

E.V.O



MATE ROV 26' TECHNICAL REPORT

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1.Introduction:

1.1 Abstarct:

Operating within the dynamic field of Egyptian robotics, RoboCore reflects Benha National University's commitment to practical engineering solutions and innovation. Established in 2025, the company comprises 37 interdisciplinary engineering students dedicated to designing and developing robust robotic systems tailored to address real-world challenges.

EVO embodies RoboCore's commitment to Egypt's Vision 2030 and global environmental stewardship. A primary mission for EVO is addressing the urgent spread of **water hyacinth (Nile flowers)** in Egyptian waterways. This invasive species poses a severe threat to local biodiversity, agriculture, and hydropower systems. EVO utilizes its advanced navigation and containment features to aid in the monitoring and removal of these plants, promoting a healthier aquatic ecosystem.

By tackling this local crisis while excelling in international competition, RoboCore and EVO align with the **United Nations Sustainable Development Goals (SDGs)**, specifically focusing on **Clean Water (SDG 6)**, **Life Below Water (SDG 14)**, and **Sustainable Ecosystems (SDG 15)**. We remain dedicated to using our engineering skills to solve the most pressing environmental challenges of our time.



FIGURE 1: Robocore Members

2. Mechanical Design:

2.1. Design Evolution:

Before building the advanced ROV, the team developed a prototype using PVC pipes as a lightweight and cost-effective experimental platform. The main goal of this prototype was to test fundamental concepts, such as buoyancy, basic propulsion, and control system integration, on a smaller and simpler scale. This initial design allowed the team to identify potential challenges, experiment with component placement, and refine control strategies before committing to a more complex and high-performance ROV. The prototype served as an invaluable learning step, providing practical insights that guided the development of the final, fully-featured ROV.

• Mechanical Improvements

In the new ROV design, the original PVC pipe structure was replaced with a rectangular cuboidal frame. The updated frame includes two bases made of Artilon material – one on the top and one on the bottom – which enhances rigidity, stability, and allows for more organized placement of components. Additionally, the control box was redesigned from PVC to a cuboid shape made of stainless steel, providing significantly greater strength and safety. The control box is covered on top with acrylic, allowing visibility of internal components while maintaining protection. These design changes also improve the overall modularity of the ROV, making it easier to upgrade or maintain in the future.

• Propulsion System

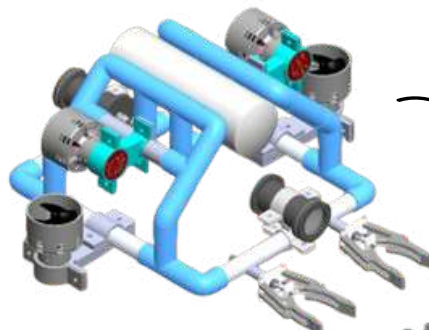
The previous bilge pumps have been replaced with T200 thrusters, providing significantly higher thrust and more precise control. This upgrade allows the ROV to maneuver more efficiently and handle challenging underwater conditions with improved stability and responsiveness.

• Electrical and Control System

Relays used in the older version have been replaced with Electronic Speed Controllers (ESCs), enabling smoother and more accurate motor operation. Alongside this, the integration of PID control has greatly enhanced the ROV's stability, allowing precise adjustments to maintain orientation and movement based on real-time sensor feedback.

• Sensing and Perception

The number of cameras has been increased from two to four, which provides better underwater visibility and situational awareness. This improvement allows for enhanced navigation, monitoring, and inspection capabilities, making the ROV more versatile for complex tasks.



• FIGURE 2: Prototype Rov



• FIGURE 3: New EVO ROV

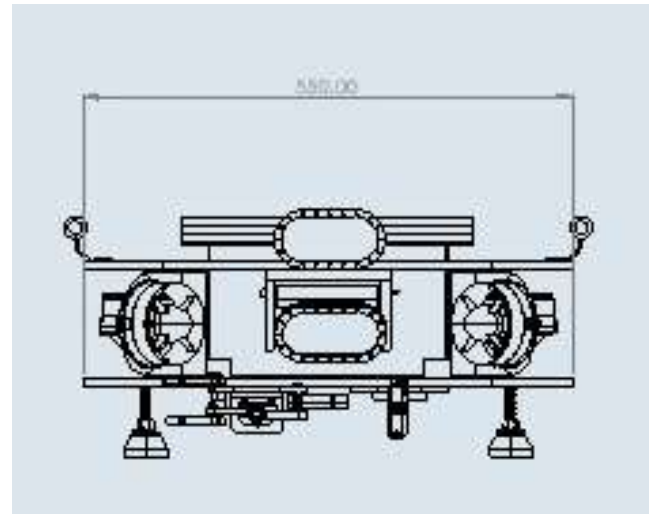
2.2 Frame:

The frame of the ROV was developed with a clear focus on cost-effectiveness, modularity, and ease of assembly, while ensuring the structural integrity required for shallow-water operation. To achieve this, the team selected **Artylon Sheets of 12 mm thickness** as the primary construction material. Artylon was chosen due to its low cost, natural buoyancy, and corrosion resistance, making it well-suited for aquatic applications. Additionally, the use of Artylon eliminates the need for welding or specialized fabrication techniques, allowing the frame to be assembled using simple cutting tools, adhesives, and mechanical fasteners such as screws or bolts.

