matching that of freshwater, provides MEGALODON with natural flotation, reducing the need for additional buoyancy modules. The frame's design emphasizes simplicity, modularity, and durability, resulting in a compact and lightweight structure—measuring 850 × 550 × 600 mm and weighing only 10 kg. This configuration not only ensures structural integrity under pressure but also facilitates quick assembly and efficient component integration, laying the groundwork for optimal performance across diverse underwater missions.

ELECTRONICS ENCLOSURE

This year, the electronics enclosure was redesigned using 2mm stainless steel, replacing the previous acrylic and aluminum models. This new material provides superior strength, corrosion resistance, and thermal durability—making it ideal for harsh underwater environments. The enclosure's refined geometry maintains optimal space for cable glands and internal components, enabling the integration of complex systems with improved protection. This upgrade significantly boosts MEGALODON's reliability and endurance during long-term missions in challenging conditions.

MECHANISMS

MEGALODON is equipped with multi-functional mechanisms designed to tackle complex underwater tasks with precision and flexibility. The mechanical systems are modular and easily configurable, allowing the ROV to adapt quickly to various mission requirements—ranging from object manipulation to environmental sampling—while ensuring consistent high performance across all operations.

1.1.2- ELECTRICAL SYSTEM DESIGN EVOLUTION

ESP32

This year, we replaced the previously used "Arduino Mega Pro" with the ESP32 microcontroller, driven by its superior performance and cost-efficiency. The ESP32 features a 32-bit dual-core processor running at 240MHz, compared to the 8-bit 16MHz AVR chip in the Arduino Mega. In addition to being significantly more powerful, the ESP32 offers built-in Wi-Fi and Bluetooth capabilities, all at a lower cost—making it a more versatile and future-proof solution.

LEAKAGE SENSOR

For enhanced underwater monitoring and safety, we integrated a leakage sensor system capable of detecting water intrusion inside the electronics enclosure. This sensor serves as a critical fail-safe component, triggering emergency responses and protecting sensitive components from water damage.

PRESSURE SENSOR

Additionally, we utilized a pressure sensor to monitor depth in real time. This sensor enables precise control and depth regulation, which is essential for maintaining stability, executing automated depth-based tasks, and improving overall mission accuracy.

MPU6050 IMU

To improve orientation and control, we maintained the use of the MPU6050 IMU due to its compatibility with our PID control system, low power consumption, simplicity, and cost-effectiveness compared to more complex alternatives.

1.1.3- SOFTWARE SYSTEM DESIGN EVOLUTION

COMMUNICATION SYSTEM

We use USB to TTL UART for serial communication, ensuring efficient data transfer between the Top-side Control Unit (TCU) and the microcontrollers. This setup allows easy firmware updates without the need for replacing microcontrollers, enhancing system flexibility and maintenance.

GUI DESIGN

Our GUI developed using Qt Framework, allows intuitive control over the ROV through joystick input. It features an organized interface with widgets for different mission tasks. The Head-Up Display (HUD) provides real-time telemetry, displaying motor currents, depth, temperature, leakage alerts, and orientation data like yaw and roll, ensuring smooth operation and mission success.

1.1.4- DESIGN AND MANUFACTURING PROCESS

DESIGN PROCESS

Based on our analysis of last year's ROV design, we decided to change the enclosure material from aluminum to stainless steel for this season. The reason for this change was the corrosion of aluminum caused by the purity of the material used last year. Additionally, we modified the number of converters, using 4 converters instead of 6 to power the T200 Thrusters and the rest of our system, improving performance and simplifying the setup.

2D SKETCH

manufacturing process ensures dimensional accuracy and structural integrity while maintaining cost-effectiveness. High-Density Polyethylene (HDPE) and aluminum plates were precision laser-cut and routed using a CNC machine. The aluminum plates were then welded together to create an airtight seal. 2D CAD drawings were prepared for CNC cutting, optimizing material sheet usage to minimize waste.

1.2- MECHANICAL SYSTEM

FRAME

The frame of our ROV, MEGALDON, is constructed from 10mm thick ARTELON

(HDPE), a material selected for its excellent balance of ductility, machinability, availability, and cost-effectiveness. One of ARTELON's key advantages is its neutral buoyancy, as its density is nearly equal to that of fresh water, allowing the ROV to naturally float without the need for excessive buoyancy adjustments. The frame is lightweight (10 kg) and features compact dimensions of 850x550x600 mm, ensuring ease of maneuverability underwater. The design includes a main Upper Plate that supports critical components such as the cylindrical canister, camera housings, and the holding system, while the Base Plate serves as the foundation for the electronics enclosure and the gripper systems. To withstand operational stresses, the frame uses M8 stainless steel fasteners and 3mm aluminum support joints, enhancing structural integrity and stress distribution.

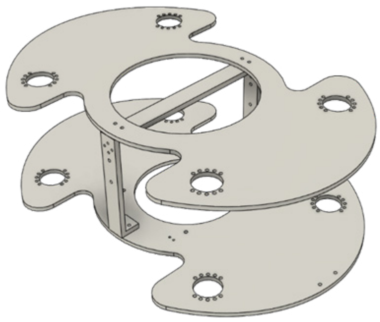

Figure (3). ROV Frame

MANUFACTURING PROCESS

The manufacturing process ensures dimensional accuracy, structural integrity, and cost efficiency. High-Density Polyethylene (HDPE) and aluminum plates were precisely laser-cut and routed using CNC machines. The aluminum components were then welded to achieve an air-tight seal. Detailed 2D CAD drawings were developed to guide the CNC cutting process, with careful planning to optimize material usage and minimize waste.

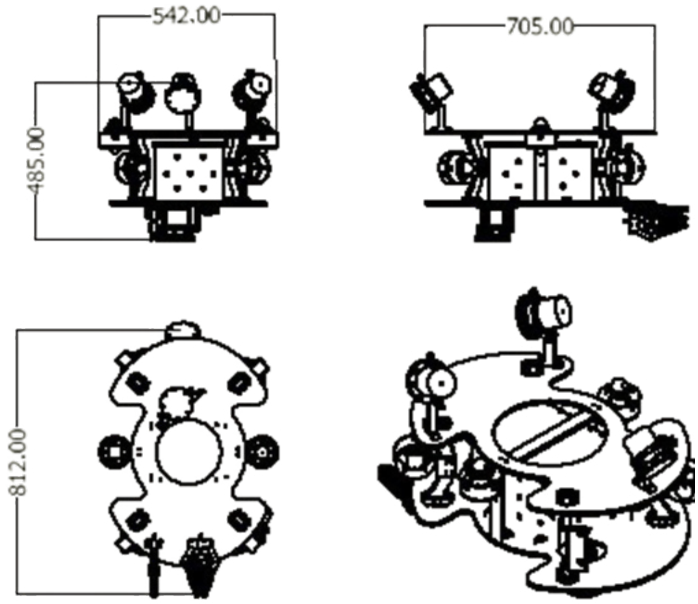

Figure (4). Mechanical Drawing

THRUSTERS

For better efficiency, T200 brushless thrusters are used, where two thrusters are used for vertical movement, and four brushless thrusters are used for horizontal movement. They are placed at 45 degrees from the neutral axis, allowing maximum torque, and there is a thruster in the rear of the vehicle to stabilize the vehicle.

