

MATE ROV 26

TECHNICAL DOCUMENTATION

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ABSTRACT

MGRC Marines is a passionate team of Computer Science students from Al-Obour Institute, united by a shared interest in robotics, embedded systems, and underwater technologies. Although this is our first year participating in the MATE ROV Competition, we see it as the start of a long journey driven by curiosity, innovation, and continuous learning. Our goal goes beyond competing—we focus on building, experimenting, and gaining real hands-on experience. This year represents a major milestone as we designed and developed our first ROV, Octa. The vehicle reflects our learning and is fully engineered to complete competition missions while emphasizing self-reliance and local innovation. Instead of relying on expensive commercial solutions, we developed key components our selves, including an ESP-based control system and custom-built thrusters, reinforcing our belief that true learning comes through creating and pushing limits.

Our vision is to become a leading robotics team advancing local ROV development and embedded systems while inspiring others. This project is more than a competition—it is a mission to apply academic knowledge, promote cost-effective solutions, and strengthen our technical and problem-solving skills. With 16 dedicated engineers, we aim to build a strong foundation for future achievements, including reaching international competitions like the MATE ROV World Championship.



(Figure 1). MGRC Team



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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 supporting our company in all at our beginning this year and trust us.
- **Mate Egypt Competition** for helping us and their effort
- **Arab Academy for Science and (AAST)** for hosting and organizing the regional Technology competition.
- **Eng. Waleed EL-Dahshan, Prof. Ehab Ashour Farag, and Dr. Saad ElSayed** have all provided invaluable technical and non-technical support.
- **A.T.E.C** for being our strategic partner and continuously supporting our vision.
- **SolidWorks, Altium, Ansys** for providing the team members with access to their products.
- **Our Families and friends** - Their encouragement and support.



معاهد العصور
Obour Institutes



ALTIUM
DESIGNER



1- COMPANY & PROJECT MANAGEMENT

1.1- COMPANY STRUCTURE

MGRC Marines operates under a well-defined organizational structure designed to ensure efficiency, collaboration, and clear distribution of responsibilities across all team members.

At the top of the hierarchy is the Chief Executive Officer (CEO), who serves as the team leader. The CEO is responsible for strategic planning, competition preparation, task distribution, and overall team direction.

Supporting the CEO is the Chief Technology Officer (CTO), who acts as the technical leader of the team. The CTO oversees all engineering divisions and ensures the successful integration of technical systems.

The technical side of the team is divided into three main departments:

Software Team

Electrical Team

Mechanical Team

In parallel, the team includes a Chief Financial Officer (CFO) responsible for financial management, as well as a Non-Technical Leader who supervises all non-engineering functions.

Department Responsibilities:

1. CEO (Chief Executive Officer)

Leads the entire team and defines the overall vision

Plans for the competition and sets strategic goals

Assigns tasks and ensures smooth workflow across all departments.

2. CTO (Chief Technology Officer)

Manages all technical teams (Software, Electrical, Mechanical)

Ensures coordination between different

engineering disciplines

Oversees the development and integration of the ROV systems

Technical Departments.

3. Software Team

Responsible for all programming-related tasks

Develops control systems, user interfaces, and AI functionalities handles data processing and system automation.

4. Electrical Team

Manages wiring and hardware connections of all components performs power calculations and ensures safe power distribution responsible for circuit design and electrical reliability.

5. Mechanical Team

Designs the mechanical structure of the ROV

Develops waterproofing and insulation systems builds and optimizes manipulators (grippers) and physical components

Administrative & Support Departments.

6. CFO (Chief Financial Officer)

Manages the team's budget and financial planning handles expenses, funding, and cost optimization.

7. Non-Technical Leader

Oversees all non-technical teams ensures coordination between support functions under the Non-Technical Leader, the following teams operate:

PR Team: Handles public relations, partnerships, and sponsorships

HR Team: Manages team organization, internal communication, and member coordination

Media Team: Responsible for content creation, branding, and social media presence

Documentation Team: Prepares technical reports, presentations, and official submissions



1.2- PROJECT TIMELINE

The development of our ROV project followed a structured timeline, allowing the team to progress efficiently from research to deployment.

October – December: Research & Development (R&D) and Team Expansion

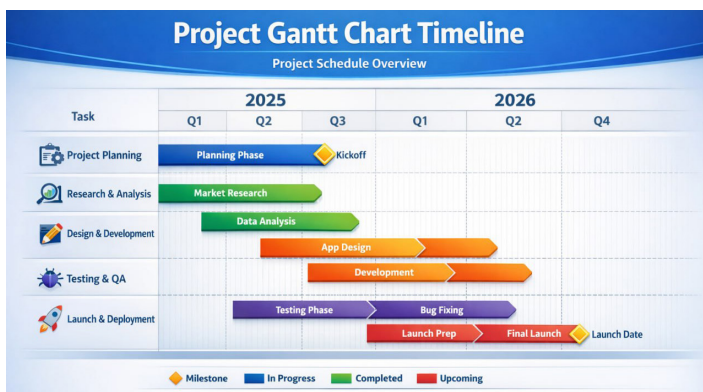
During this phase, the team focused on conducting in-depth research and exploring suitable technologies and design approaches. Simultaneously, new members were recruited and integrated into the team to strengthen technical and organizational capabilities.

January – March: System Design and Documentation

In this stage, the team worked on designing all major systems of the ROV, including the mechanical structure of the vehicle and the floating device. Alongside technical design, significant effort was dedicated to non-technical aspects such as documentation, planning, and preparation of required reports.

April: Manufacturing, Integration, and Testing

This phase involved the physical construction of the ROV, integration of all components, and extensive testing to ensure system reliability. Additionally, the team conducted intensive training sessions to practice and optimize performance for the competition tasks.