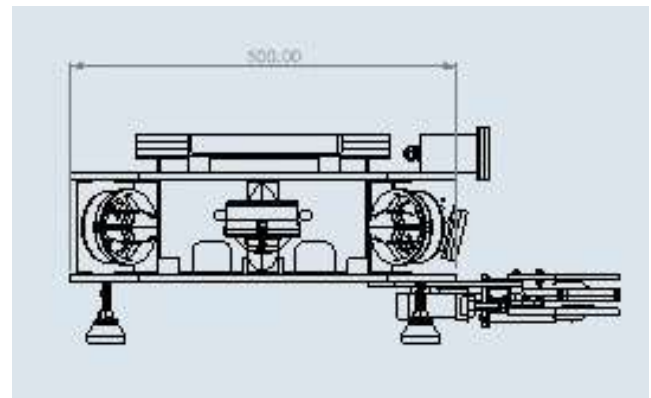
The frame consists of two layers of Artylon Sheets. The lower board serves as a platform for mounting hardware and selected manipulators, while the upper board functions as a strain relief mechanism, enhancing rigidity and distributing loads. The frame holds the thrusters, electrical enclosure, tools, cameras, lights, and sensors; therefore, it is required to be rigid and mechanically stable to ensure that all components function together as an integrated system. The top plates are connected to the bottom plate using **3 mm aluminum sheets**, which also serve as mounting points for the thrusters.

The resulting structure is a rectangular modular frame that provides both stability and flexibility. The frame dimensions are **[550 × 500 × 190] mm**, designed to balance compactness with sufficient internal space for tool and component integration. The modular design enables straightforward scalability, allowing additional sensor mounts or structural extensions to be integrated without requiring a complete redesign. The combination of Artylon sheets and aluminum connectors provides structural rigidity while also

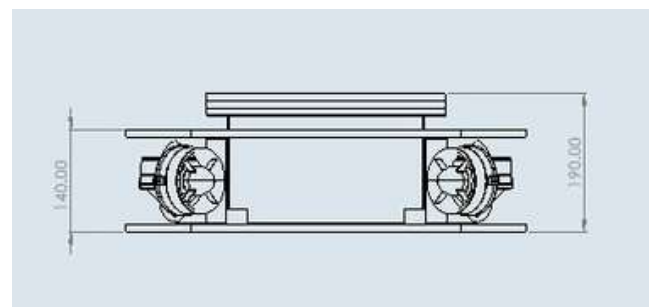
allowing the panels to function as cable channels for motors and sensors. This integration minimizes external clutter and enhances the overall organization of the system.



• FIGURE 4: EVO Front View



• FIGURE 5: Evo Side View



• FIGURE 6: Evo Height

2.3 Tools & Equipments:

1. Grippers

The manipulator system of EVO is designed to be both lightweight and versatile, capable of handling a variety of mission tasks. The gripper features 3D-printed jaws connected through aluminum linkages to a pneumatic cylinder actuated via a solenoid valve. This setup allows for reliable clamping force while maintaining a compact form factor. The air supply is delivered from the surface through the tether, ensuring continuous and controlled operation during missions. The jaws are shaped to accommodate objects of different diameters, with the ability to securely grasp and hold pipes or cylindrical objects up to **80 mm in diameter**.



- FIGURE 7: EVO Grippers

2- T200 Thrusters

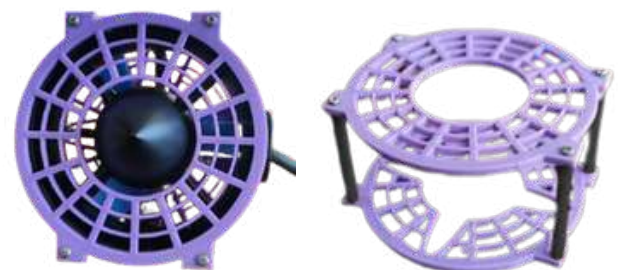
The system utilizes Six T200 Blue Robotics thrusters with two dedicated to vertical movement and the remaining four for horizontal movement. These pumps are positioned at a 45-degree angle from the neutral axis, optimizing torque generation for improved performance.



- FIGURE 8: T200 Thrusters

3- Shrouds

To enhance thrust efficiency and protect the thrusters custom shrouds were designed by the mechanical team using SolidWorks CAD software. These shrouds were then manufactured through 3D printing, allowing for precise geometry, lightweight construction, and rapid prototyping.