Figure (5). T200 Thruster

GRIPPER MECHANISMS

The four-bar mechanism-based manipulator is a versatile and essential component of the ROV, acting as its primary underwater “hand” for object manipulation. The mechanism is pneumatically actuated using a 25 mm diameter piston, capable of delivering forces ranging from 110 N (forward) to 135 N (backward) at an operating pressure of 40 psi. The end effectors are engineered to grasp objects with various cross-sectional shapes, supporting diameters of up to 100 mm. The kinematic design of the four-bar linkage ensures parallel motion of the end effectors during actuation, maintaining a large and stable contact area. Additional spacers and rubber grips are integrated to enhance vertical contact surface and increase friction, enabling a secure and reliable grip. To accommodate different operation angles and tasks, slots are incorporated into the base plate, allowing for adjustable positioning of the gripper. The entire gripper structure is fabricated from 8 mm thick high-density polyethylene (HDPE), precisely cut using a CNC router for accuracy and durability. MEGALODON is equipped with two of these manipulators: one horizontally mounted and the other vertically mounted, offering high adaptability and multifunctionality for handling a wide range of underwater tasks and object types.

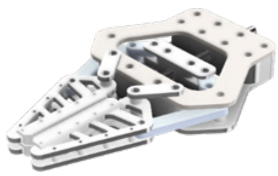

Figure (6). rendered gripper

Figure (7). Gripper

VERTICAL FLOAT

The vertical float system controls buoyancy using two 12V DC water pumps mounted in the top compartment. These pumps either draw water into the internal chamber to increase weight and descend, or expel water to reduce weight and ascend. This water transfer mechanism enables precise vertical movement within the water column by adjusting the system’s buoyancy dynamically.

Figure (8).Vertical Float

SEALING

ELECTRONICS ENCLOSURE

The enclosure is fabricated from 1.5 mm thick stainless steel sheets, precisely cut and shaped using metal forming technology. The sheets are welded using Gas Tungsten Arc Welding (GTAW) to form a robust housing with internal dimensions of 320 × 210 × 175 mm³. The top-mounted cover is sealed with 8 mm thick rubber gasket, ensuring a watertight seal capable of withstanding high-pressure underwater conditions, making it suitable for operations at depths of up to 50 bars. Additionally, the front face of the enclosure is made of 1 cm thick acrylic, providing enhanced visibility and protection for the internal components.

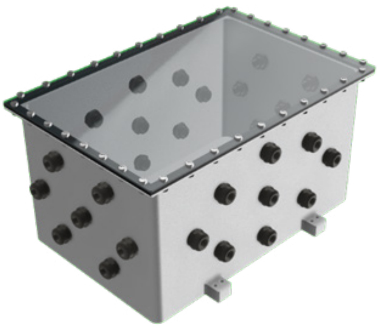

Figure (9).Electronics Enclosure

CAMERAS HOUSING

There are four camera casings in our ROV . Using HDPE was the optimum choice due to its low density. HDPE's casings were fabricated using a lathe machine, while a Laser was used for the 6 mm acrylic gaskets. We used an O-ring between the acrylic gasket and camera casing to reach the most stable sealing system.

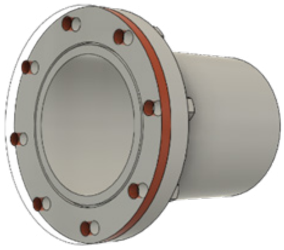

Figure (10).Cameras Housing

CFD

To assess the hydrodynamic performance of the ROV "MEGALODON," CFD simulations were conducted. The ROV's velocity was set at 0.8 m/s, and the outlet pressure was 98 kPa, matching conditions at 10 meters underwater. A symmetry boundary was used to reduce computation time. Drag force was calculated using the standard drag equation:

$$A \cdot {}_{D}C \cdot {}^{2}u \cdot \rho \cdot ½ = {}_{D}F$$

Tetrahedral meshing ensured accurate simulation results. The analysis showed a maximum pressure of 0.3849 kPa on the electronics enclosure and a peak velocity of 1.312 m/s around the ROV. These results confirm the ROV's ability to withstand underwater forces and guide improvements in design and performance.

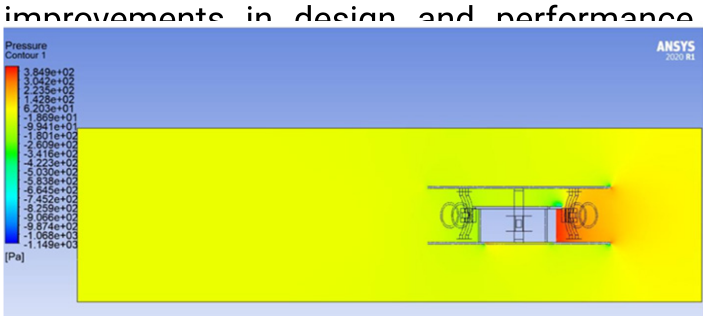

Figure (11). Pressure Distribution

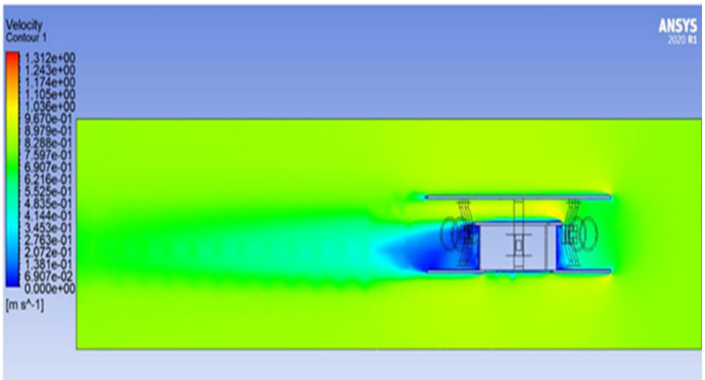

Figure (12). Velocity Analysis

PROPULSION

MEGALDON is equipped with six newly acquired Blue Robotics thrusters, replacing the previous year's setup, which relied on waterproofed standard brushless motors. This upgrade significantly enhanced the propulsion system's efficiency and reliability. Each thruster underwent a rigorous performance evaluation to ensure suitability for deployment. One of the main limitations of last year's ROV was the lack of roll motion, restricting its maneuverability during complex tasks. In contrast, MEGALDON's current thruster configuration provides full six degrees of freedom, enabling enhanced maneuverability, stability, and precise control—allowing it to execute a wide range of underwater missions more effectively.

Figure (13).Thrusters Configuration

The mechanical team encountered significant challenges related to stability configurations during the design process. To address these challenges, we set specific goals, including achieving smooth suspension of the vehicle in water to enhance navigation, attaining neutral buoyancy underwater, and ensuring that the buoyancy force slightly exceeded the vehicle's weight for safety and maintenance purposes. The vehicle needed to float slightly to perform all necessary tasks.

BUOYANCY SYSTEM AND STABILITY

To meet these objectives, we carefully considered the design of various components. The space occupied by the frame and the electronics housing had a significant impact on the overall design. Through precise calculations, we determined that the total mass of the MEGALODON ROV was 18 kg. By calculating the mass of displaced water, we confirmed that the ROV would float, thus ensuring its safety. By addressing stability configurations and incorporating the necessary design elements, we successfully achieved the desired objectives: smooth suspension, neutral buoyancy, and safe floating.