(Figure 2). Project Timeline

1.3- TEAM MANAGEMENT

MGRC Marines relies on Discord as the primary communication platform for all

team activities. Discord provides a robust and flexible environment that supports real-time messaging, voice and video calls, and organized channels for different topics and departments.

Advantages of Using Discord:

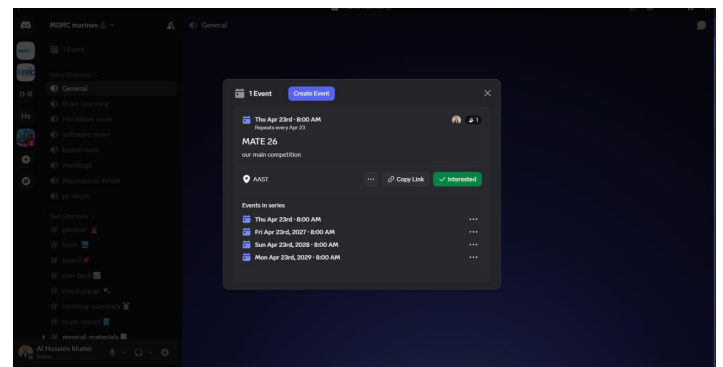
Real-Time Collaboration: Team members can instantly share updates, discuss ideas, and solve technical issues, ensuring that projects progress efficiently. **Organized Channels:** Separate channels for Software, Electrical, Mechanical, PR, HR, Media, and Documentation teams allow focused discussions while minimizing distractions.

Task Management: Through pinned messages, dedicated threads, and integrated bots, Discord helps track tasks, deadlines, and responsibilities effectively.

Cross-Platform Access: Team members can stay connected from PCs, laptops, and mobile devices, which ensures continuous communication regardless of location.

Integration with Tools: Discord can integrate with project management tools, GitHub, and other productivity apps, enhancing workflow and coordination.

By centralizing communication on Discord, MGRC Marines maintains a structured and transparent management system, allowing the CEO, CTO, and team leaders to oversee progress, address issues promptly, and keep every member aligned with the team's goals.



(Figure 3). MGRC Discord Server



1.4- PROCEDURES & PROTOCOLS

Team Operations & Technical Management : Engineering Workflow

Our engineering team follows a structured approach to ensure efficiency and high-quality results:

Component Fabrication: All parts are designed using detailed CAD models and reviewed by senior engineers before production. Mechanical assemblies undergo pre-assembly trials to detect issues early.

Subsystem Integration: Modules are connected based on verified schematics, with weekly integration tests to ensure proper system interaction.

Testing Process: Testing is conducted in stages—component, subsystem, and full ROV—along with regular in-water simulations to validate real-world performance.

Protocols & Standards

Safety Procedures: Team members strictly follow lab safety rules, including protective gear, ESD precautions, and safe handling of electrical and mechanical components.

Operational Guidelines: Standard Operating Procedures (SOPs) are applied for tasks like PCB soldering, software uploading, and ROV deployment to ensure consistency and minimize errors.

Problem-Solving Approach: Issues are handled within subteams first, then escalated if needed. All incidents are documented in Notion for tracking and follow-up.

Project Meetings & Communication

Weekly Leadership Review: Department heads meet with the project manager every Friday to review progress, KPIs, and coordination plans.

Subteam Meetings: Weekly sessions are held to assign tasks, track progress, and resolve challenges.

All-Hands Meeting: The full team meets weekly to share updates, discuss progress, and highlight challenges or improvements.

Daily Communication: Ongoing collaboration happens Discord through dedicated channels for updates, technical discussions, and urgent matters.

2- SAFETY

2.1 Safety Commitment

At MGRC Marines, the well-being of our team is our top priority. We aim to create a workplace where risks are minimized and staff feel confident performing their tasks. By identifying potential hazards early and implementing preventive measures, we reduce the chances of accidents and ensure smooth project operations.

2.2 Staff Education and Awareness

Even in a limited lab space, we maintain high efficiency through organized workflows and open communication. Every new member participates in an introductory safety program, covering proper equipment handling, emergency procedures, and best practices for working around robotic systems. This approach not only protects our staff but also enhances focus, teamwork, and innovation. Regular refresher sessions are conducted to keep everyone updated on safety protocols and emerging risks.

2.3 Standard Operating Procedures

All personnel are required to follow detailed safety guidelines before engaging with the ROV. This includes completing hazard simulations and hands-on exercises designed to familiarize staff with emergency scenarios.

A dedicated Safety Officer monitors all activities to ensure compliance with internal protocols. During testing—whether in the pool, lab, or workshop—employees follow a structured checklist (see Appendix B) to verify that all safety measures are observed.

Mandatory personal protective equipment (PPE), such as gloves, goggles, and non-slip footwear, is always worn when interacting with OCTA or other heavy machinery.



2.4 ROV SAFETY FEATURES

Our OCTA ROV integrates safety measures into both its design and operation:

Mechanical safety: Edges and surfaces are smoothed, fasteners are shielded, and thruster guards prevent contact with spinning propellers.

Electrical safety: Tether cables include reinforced strain reliefs to protect connectors, and fuses are strategically placed to prevent short circuits. Emergency cut-off switches on the main power supply and control unit allow instant shutdown if needed.

Environmental protection: The electronics, cameras, and thrusters are fully sealed against water, ensuring safe operation in aquatic conditions.

Additional measures, like tool organization, signage in the workspace, and regular equipment inspections, further reduce risks. Collectively, these systems create a controlled and secure environment, allowing our team to operate OCTA efficiently while minimizing hazards.