Part	Quantity	Weight Outside Water (N)	Buoyancy (N)	Weight Inside Water (N)
Top plate	1	11.7267	11.5434	0.1833
Bottom plate	1	35.6338	13.4467	22.1871
Thruster	6	26.0946	12.8628	13.2318
Camera Housing	4	3.2032	3.3959	-0.1927
Leg	4	2.2241	1.8423	0.3818
Control box	1	52.2873	22.3038	29.9835
Gripper	2	7.848	1.4508	6.3972
Valves	2	10.0062	2.6907	7.3155
Fixed	2	0.5319	0.5215	0.0104
Total	-	179.6797	66.2364	113.4433

1.3- ELECTRICAL SYSTEM

STRUCTURE OVERVIEW

In pursuit of a modular and efficient electrical design, our enclosure was segmented into three primary layers, each responsible for managing a specific subsystem. This modular structure not only supports system scalability but also significantly simplifies maintenance and troubleshooting by isolating frequently accessed components.

POWER DISTRIBUTION LAYER

The ROV receives 48V from the surface through a tether connected to the main station, where two 24V, 15A power supplies are connected in series to produce 48V and in parallel to double the current to 30A. This voltage is distributed to four DC-DC buck converters, each stepping it down to 12V with a current rating of 30A to meet the high-power demand of the thrusters, camera board. A dedicated buck converter is also used to step down from 12V to 5V to power low-voltage components like the ESP32 microcontroller and relays. The power layout ensures stable operation and protection for all subsystems. This layer manages the propulsion system through the coordination between the ESP32 microcontroller and the Electronic Speed Controllers (ESCs). The ESP32 handles wireless and wired communication and sends precise control signals to each ESC. Each ESC receives its control signal from the ESP32 and power from an individual 12V converter to operate the T200 thrusters. The T200 thruster is selected for its high durability, torque efficiency, and self-cooling mechanism in underwater environments, thanks to its flooded design. The decision to assign one converter per thruster guarantees consistent and uninterrupted power delivery during intensive operations. A custom-designed PCB is used to streamline signal routing, manage sensor connections, and integrate additional low-voltage control components. This layer houses the ESP32, power relays, and environmental sensors, all powered through the regulated 5V output. The PCB not only enhances circuit organization and stability but also allows for future upgrades and easier debugging. This architecture also includes voltage regulation for specific needs, such as an 8.4V output from a buck converter to power a high-torque servo motor after extensive load testing.

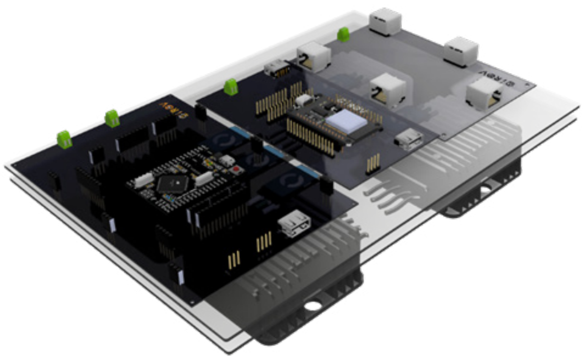

Figure (14). Electrical System

CONTROL STATION

The ROV's control station serves as the central hub for efficient and precise vehicle operation. It integrates essential components—including a computer, router, monitors, and controller—into a single, compact, and portable unit designed for rapid deployment with minimal setup and clutter. For optimal mobility, the router and power supply are securely housed in the lower compartment to maintain stability during transport, while the monitor is mounted on the upper section to provide clear visibility and quick access for the pilot. The station features a unified user interface with advanced control buttons and seamless access to all embedded systems, enabling smooth, reliable operation even in demanding environments.

Figure (15). Control Station

ESP32

This year, we replaced the previously used "Arduino Mega Pro" with the ESP32 microcontroller, driven by its superior performance and cost-efficiency. The ESP32 features a 32-bit dual-core processor running at 240MHz, compared to the 8-bit 16MHz AVR chip in the Arduino Mega. In addition to being significantly more powerful, the ESP32 offers built-in Wi-Fi and Bluetooth capabilities, all at a lower cost—making it a more versatile and future-proof solution.

Features	ESP32	Arduino Mega Pro
Microcontroller	ESP32-D0WDQ6	ATmega2560
CPU	Dual-core Xtensa® 32-bit LX6	8-bit AVR
Clock Speed	Up to 240 MHz	16 MHz
Architecture	32-bit	8-bit
RAM	520 KB SRAM	8 KB
Flash Memory	4MB Flash (external)	256 KB (of which 8 KB used by bootloader)
Analog Output (DAC)	2 DAC channels	No DAC
Communication Interfaces	UART, SPI, I2C, CAN, I2S	UART, SPI, I2C
Wi-Fi	Yes (802.11 b/g/n)	No
Bluetooth	Yes (Bluetooth v4.2 BR/EDR and BLE)	No
USB Support	Yes (via micro USB)	Yes (via micro USB or UART)
Operating Voltage	3.3V	5V
Input Voltage	5V via USB	7-12V
Power Consumption	Low (especially in deep sleep)	Higher than ESP32

TETHER

The tether is a compact, flexible cable that transmits power and data between the surface station and the ROV. It includes two CAT6 Ethernet cables (for camera signals and control/data transmission), a 12 AWG DC power cable, and a pneumatic line, all enclosed in a protective sheath. CAT6 cables are used for their high bandwidth (1 Gbps) and low signal loss, allowing the tether to extend beyond 30 meters without degradation. The 12 AWG power cable, made of tinned copper, ensures minimal voltage drop and enhanced durability against moisture and dust.

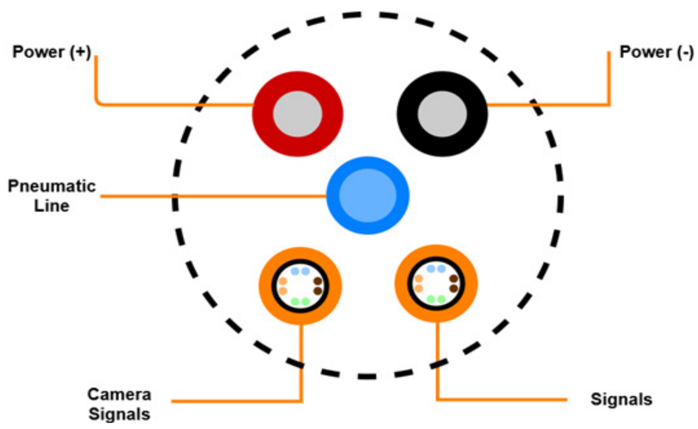

Figure (15). Tether Section

THRUSTER

Thruster Board is a core component of the ROV, managing both propulsion and pneumatic systems through connections to six ESCs and a three-channel relay module. It receives control signals from the ESP32 to precisely regulate thruster speed and direction, enabling smooth underwater movement. Simultaneously, it controls solenoid valves for pneumatic functions, all powered by a stable 5V supply from the onboard regulator. Communication with the surface station is handled via a CAT6 cable carrying TTL signals, ensuring fast and noise-resistant data transmission. Designed for modularity and efficiency, the board serves as the central control hub within the ROV's embedded system.

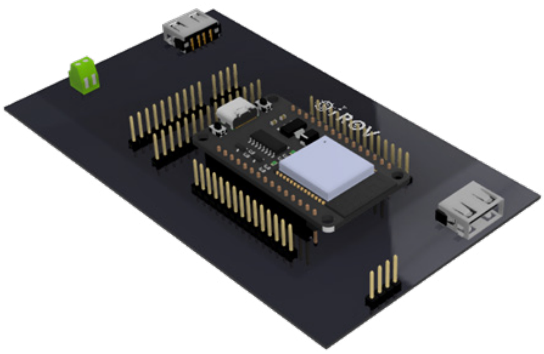

Figure (16). Thruster Board

CAMERA'S BOARD

Camera Board manages power distribution and signal transmission for the ROV's four onboard cameras. Each camera connects via a CAT6 extension cable, with twisted pairs assigned to power, ground, and video signal, and interfaced through RJ45 connectors. A main CAT6 cable carries all video signals, with each twisted pair dedicated to one camera's output. Power is delivered via a voltage converter and evenly distributed to all channels. On the station side, the main cable is split using four video baluns to ensure stable, high-quality video transmission to the monitoring system.