(Figure 4). Thruster Guard

3. EVALUATION AND DEBUGGING

3.1 ASSESSMENT APPROACH

To guarantee the reliability and efficiency of OCTA, a structured and thorough evaluation protocol was applied across all subsystems. This approach allowed us to confirm operational integrity, detect possible malfunctions, and fine-tune the system for both routine and extreme underwater scenarios. By performing detailed examinations, we ensured OCTA is

fully prepared for its missions and capable of coping with challenging aquatic conditions.

Electrical Evaluation

Component Verification: Every electrical element was individually examined to ensure correct functionality and integration within the system. Tools like multimeters and oscilloscopes were utilized to identify irregularities. Expected power usage was cross-checked against actual measurements to confirm reliable energy distribution under full operational load.

Circuit Modeling: Prior to assembling physical circuits, simulation software was employed to predict voltage and current behaviors. Prototypes were constructed and tested, while components were continuously assessed during PCB assembly to catch potential defects early.

Mechanical Evaluation

Waterproof Integrity Testing: The electronics housing was subjected to high-pressure trials to verify its watertight performance. A hydrostatic test setup was used to gradually raise pressure to 6 bars, simulating a depth of 60 meters—well beyond the competition requirement of 5 meters—ensuring OCTA operates safely under demanding conditions.

Pneumatic System Inspection: All air-driven circuits were examined and repeatedly tested to confirm proper sealing and functionality. Every joint and connection was carefully scrutinized to guarantee safe, leak-free operation during missions.

Task-Specific Trials

To prepare for the competition, scenario-based testing was conducted, leading to adjustments in camera positioning, maneuverability, stability, and manipulator mechanisms. Simulated exercises, such as underwater photography, object retrieval, and obstacle navigation, also improved pilot handling and overall system performance.



3.2 DEBUGGING PROCEDURES

When problems occur, a systematic problem-solving workflow is applied to efficiently identify and resolve issues without affecting other subsystems.

Detection of Anomalies

Performance logs and telemetry are continuously monitored to spot deviations from expected behavior. By referencing baseline data, irregularities are quickly pinpointed, allowing the team to focus on the affected subsystems.

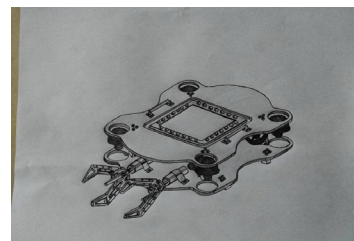
Isolation and Analysis

Problems are classified into mechanical, electrical, or software categories to streamline corrective measures. Electrical issues are investigated using diagnostic tools like oscilloscopes, while software or control faults are analyzed with debugging utilities. A logical, stepwise approach is used to isolate the faulty component or module.

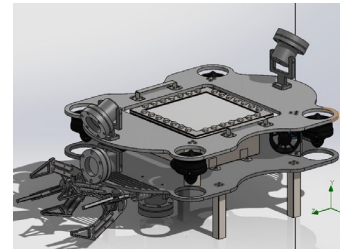
Remediation and Confirmation

After determining the root cause, corrective actions are applied, such as replacing defective parts or updating software modules. The repaired subsystem is re-tested independently to verify the issue is fully resolved without impacting other components. Each case is meticulously documented including observed symptoms, identified faults, and implemented solutions to enhance future troubleshooting efforts.

Works to ensure precise geometry, proper component integration, and interference-free assembly. The vehicle has overall dimensions of 800 mm in length, 625 mm in width, and 145 mm in height, with a total volume of 0.00957 m³. Structurally, the ROV consists of two primary horizontal plates (top and bottom) connected by four aluminum standoffs, forming a rigid sandwich-like configuration achieved through laser-cut precision manufacturing. This design provides high rigidity, even load distribution, and strong resistance to bending and torsion, while also offering a stable platform for mounting all components and facilitating easy assembly and maintenance. The internal layout is carefully arranged to ensure optimal performance and stability, with the control box positioned centrally, thrusters symmetrically distributed around the frame, and pneumatic grippers mounted at the front. Heavy components are placed near the center and vertically aligned to maintain a low center of gravity, which minimizes roll and pitch motion, improves directional stability, and ensures smooth, controlled underwater maneuvering.



(Figure 5). Hand Sketch



(Figure 6). Octa CAD

4- DESIGN RATIONALE

4.1 MECHANICAL SYSTEM

4.1.1 DESIGN OVERVIEW

After determining the root cause, corrective The ROV is designed as a compact, lightweight, and structurally robust underwater vehicle capable of performing manipulation and inspection tasks. It follows an open-frame architecture that allows free water flow through the structure, reducing hydrodynamic drag and enhancing maneuverability. The complete mechanical design was developed using Solid

MASS DISTRIBUTION TABLE

Component	Mass (kg)
Top Frame Plate	3.10
Bottom Frame Plate	4.47
Aluminum Standoffs	0.51
Control Box	2.88
Thrusters (8 units)	3.20
Pneumatic Grippers	1.20
Camera System	0.75
Total Mass	16.11 kg



4.1.2 FRAME MATERIAL

The frame is constructed from coated structural polymer (commercially known as Artiron) with

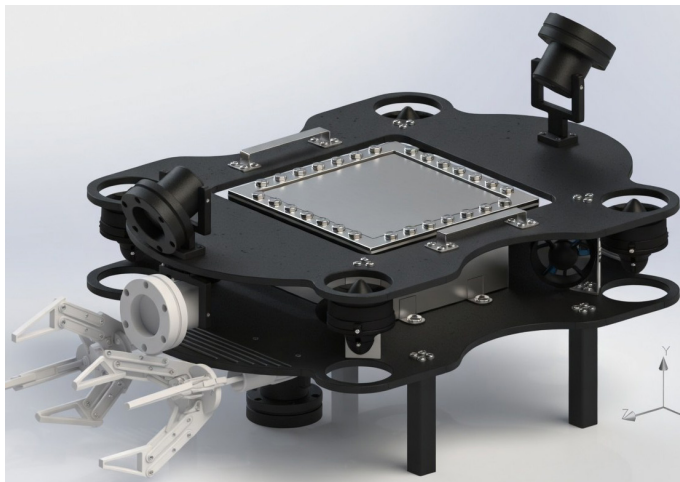
a thickness of 10 mm.

Engineering Justification:

- High structural rigidity comparable to acrylic materials
- Enhanced impact resistance compared to brittle plastics
- Excellent corrosion resistance in aquatic environments
- Density is relatively close to water, aiding buoyancy balance

The selected thickness (10 mm) ensures:

- Minimal structural deformation under load
- High vibration damping during thruster operation.



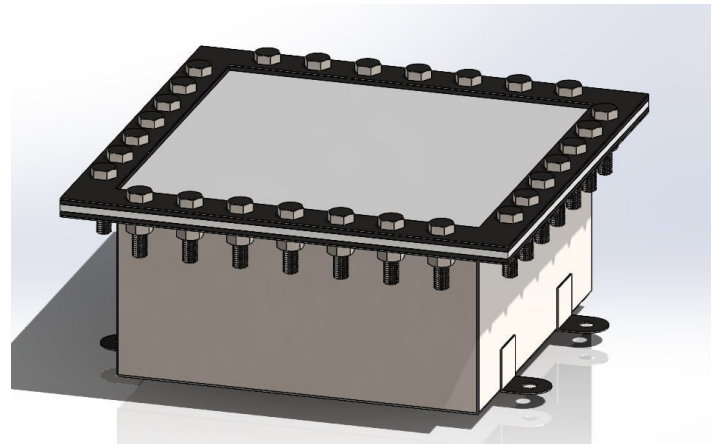
(Figure 7). Octa

4.1.3 Control Box Material

The control box is fabricated from stainless steel sheets (1 mm thickness).

Advantages:

- Superior corrosion resistance in underwater environments
- High mechanical protection for sensitive electronics
- Reduced weight due to thin sheet design



(Figure 8). Control Box

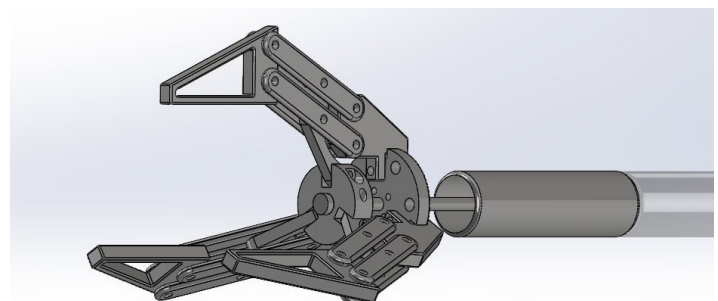
4.1.4 Manipulator System

The ROV is equipped with:

- Two pneumatic grippers with a 3-finger configuration

Features:

- Capable of handling various shapes and sizes
- Even force distribution across three points
- Suitable for underwater object manipulation tasks.



(Figure 9). gripper

4.1.5 Manufacturing Process

Fabrication Methods:

- Laser cutting for frame components
- Manual fabrication for control box
- Mechanical assembly using bolts and fasteners

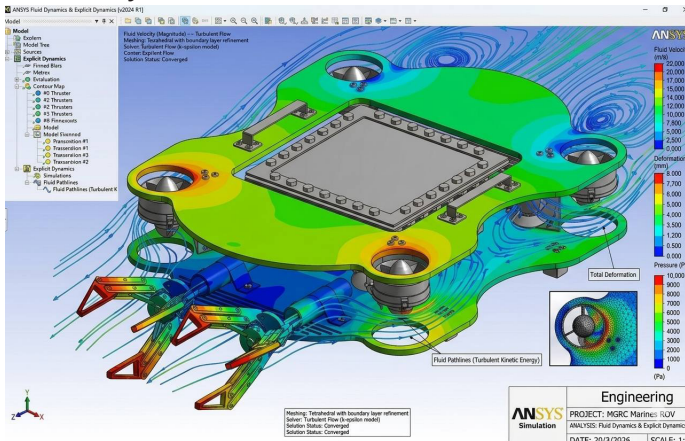
Benefits:

- High dimensional accuracy
- Repeatability in production
- Reduced fabrication errors



4.1.6 CFD ANALYSIS

A computational fluid dynamics (CFD) assessment was carried out on the OCTA ROV to investigate the flow behavior around its structure, evaluate its ability to endure external pressure loads, and estimate the drag acting on the vehicle. The results, presented in the figure, illustrate the flow distribution surrounding the OCTA design developed by MGRC Marines. The open-frame configuration, with carefully designed gaps and internal passages, supports a more uniform water flow, minimizing turbulence and drag while enhancing the vehicle's overall hydrodynamic efficiency.



(Figure 10). Octa CFD

4.1.7 BUOYANCY

The MGRC Marines mechanical team faced notable challenges when dealing with stability and balance during the design phase of OCTA. To address these issues, a set of clear objectives was established. These included ensuring that the vehicle remains smoothly suspended in water to improve maneuverability, achieving near-neutral buoyancy while submerged, and slightly increasing the buoyant force so it exceeds the system's total weight. This slight positive buoyancy was essential to enhance operational safety, simplify handling, and support reliable task performance.

4.1.8 THRUSTERS

Due to the high cost and limited availability of T200 thrusters, our team decided to develop an in-house alternative solution. We successfully designed and manufactured our own custom

thrusters to meet the requirements of our ROV.