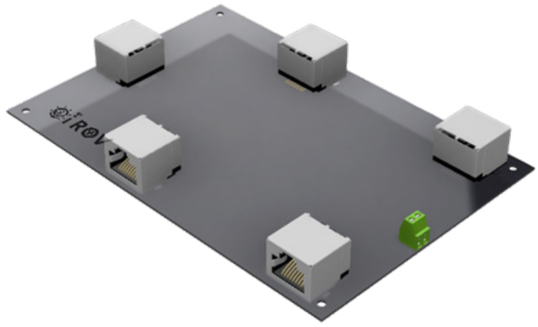

Figure (17). Camera Board

SENSOR'S BOARD

The Sensors Board efficiently interfaces multiple onboard sensors with the Arduino Mega Pro, offering two power input options: a direct 5V supply via a 12V-to-5V converter or a 12V input through the Arduino's built-in regulator, providing flexibility for various setups. It transmits real-time data to the surface station, including pressure, depth, orientation, thruster current consumption, and water leakage alerts, ensuring effective monitoring and enhancing the ROV's safety and stability during operation.

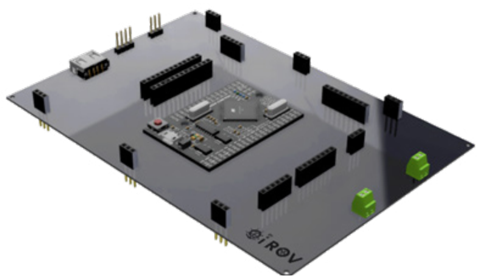

Figure (17). Sensors Board

VISION SYSTEM :

The Megalodon's camera system is designed for high underwater performance and reliability. It includes four high-quality analog cameras (up to 1080p HD), strategically placed to provide a wide and clear field of view. One main front-facing camera serves as the primary navigation tool, while the other three monitor different mechanisms to support precise maneuvering. Each camera offers a wide viewing angle—96.5° horizontal, 48.9° vertical, and 120.5° diagonal—and operates efficiently up to 20 meters with low power consumption. All camera signals are transmitted through a single CAT6 cable. Each signal is connected to a video balun to reduce noise and enhance signal quality before being fed into separate DVR channels at the control station for real-time processing and display. A custom PCB distributes 12V power to each camera and organizes signal paths within the main cable, ensuring clear video transmission and efficient system performance.

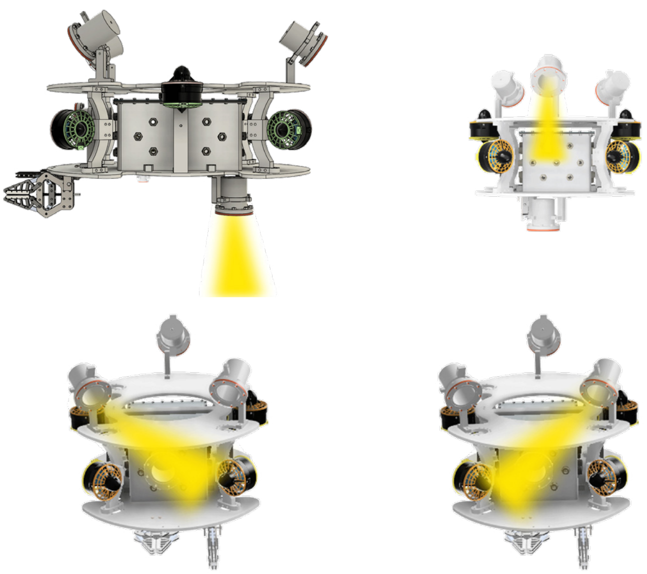

Figure (18). Vision System

1.4- SOFTWARE SYSTEM

SOFTWARE OVERVIEW

The software team held a meeting to assess last year's performance, resolve past issues, and establish a clear development roadmap. Early in the year, a training phase was conducted to improve development quality and transfer knowledge to new team members. The software structure maintained its two-layer architecture:

•**Top-side:** Developed in Python using the Qt framework for a responsive and user-friendly interface.

•**Bottom-side:** Written in C++ and deployed on Arduino boards for higher speed and efficiency

MOTION CONTROL SYSTEM

Smooth and precise motion is essential for any ROV. To achieve this, OI developed a sophisticated motion control system. A PID control system can be activated by the pilot to enhance motion precision and stability during navigation. Additionally, a "Focus Mode" can be enabled to reduce the ROV's speed, allowing for finer control near mission-critical targets. When stationary, thrusters operate in opposing directions at low speed to counteract water currents and maintain stability.

GRAPHICAL USER INTERFACE (GUI)

The GUI serves as the main control bridge between the pilot and the ROV, offering a modular, user-friendly interface built entirely with Python and Qt for real-time control and customization. It includes three primary buttons: "3D Mission" for rotating the ROV around its vertical axis and capturing images for a 360° view, with images processed using OpenCV for a high-quality panoramic result; “Focus Mode” for enabling slow, precise movement to handle delicate tasks; and “Upload Code,” which allows wireless OTA code updates to the ROV via the ESP32, eliminating the need for disassembly and preserving the vehicle’s waterproof integrity.

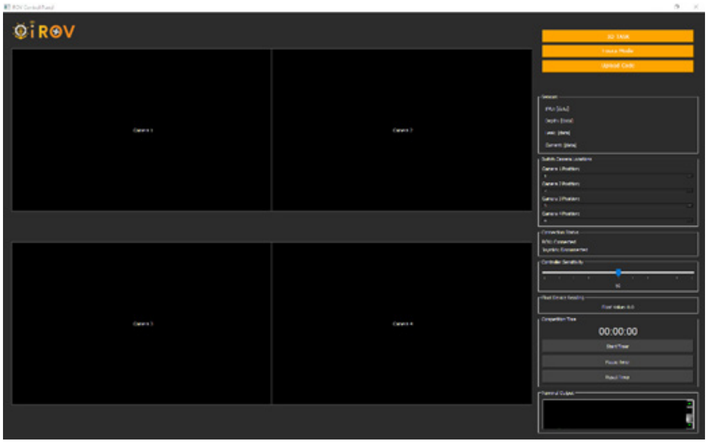

Figure (19). GUI

SENSOR PANEL & REAL-TIME FEEDBACK

A dedicated panel displays real-time data from various onboard sensors, providing the pilot with the critical information needed during missions:

IMU SENSOR (MPU-6050)

Measures the yaw angle and provides 6 degrees of freedom (angular rate + acceleration). It’s vital for stability and PID control, offering precise feedback for rotation along the Z-axis.

SOS LEAKAGE SENSOR

Monitors all watertight enclosures for leaks using four sponge-tipped probes. If a leak is detected, the system triggers a red LED alert, helping prevent electronic damage. This acts as a secondary layer of safety even with high-quality sealing.

ACS712 CURRENT SENSOR

Tracks the current consumption of each thruster in real time, updating the GUI continuously. This allows the team to detect issues such as overloads, contributing to better maintenance and motor protection.

MS5540C WATER PRESSURE SENSOR

Calculates the ROV’s depth underwater using the formula:

$h=p/(\rho \times g)$

Where:

- h: depth (m)
- p: pressure (Pa)
- ρ: water density (kg/m^3)
- g: gravitational acceleration (m/s^2)

This helps the pilot accurately control the ROV’s depth during missions.

VERTICAL FLOAT

vertical float system is a fully autonomous device designed to control its vertical movement within the water column using an ESP32 microcontroller. It collects real-time pressure data to determine depth and operates two 12V DC pumps via a relay module to adjust buoyancy by drawing in or expelling water. Powered by 8 alkaline batteries (12V), the system also includes a real-time clock (RTC) for accurate task scheduling and a 5A fuse for electrical protection. The software processes sensor input and manages pump control based on depth readings. Designed for stability, it maintains balance with a low center of gravity and can self-correct if disturbed. Future upgrades may include wireless communication for live data transmission and advanced data visualization tools, enhancing both control and monitoring capabilities.

2- SAFETY

At OI ROV, safety is not just a priority—it is a core value. We firmly believe that every task can be completed without incident when supported by proper training, strict adherence to safety protocols, and the use of appropriate tools and protective equipment. We are committed to maintaining a risk-free environment that empowers our team to perform with confidence and security at every stage of operation.

2.1- WORKSHOP SAFETY

OI ROV acknowledges the inherent risks associated with the development and operation of Remotely Operated Vehicles. To mitigate these risks, we foster a strong culture of safety that is embedded into every aspect of our workshop practices. All team members are required to wear properly sanitized Personal Protective Equipment (PPE) such as gloves, safety goggles, and earmuffs whenever performing tasks in the workshop. Each procedure is carried out under the supervision of a designated safety officer who ensures full compliance with safety standards and protocols. This proactive approach, combined with a well-organized and hazard-free workspace, allows our team to contribute effectively while maintaining a secure environment.

2.2- SAFETY TRAINING

We believe that true expertise includes a strong foundation in safety. That's why every new team member undergoes comprehensive safety training led by experienced personnel. This training combines theoretical knowledge with practical, hands-on sessions conducted in a controlled environment. Through this method, new members gain a deep understanding of operational risks and learn how to navigate them with confidence and responsibility. Our goal is to prepare each individual to perform every mission safely and efficiently, both in the workshop and in the field.

2.3- SAFETY FEATURES

In accordance with MATE ROV competition guidelines, our vehicle incorporates several built-in safety features to ensure both operator and environmental protection. A properly rated fuse is placed 30 centimeters from the Anderson Powerpole connectors to guard against electrical faults. Strain relief is applied at both ends of the tether to prevent damage to the connectors and ensure uninterrupted power and data transmission. Each thruster is equipped with a custom 3D-printed shroud that covers both intake and exhaust ports, preventing accidental contact without impeding flow efficiency. Emergency kill-switches are installed on the main power supply unit of the Tether Control Unit (TCU), and all power terminals are fused to provide overcurrent protection. In addition, fuses are strategically located on the power distribution boards to simplify troubleshooting and allow for quick replacements. The electronic housing, thrusters, and camera modules are fully waterproofed to prevent short circuits and protect personnel from exposure to live components. Warning labels are placed on all high-risk areas such as thrusters and electronics enclosures. Furthermore, the camera housing is physically separated from the electronics compartment using O-rings to enhance waterproofing, while a transparent acrylic dome allows for immediate visual inspection for leaks by checking for the presence of water droplets. These safety measures work together to create a system that is not only functional but also safe for all users and compliant with industry standards.

3- TESTING AND TROUBLESHOOTING

Effective testing and troubleshooting of MEGALODON is a carefully structured process that begins well before the ROV is subjected to any dry or underwater conditions. Our core philosophy revolves around a methodical "isolate, divide, and conquer" strategy. When an issue arises, the team uses deductive reasoning to determine the source of the problem. The first step is to identify whether the issue is mechanical or electrical. Once this distinction is made, the problem is broken down into smaller subsystems, allowing each department to focus on resolving the issue within their area of expertise.

3.1- MECHANICAL TESTING

Mechanical testing begins with a rigorous sealing test, designed to ensure that no water can enter sensitive enclosures. A pneumatic hose is inserted into each enclosure or component that must remain dry. The ROV is then submerged in water, and pressure is increased using a compressor. If any component is improperly sealed, air will escape as bubbles, revealing the location of the fault. In addition to this, a pneumatic system test is conducted to verify the connectivity and integrity of the pneumatic circuits. All joints are visually inspected and tested repeatedly to confirm airtight connections. This process ensures the reliability and safety of MEGALODON's pneumatic system.

3.2- ELECTRICAL TESTING

Electrical testing follows a bottom-up approach, starting with the individual testing of each Printed Circuit Board (PCB). Each board is validated for proper function and, if necessary, its design is optimized for improved efficiency and reliability. Once the PCBs are verified, each electrical subsystem is tested independently to evaluate its performance and stability. This subsystem-level testing significantly reduces the time and effort required during the final integration phase. After confirming the stability of each unit, all systems are assembled together and undergo integrated testing to monitor the overall performance, electrical safety, and system robustness under realistic operating conditions.

3.3- SOFTWARE TESTING

Software testing ensures that the control system operates smoothly and responds accurately. Each software module is tested individually, followed by integration testing with the hardware. Key features such as thruster control, sensor readings, and safety alerts are validated in both simulated and live environments. This ensures that MEGALODON's software remains stable, efficient, and mission-ready.

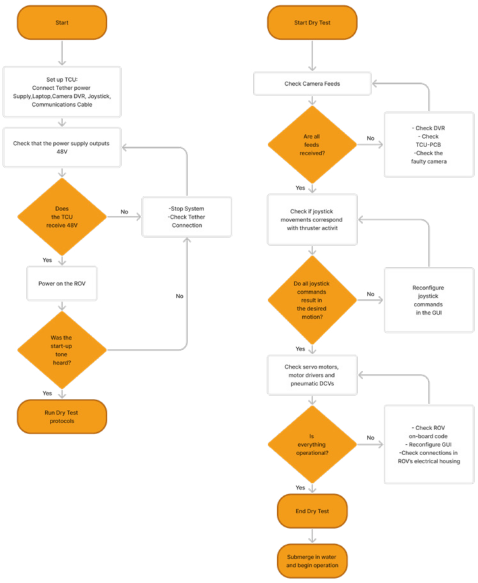

Figure (20). Troubleshooting Flowchart

4- LOGISTICS

4.1- COMPANY HISTORY

OI ROV was established in 2022 and is proudly competing for the second time in the MATE Egypt ROV Competition. During their debut, the team earned the "No Pain, No Gain" award, which served as a valuable learning opportunity. The team also participated in the 2023 season, continuing to grow and gain experience. Since then, OI ROV has made significant improvements in both technical systems and organizational structure. With an ambitious and knowledge-driven mindset, the team is determined to reach new milestones in underwater robotics.

4.2- COMPANY STRUCTURE

OI ROV consists of 42 dedicated members divided into six main departments—three technical (Mechanical, Electronics, Software) and three non-technical (Media, Documentation, Public Relations). Each department is broken down into smaller project-based teams focused on specific subsystems. The team is managed by a CEO, with a CTO supervising all technical operations and a CFO overseeing non-technical tasks and financial planning. A detailed company structure and role descriptions can be found in Appendix D.

4.3- PROJECT MANAGEMENT

PROJECT SCHEDULING

To ensure streamlined project execution, OI ROV uses Notion as a digital project management platform, with a dedicated workspace for each team. A comprehensive project timeline is created by the CEO and CTO, and includes clearly defined phases for design, manufacturing, and testing. Weekly departmental meetings are held to assign tasks, monitor progress, and encourage collaboration. For discussions and real-time communication, the team uses Discord, facilitating quick feedback and seamless coordination. Company-wide meetings are also scheduled to align all departments and address shared goals and challenges.