The system is based on a brushless motor, which we carefully sealed and waterproofed to ensure reliable underwater operation. The motor housing was designed and fabricated using 3D printing, allowing for precise customization and structural efficiency. Additionally, the propeller was manufactured using 3D-printed resin to achieve optimal performance and durability.

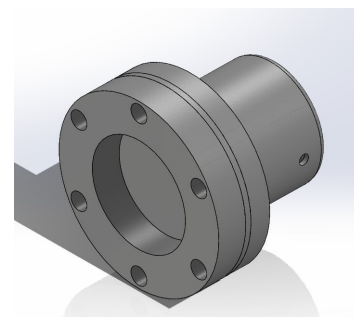
This custom thruster design has demonstrated high efficiency and stable performance during operation. Our ROV is equipped with a total of eight thrusters—four arranged horizontally and four vertically—to provide enhanced maneuverability, improved control, and increased overall efficiency in underwater navigation.



(Figure 11). thrusters configuration

4.1.9 CAMERAS HOUSING

There are four camera casings in OCTA. Using HDPE was the optimal choice due to its low density. HDPE's casings were fabricated using a lather 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 11). Camera Housing



4.2 ELECTRICAL SYSTEM

The Electrical Team at MGRC Marines plays a crucial role in the development and success of the ROV OCTA. Our responsibilities include the design, development, and integration of all electrical systems that enable the vehicle's operation and control.

Our work covers several key areas:

Power Distribution – We provide stable and efficient power flow from the topside system to all onboard subsystems, ensuring consistent performance.

Sensor Integration – We incorporate a range of sensors such as pressure, IMU, leakage, and temperature sensors into the electrical architecture, enabling accurate real-time monitoring for navigation, control, and environmental awareness.

Communication Systems – We establish a robust communication link between OCTA and the surface station, allowing seamless command transmission and reliable data exchange.

Control Unit – We develop and manage the control infrastructure that processes commands and handles system operations.

Safety Systems – We implement protective mechanisms to detect faults, prevent overloads, and ensure safe operation in all conditions.

Our system is designed to be dependable, modular, and adaptable, allowing for continuous improvement and future upgrades. We prioritize achieving high performance while maintaining safety and efficiency.

Our approach is built on three main principles:

Reliability – Ensuring all electrical components can withstand harsh underwater environments.

Maintainability – Designing systems that are easy to access, troubleshoot, and repair.

Scalability – Allowing for future expansion and the integration of new features without major redesigns.

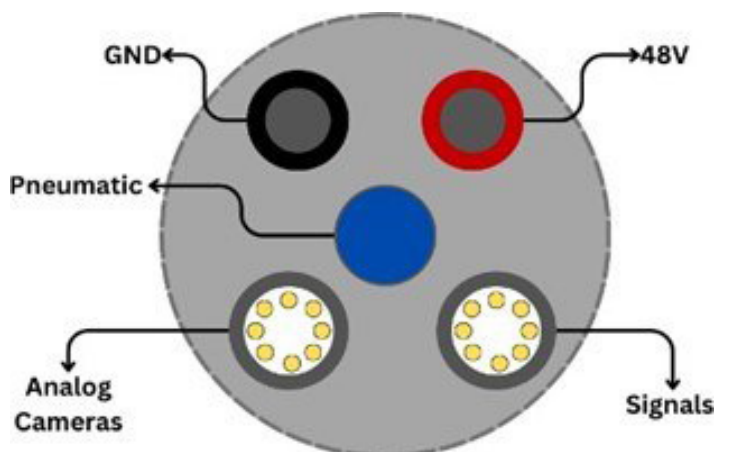
4.2.1 TETHER

The tether serves as the primary link between the control station and the ROV, OCTA, enabling both power delivery and data transmission. It is constructed from two CAT6 Ethernet cables, a 12 AWG DC power line, and a pneumatic line. All components are enclosed within a flexible outer jacket that provides protection and durability for the internal wiring.

Within the tether, one CAT6 cable is dedicated to transmitting analog camera feeds, while the other handles communication for control commands and sensor data. The team MGRC Marines selected CAT6 cables over alternatives such as CAT5 or lower-grade options due to their superior bandwidth capacity (up to 1 Gbps) and improved signal-to-noise performance.

The use of high-speed CAT6 cables allowed for a more compact and lightweight tether design, while still supporting stable signal transmission over extended distances beyond the initial 30 meters without degradation.

For the power line, a 12 AWG cable was chosen because of its low electrical resistance, which helps minimize voltage drop during power transfer from the station to OCTA. The cable is made from high-quality tinned copper conductors, enhancing conductivity while also offering better resistance to moisture and environmental contaminants such as dust.



(Figure 12). Cross-Sectional View of Tether



4.2.2 POWER SYSTEM

Starting from our main station, two power supplies rated at 24V, 15A are connected in series to obtain a total output of 48V. In parallel, the same configuration is used to increase the available current to 30A, ensuring sufficient power delivery. The resulting power is transmitted to the ROV through the tether.

Inside the ROV, the incoming voltage is distributed among four buck converters, which step down the voltage to the required levels suitable for the onboard electronics and actuators. These converters ensure efficient and stable power regulation across the system.

The regulated power is then supplied to eight standard motors, which are responsible for the vehicle's propulsion and maneuvering. The power distribution is designed to maintain stable operation, minimize losses, and ensure reliable performance of all subsystems.

4.2.3 MOTOR CONTROL SYSTEM

It starts with the core control unit of MGRC Marines' OCTA, the our ESP32, which acts as the central controller responsible for communication and distributing control signals to each ESC individually. The ESCs receive regulated power from the converters and respond to the signals from the ESP32 to precisely control the speed of the our thrusters.

These thrusters are selected for their durability and strong torque performance in underwater conditions. Their fully flooded structure allows natural water cooling, while the internal components are designed to operate efficiently with water-lubricated bushings, eliminating the need for external cooling or lubrication systems.

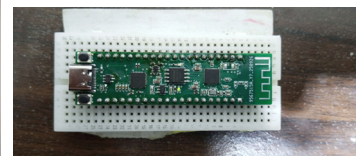
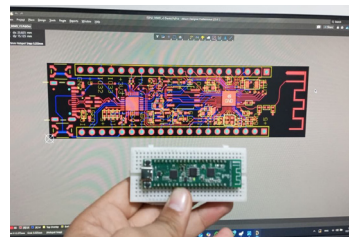
Each thruster is powered through its own dedicated converter to handle its high power demand. Additionally, a custom PCB was developed to enhance the motor control system, simplify maintenance and troubleshooting, and ensure the design remains scalable and easy to upgrade in the future.

4.2.4 OUR ESP 32

The commonly available ESP32 modules in the market presented several limitations and reliability concerns, including inconsistencies in performance and constraints that did not fully align with our system requirements. These challenges motivated us to explore the possibility of developing our own customized solution instead of relying entirely on off-the-shelf modules.

Accordingly, we designed and developed our own ESP32-based board tailored specifically to our application needs. The design process involved careful hardware selection, schematic development, and PCB layout optimization to ensure stability, efficiency, and compatibility with our system architecture. Special attention was given to signal integrity, power distribution, and overall robustness to meet the operational demands of our project.

After completing the design and manufacturing stages, we proceeded with comprehensive testing and validation procedures. The custom ESP32 successfully passed all functional and performance tests, demonstrating stable operation and meeting the required specifications. This achievement not only improved system reliability but also gave us greater flexibility and control over future developments.



(Figure 13). Our ESP Design (Figure 14). Our ESP32

4.2.5 SENSOR INTERFACING SYSTEM

- ACS712 Current Sensor: They are used for measuring the current drawn by each thruster, and continuously updating the GUI with live current consumption.

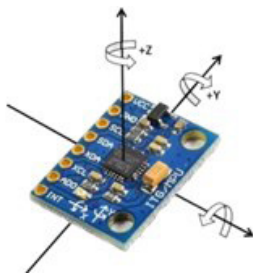


The system can monitor motor health and identify potential issues like overload malfunction. This allows for easier maintenance and avoids risking motor damage.



(Figure 15). Current Sensor

- **IMU Sensor (MPU-6050):** It is used to measure the value of the yaw angle to set the desired angle of rotation around the Z-axis for both high-quality PID control and stability, IMU is a MEMS (Micro- Electro-Mechanical System) accelerometer and gyroscopes sensor that measures and reports MEGALODON's angular rate, and acceleration (providing 6 degrees of freedom measurements). It provides the feedback signal to the PID controller .



(Figure 16). IMU Sensor

- **MS5540C Water Pressure Sensor:** It is used for measuring the water depth level by using the following relation: $h = p / \rho g$ Where: h : height (m), p : pressure (Pa), ρ : density of fluid (kg/m^3), g : gravity (m/s^2). We can calculate the depth of the ROV to facilitate the mission of pilot.



(Figure 16). Pressure Sensor

4.2.6 ELECTRONIC HOUSING

This geometry also simplifies wiring, routing, and overall cable management. The electrical enclosure is structured into three distinct layers:

First Layer: Power Conversion and Distribution

This section includes four DC-DC buck converters, each protected with appropriate fuses to ensure safe operation. These converters are designed for high efficiency, reliability, and robust performance, and they incorporate multiple protection mechanisms such as over-current, over-voltage, under-voltage, and short-circuit protection. The system receives a 48V input through the tether, which is then stepped down to 12V to supply the 8 thrusters, along with solenoids, lighting, and camera systems. Additionally, the aluminum structure of the enclosure acts as a passive heat sink, positioned to enhance thermal dissipation by transferring heat directly to the surrounding water.

Second Layer: ESCs

This layer contains the 8 Electronic Speed Controllers (ESCs), each dedicated to one of the thrusters. Every ESC is connected to its corresponding buck converter and integrated with an ACS712 current sensor module. This setup allows continuous monitoring of the current drawn by each thruster, improving system protection and enabling rapid fault detection and diagnosis.

Third Layer: Control Boards

The final layer houses the main control electronics, which include the thrusters control board, the sensors interface board, and the camera control board.

All these systems are developed and integrated by MGRC Marines for the OCTA ROV, ensuring a compact, efficient, and reliable electrical architecture.



4.3 SOFTWARE SYSTEM

Our system is designed to be simple in architecture while maintaining high performance, speed, and reliability. At the core of the system, we utilized our custom-developed ESP32 board as the main controller, ensuring flexibility and full control over hardware integration.

On the software side, we developed the graphical user interface (GUI) using Python, providing an efficient and user-friendly platform for monitoring and control. Additionally, a PID control algorithm was implemented to achieve precise and stable system behavior during operation.

Throughout this season, we successfully worked on the required tasks and integrated artificial intelligence into our workflow. Python was also used to develop and train the AI models, enabling advanced capabilities and enhancing the overall performance of the system.

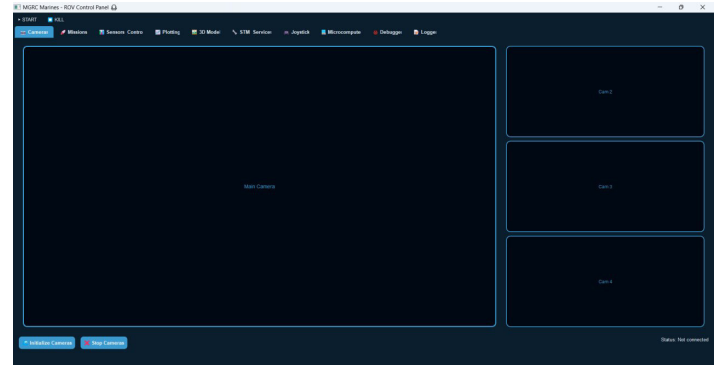
4.3.1 GUI

The Topside Control Unit (TCU) serves as the primary interface for operating the ROV OCTA, providing full control through a custom-designed Graphical User Interface (GUI) developed using python.