WORKSPACE MANAGEMENT

The team operates out of a well-equipped workspace divided into specific zones: a PCB soldering station, a water-testing tank area, a manufacturing and assembly zone, and organized storage. Cleanliness and preparedness are emphasized before starting any task to ensure safety and efficiency.

SHARED FILES & LIBRARIES

The software department uses GitHub for version control, ensuring smooth and collaborative code development. GitHub's integration with Microsoft Teams allows for real-time updates and notifications. This enables remote collaboration and efficient task tracking, even outside of physical meetings.

BUDGET AND ACCOUNTING

OI ROV operates on a limited, self-funded budget, which is carefully allocated to maximize value. The CFO is responsible for financial planning, monitoring monthly expenses, and identifying the need for additional resources. Detailed budget reports and funding allocations are provided in Appendices D and E.

5- CHALLENGES

One of the biggest challenges faced by OI ROV was the scarcity of electronic components in local markets. This forced the team to rely on imported parts, which often caused delays due to customs clearance and foreign currency shortages. Additionally, being a self-funded team made financial planning more complex, especially when trying to balance innovation with limited resources. These challenges tested the team's resilience and pushed them to develop smarter, more cost-effective solutions.

6- FUTURE PLANS

OI ROV is looking to integrate ROS 2 as the core communication protocol for the control system. ROS 2 offers real-time performance, scalability, and reliability, allowing direct communication between system nodes without a central hub, and enhancing fault tolerance. Another future goal is to build custom ESCs instead of relying on commercial ones, offering more control and flexibility. In terms of hardware, the team plans to switch to aluminum for the frame, optimizing weight without compromising strength. Finally, a major vision for the upcoming years is to create a Virtual Reality (VR) interface, allowing pilots to "see and feel" what the ROV experiences — a step toward semi-autonomous missions where the robot can execute logic-based tasks like object retrieval.

7- LESSONS LEARNED

Throughout the season, OI ROV members gained practical experience in their respective fields. The software team developed skills in Python, C++, Git, and ROS, while the mechanical team enhanced their capabilities in CAD design and material testing. Electronics members deepened their knowledge of PCB design and soldering techniques. On the soft skills side, the team improved their project coordination, documentation practices, and cross-team communication, learning how to handle pressure and solve problems effectively. The challenges faced served as real-world lessons, strengthening the team's foundation for future success.

8- REFERENCES

- MATE ROV Competition Manual 2025
- HDPE material specifications
- Blue Robotics store
- Qt Documentation | Home
- PID Documentations
- IMU 6050
- T200 Thrusters Documentation

9- APPENDIX

A- SID`s

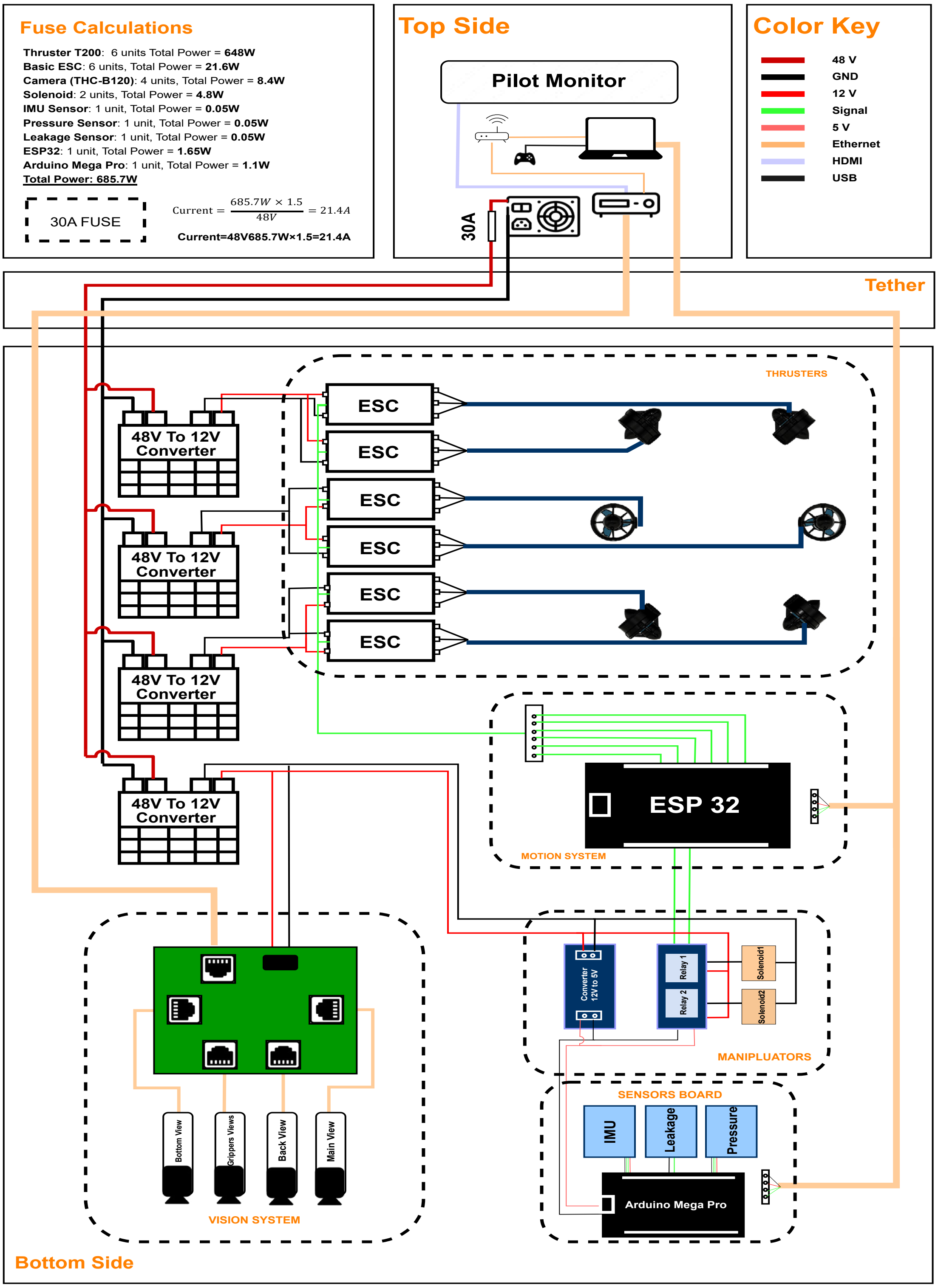

Figure (21). Electrical System

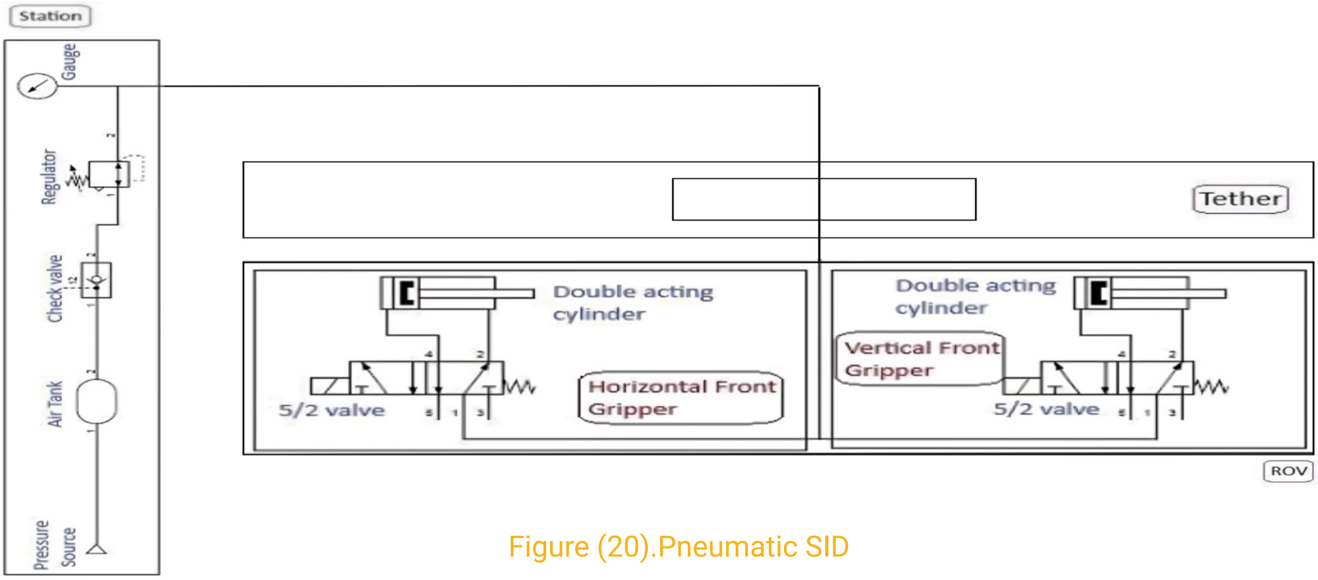

Figure (20).Pneumatic SID

B- POWER BUDGET

Component	Volt (V)	Current (A)	Qty	Power/Component (W)	Total Power (W)
Thruster T200	12	9	6	108	648
Basic ESC	12	0.3	6	3.6	21.6
Camera (THC-B120)	12	0.175	4	2.1	8.4
Soleniod	12	0.2	2	2.4	4.8
IMU Sensor	5	0.01	1	0.05	0.05
Pressure Seensor	5	0.01	1	0.05	0.05
Leakage Sensor	5	0.01	1	0.05	0.05
Esp 32	3.3	0.5	1	1.65	1.65
Arduino Mega pro	5	0.22	1	1.1	1.1
Total Power (W)			685.7		
Fuse Calculations			685.7 * 1.5 / 48 = 21.4 A		
			So we use a fuse 30 A		

C- SAFETY CHECK LIST

Construction	Pre-Power Test	Operational Safety
☐ Keep the workspace clean and free of debris.	☐ Ensure area is safe (no tripping hazards or obstructions).	☐ Only designated crew on deck.
☐ Store materials properly to prevent tripping hazards.	☐ Switches and circuit breakers are off.	☐ All crew in proper safety gear (PPE).
☐ Use safety goggles or face shields during cutting and grinding.	☐ Tether is securely attached to ROV.	☐ Poolside and deck area are clear.
☐ Use proper gloves and handling tools.	☐ Strain relief properly connected.	☐ Power remains off until all systems are checked.
☐ Inspect all machinery for wear or damage before use.	☐ Electronics housing is sealed and undamaged.	☐ No exposed wires or loose connections.
☐ Ensure guards and safety devices are in place and functioning.	☐ Visual inspection of wiring and housing nuts.	☐ Electronics housing sealed before launch.
☐ Follow manufacturer's instructions and safety guidelines.	☐ Thrusters are clear from debris.	☐ Control computer is running before power-up.
☐ Properly isolate energy sources before servicing.	☐ Set compressor output to 2.75 bar before powering up.	☐ ROV and Control Unit are powered down after retrieval.
☐ Store materials securely to avoid spills or instability.	☐ Confirm power source and TCU voltage (48V nominal).	☐ Dry test of thrusters, manipulators, and payloads.
☐ Inspect electrical cords and ensure grounding.	☐ Computers and TCU are operational.	☐ Check all video feeds.
☐ Disconnect power when making modifications.	☐ Verify thruster functionality and video feeds.	☐ Pilot surfaces the ROV before retrieval.
☐ Ensure proper grounding of electrical equipment.	☐ Ensure all deck crew members are attentive and prepared.	☐
In-Water	**Loss of Communication**	**Pit Maintenance**
☐ Two operators handle ROV during deployment.	☐ Cycle power on TCU to attempt reconnection.	☐ Check thrusters for foreign objects.
☐ Tether-man maintains control of tether.	☐ If unsuccessful, power down and retrieve ROV.	☐ Visually inspect ROV for any damage.
☐ Visually inspect for leaks and bubbles.	☐ Inspect for physical damage or leakage.	☐ Ensure cables are properly secured.
☐ Engage thrusters and begin functional checks.	☐ Resume operations only after confirming safety and function.	☐ Check tether for kinks or tangles.
☐ Test manipulators and payload tools.		☐ Confirm watertight seals and component alignment.
		☐ Test all onboard tools, cameras, and thrusters.
		☐ Clean and wash down thrusters after use.

D- CONSTRUCTION CHECKLIST

-Sanitized proper personal protective equipment (PPE) (e.g. gloves, goggles, and earmuffs) are worn 120 W

-Sharp tools are handled carefully, when not in use, they are stored in racks and boxes, and their sharp when performing any task.

-Maintenance and repairs are performed proactively.

-Emergency kits (including fire extinguishers and first-aid kits) are checked regularly to make sure they're stocked and functional.

-Hazardous materials are clearly marked and stored separately to ensure they're handled carefully. edges are covered with a cap -if available.

-Any in-water tests are performed far away from the Electrical Team's work area. The work area is well-ventilated, and additional fume extractors are used– to avoid the inhalation of harmful fumes when working with epoxy, glass fiber, etc... or soldering.

E- PROJECT BUDGET

	Source	Category	Total (USD):
Income	Obour Institute	cash donate	1,640
	Iraq Competition	Cash Rised	350
	ARC Competition	Cash Rised	410
	Employee Dues	self-fund	1,246
	JLCPCB	cash donate	250
	Last Season	other	150
	Total (USD) :		4046

Table (1).Income

	Category	Total (USD):
Expenses	Product Costs	2,969.60
	Equipment Costs	295.68
	Total	3,265.28

Table (2).Products/Operation

Category	Amount (USD) :
Total Income	4046
Total Expense	3,265.28
Total Expenses-Re-Used/ Donation	2330.85

Table (3).Total Cost

The exchange rate between the U.S. dollar (USD) and Egyptian pound (EGP) is 51.29EGP per dollar