The GUI acts as the communication bridge between the joystick inputs and the onboard systems of OCTA, allowing the operator to precisely manage the speeds of the 8 thrusters via 8 ESCs, while ensuring smooth and intuitive interaction. The interface is structured into multiple dedicated panels tailored for different mission tasks, enhancing clarity and ease of navigation.

To further improve operational awareness, the GUI integrates a pilot-friendly Head-Up Display (HUD) that presents real-time telemetry and sensor data. This includes live current readings for each motor, depth measurements, temperature monitoring, and leakage detection alerts that immediately notify the operator of any water ingress. Additionally, key orientation parameters such

as yaw and roll are continuously displayed, enabling accurate and stable maneuvering throughout the mission.



(Figure 16). GUI

4.3.2 PID

The operational requirements of the ROV range from precise, delicate positioning to rapid and dynamic motion, which demands both accuracy and responsiveness. To ensure stable and reliable performance under these varying conditions, a PID (Proportional–Integral–Derivative) control strategy has been adopted.

This control approach enables OCTA, developed by MGRC Marines, to maintain smooth and consistent behavior by continuously correcting errors in real-time. By tuning the proportional, integral, and derivative components, the system achieves a balanced response that enhances stability, minimizes overshoot, and improves overall control efficiency across all operating scenarios.

5 FLOATING DEVICE

5.1 CONTROLLING SYSTEM

The vertical float system operates autonomously by controlling its vertical movement within a water column, collecting environmental data such as pressure. The heart of the control system is the ESP32 microcontroller, which processes data from a pressure sensor to determine the device's depth and decide whether to ascend or descend. The system uses a relay module to activate two 12V DC water pumps in the top compartment. These pumps adjust the buoyancy of the system by either drawing



water into the internal chamber or expelling it. Additionally, a real-time clock (RTC) ensures accurate timekeeping for data logging and scheduling tasks. The system is designed to be fully autonomous, with the ESP32 microcontroller making decisions in real time based on pressure data, allowing the system to adjust its vertical position in the water column efficiently.

5.2 SYSTEM DESIGN

The design of the vertical float system is divided into two main compartments: the bottom compartment housing the electronics and power components, and the top compartment containing the buoyancy system. The bottom compartment includes key components such as 8 alkaline batteries providing power, the ESP32 microcontroller that controls the system, a relay module to operate the pumps, and a pressure sensor to measure the water depth. The top compartment holds two 12V DC water pumps, one responsible for increasing the system's density by drawing water in and the other for expelling water to decrease density and allow the device to rise. The system's design allows for precise control of buoyancy and depth, ensuring smooth, autonomous vertical movement within the water column.

5.3 STABILITY

For the vertical float system to function effectively in a water column, stability is a key factor. The system's design ensures that the center of buoyancy (CB) is positioned above the center of gravity (CG), which is essential for maintaining a stable dive path. This orientation prevents the system from tipping or rolling during vertical movements. Additionally, the system is designed to self-correct its orientation in response to external disturbances. The righting moment created by the relative positions of the CG and CB ensures that if the system experiences any deviation due to external forces, it will automatically realign itself to maintain stability. Simulation studies have confirmed that this design allows the system to reorient and stabilize

itself, ensuring smooth and stable operation throughout its vertical movements.

5.4 ELECTRICAL SYSTEM

The electrical system of the vertical float system powers all essential components, including the microcontroller, sensors, and pumps, while ensuring safe operation through protective measures. The system is powered by 8 alkaline batteries, providing a total output of 12V. The ESP32 microcontroller manages the data processing and decision-making based on inputs from the pressure sensor, which measures the depth of the system. The relay module activates the water pumps as needed, either drawing water into the internal chamber to increase the system's weight or expelling water to decrease weight and allow ascent. The system also includes a real-time clock (RTC) for accurate timekeeping, and a 5A fuse protects the system from overcurrent or short circuits, ensuring its safe and reliable operation throughout missions.

5.5 EXPANSION POSSIBILITY

The vertical float system is designed with scalability in mind. While it currently operates using wired communication for control and data transmission, the system can be upgraded to include wireless communication options such as Wi-Fi. This would enable real-time data transmission from the device to a control station, providing continuous monitoring of system parameters such as depth and pressure. Additionally, the system could include features for graphing and visualizing collected data, such as depth over time, once the device surfaces. These enhancements would greatly expand the system's capabilities, allowing for more complex missions and more comprehensive data analysis, making the system more versatile for various underwater applications.



(Figure 17). Float Device

6 BUDGET AND ACCOUNTING

The financial management approach adopted by MGRC Marines is structured to maintain clarity, precision, and efficiency in monitoring all project-related expenses for the OCTA ROV. Each team submits procurement requests that undergo careful evaluation to verify both their importance and economic viability prior to approval.

Once authorized, all expenditures are recorded in a unified financial database accessible to relevant members, enabling continuous tracking of the available budget. Expenses are systematically classified based on different system modules, while clearly distinguishing between newly acquired components and previously utilized resources.

This methodology not only reinforces financial discipline but also enhances strategic planning and promotes efficient utilization of resources across all stages of the OCTA development process.



Numbring	Item	Amount	cost
1	frame	1	10000
2	box	1	10000
3	glands	40	2000
4	O-Ring	8	1000
5	Acrilic	8	2000
6	mechanisms	3	3000
7	etharnet	70 m	600
8	power cable	70 m	700
9	pnuematic	70 m	700
10	Camera Housing	6	3000
11	cameras	6	5000
12	converters 48 - 12	5	12000
13	motors	8	20000
14	Sensors	3	3000
15	esp	3	1000
16	h-bridge	4	1000
17	esc	10	10000
18	pcbs	4	5000
19	pnuematic System	4	3200
20	Air Compressor	1	4500
21	Fasteners		2000
22	station	1	2000
23	power supply	1	2000
24	Fuses		300
25	Registration fees		34000
26	playground	1	2000
27	Connectors		1000
28	life jacket	2	1000
29	Floating Device	1	10000



7 CONCLUSION

7.1 LESSONS LEARNED

Throughout our participation in the MATE ROV competition, we gained valuable technical and organizational insights that significantly enhanced our performance. One of the key lessons was the importance of early planning and iterative design; continuous testing and refinement proved essential in improving system reliability and efficiency.

We also learned that simplicity in design often leads to greater robustness, especially in harsh underwater environments. Effective integration between mechanical, electrical, and software subsystems was critical, highlighting the value of strong team coordination and clear communication.

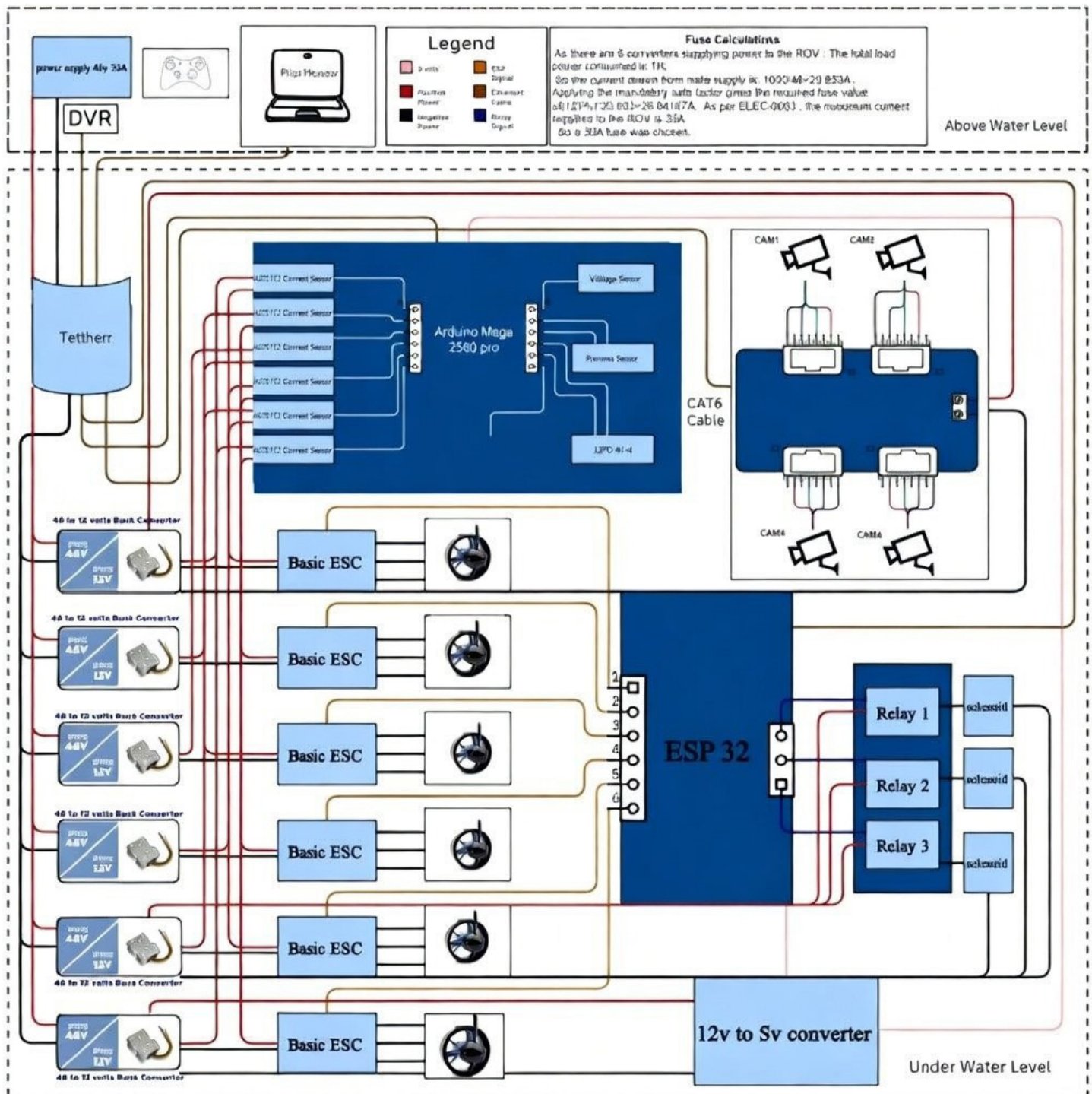
Additionally, hands-on problem-solving under real conditions helped us better understand practical limitations beyond theoretical designs. Finally, time management and proper task distribution played a major role in meeting deadlines and maintaining consistent progress throughout the project.

7.2 REFERENCES

- MATE ROV Competition Manual
- ROV Safety Guidelines – MATE Center
- ESP32 Datasheets & Technical Reference Manuals
- Power Electronics & Buck Converter Design Guides
- Microcontroller & Driver Circuits Documentation
- Python Official Documentation
- MATLAB
- ANSYS (CFD Analysis)
- SolidWorks Design & Simulation



8 APPENDIX



(Figure 18). Electrical SID