	Category	Description	Type	Projected cost (USD)	Budgeted Value (USD)
Product Costs	Thrusters	6*T200 , 6 ESC's	Re-used	1754.89	1754.89
	Material	HDPE (Sheet + Cylinder), Aluminum Sheet, Acrylic (Sheet, Cylinder,Dome)	Purchased	175.49	175.49
	Fabrication	CNC Routing, Laser Cutting, 3D printing,Lathing	Purchased	109.19	109.19
	Pneumatic System	Pistons, Valves, Fittings, tubes	Purchased	74.09	74.09
	Fasteners	Screws, Counter Nuts, Caps (Stainless Steel)	Purchased	42.9	42.9
	Sealing	Rubber gasket, O-Rings, Glands, Epoxy	Purchased	62.4	62.4
	Elecrtical System	PCBs, Electronic Components, 6*DC Converter	Purchased	434.27	434.27
	Vision System	1 IP Camera, 4 Analogue Camera	Re-used	83.84	-
	Tether	Sheath, Power Cable, Ethernet Cable, Pneumatic Cable	Re-used	36.91	-
	Control Unit	Control Box, Monitor, Buttons, Joystick, AWG-6 Wires	Re-used	161.2	-
	Vehicle Safety Equipment	Shrouds, Caps, Stickers, Fuses	Purchased	18.46	18.46
	Miscellaneous	Zipties, Heatshrink, Velcro, Weights, Buoyancy Foam	Purchased	15.96	15.96
		Total		**2,969.60**	**2,687.65**
Running Costs	Playground	PVC Pipes, PVC Connectors, Spray Colors, Ropes, Plastic crate ,Brick	Purchased	68.25	68.25
	Competition Registeration	Mate, Mate Egypt, Fluid Power Quiz	Purchased	675	622.88
	Printables	Brochures, Business Cards, Poster, Banners, Documentation Reports, Flyers	Donation	52.65	—
	T-shirts	Company Staff T-Shirts	Purchased	243.74	243.74
	Training	Transportation	Purchased	25.35	25.35
	Testing	Pool	Donation	62.4	—
		Total		**1127.39**	**960.22**
EquipmentC	Power Supply	4 *48V-30A	Re-used	62.25	-
	Compressor	15 Litre Compressor Unit+ FLR unit	Purchased	116.72	116.72
	Mechanical Tools	Driller, Screw Drivers, Piller, Angle grinder, Wrench	Re-used	77.81	-
	Electrical Tools	Soldering Iron Station, Flux, Solder, Avo Meter	Re-used	38.9	-
		Total		**295.68**	**116.72**
	Total Cost			**4392.67**	**3,764.59**

Figure (21).Expenses

Month	Income Sources	Income (USD)	Actual Expenses (USD)	Difference (USD)	Running Balance
October	ARC Competition, Employee Dues	618	498.75	119.25	119.25
November	Iraq Competition, Employee Dues	558	450.33	107.67	226.92
December	JLCPCB, Employee Dues	458	369.62	88.38	315.3
January	Obour Institute (Part 1), Employee Dues	1028	829.65	198.35	513.65
February	Last Season, Employee Dues	358	288.92	69.08	582.73
March	Employee Dues	206	166.25	39.75	622.48
April	Obour Institute (Part 2)	820	661.78	158.22	780.7

TABLE (4).BUDGET PER MONTH

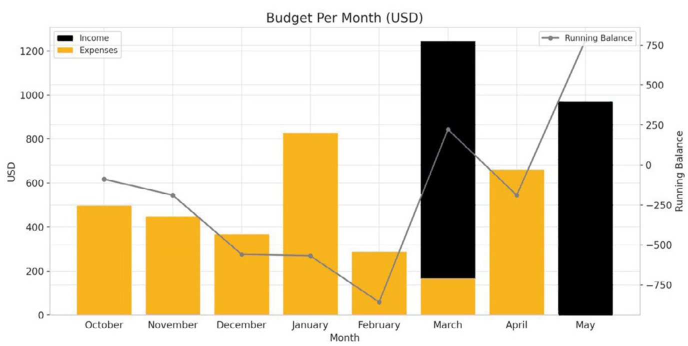

Figure (22).MONTH Expenses

F- TIME LINE

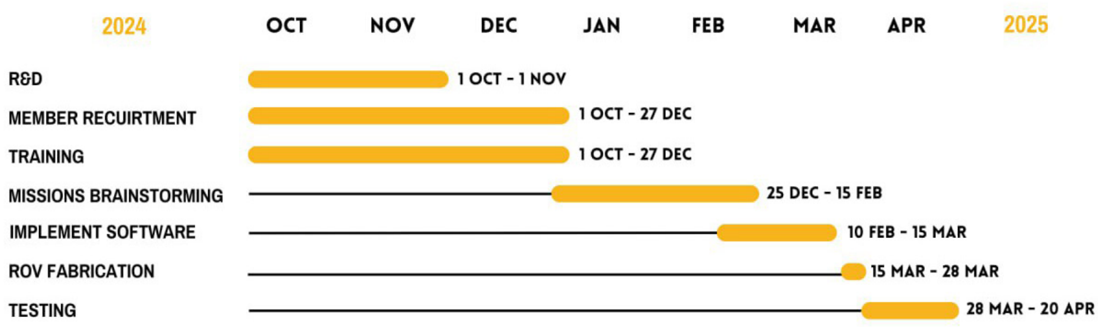

Figure (23).TIME LINE

G- FLOATING DEVICE

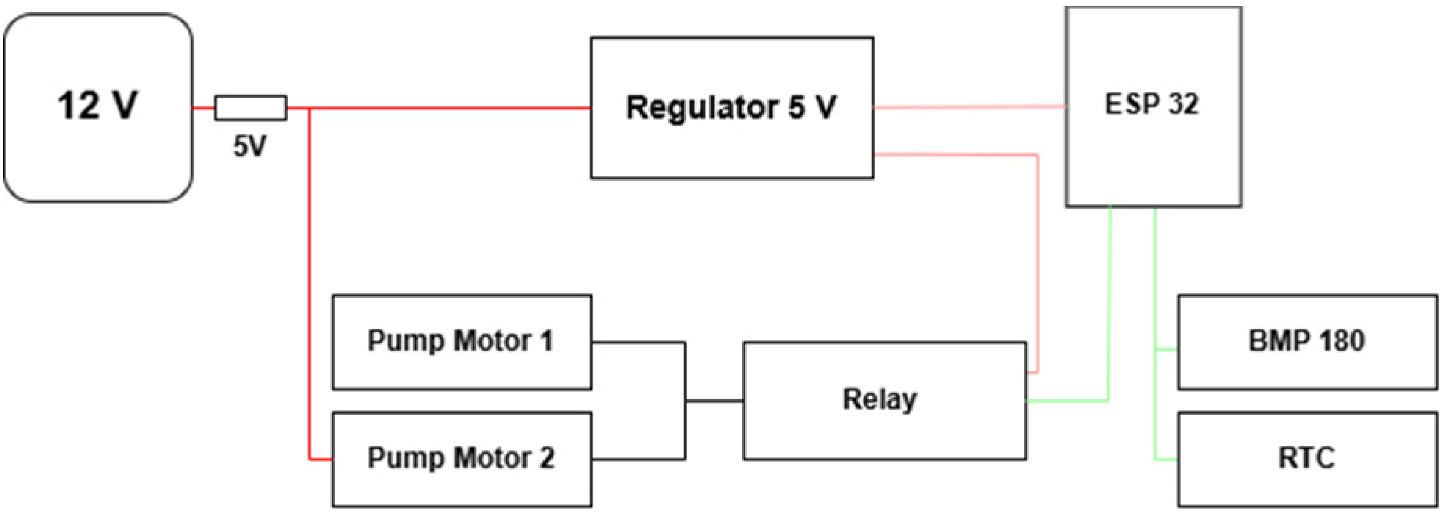

Figure (24). Float SID

Component	Volt (V)	Current (A)	Qty	Power/Component (W)	Total Power (W)
ESP 32	3.3	0.5	1	1.65	1.65
Pressure Sensor	5	0.01	1	0.05	0.05
RTC	3.3	0.002	1	0.0066	0.0066
Water Pump 12Vdc	12	1.5	2	18	36
Total Power (W)				37.71	
Fuse Calculations				37.71 / 12 = 3.14	
				So we use a fuse 5A	

Figure (25). Fuse Calculation