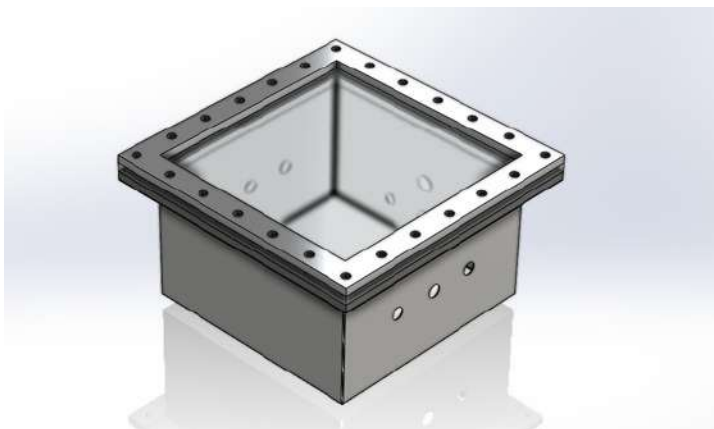
- FIGURE 9 : Thrusters Shrouds

4-Electronic Housing Design

The electronics housing is the brain of our ROV, where all the thinking and decision-making happens. Inside this sealed unit, the microcontroller, ESCs, and relays coordinate the thrusters, gripper, and camera—bringing the whole vehicle to life.

The electronic enclosure is made of **1.25 mm thick stainless steel 304 sheets**, shaped using metal forming technology and welded together via gas tungsten arc welding to create a housing with an internal volume of **330.5 × 330.5 × 150 mm³**. The enclosure is covered with an acrylic cover of 6mm, chosen for its light weight and for providing a clear view of the internal electrical components. A removable cover compresses double-layer O-rings to ensure a tight and reliable seal, providing maximum protection for the electronics.

This approach creates a robust waterproof chamber, keeping delicate electronics safe from the harsh underwater environment. Compared to simple PVC housings, the aluminum design offers superior durability, mechanical strength, and thermal stability, while the acrylic cover allows easy inspection and monitoring of the components without compromising protection.



• FIGURE 10 : Control Box

5- Camera Casing

To protect the onboard camera while ensuring clear visibility underwater, the team designed a custom camera casing in SolidWorks and manufactured it using 3D printing. The front face of the cover is fitted with an acrylic sheet, providing a clear view while keeping the camera safe from water pressure and external impacts. Sealing is achieved using an O-ring, ensuring the casing remains watertight during operation.



• FIGURE 11 : EVO Camera Casing

2.5 Bouyancy

One of the key challenges addressed by the mechanical team was configuring the ROV for optimal stability. This involved achieving smooth suspension in water to enhance navigation and ensure steady positioning. A major focus was attaining neutral buoyancy, where the buoyant force precisely balances the vehicle's weight. This careful balance minimizes the vertical workload on the thrusters, enabling efficient movement and greater control underwater, while also contributing to overall safety and energy conservation.

2.4 Propulsion

EVOs' propulsion system is designed to balance maneuverability, efficiency, and simplicity. The vehicle is powered by six T200 thrusters, arranged to provide precise control. **Four horizontally** mounted thrusters control forward and backward motion while also contributing to yaw rotation. Complementing these, **two vertically** mounted thrusters manage ascent, descent, and pitch control.

To achieve better maneuverability and enable lateral translation, four T200 thrusters are mounted at **45° angles** at the corners of the propulsion system plate, while the **two vertical thrusters are mounted on either side of the plate**. This configuration allows the vehicle to achieve **five degrees of freedom**: surge, sway, heave, yaw, and Pitch.



• FIGURE 12 : EVO Propulsion System

The net force acting on the ROV during motion is determined by the combined thrust of the motors minus the hydrodynamic drag. Drag is estimated using the standard equation:

$$F_{drag} = \frac{1}{2} \rho v^2 C_d A$$

- ρ — Water density
- v — ROV's velocity
- C_d — Drag coefficient
- A — Frontal area of the ROV

2.6 Sealing

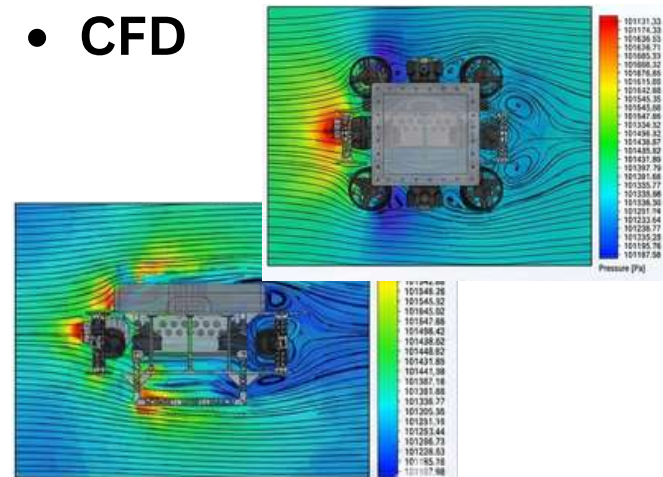
Sealing is a very important part of the ROV design because it protects the electronic components from water. In the EVO ROV, a rubber square band was used to seal the main electronics enclosure, which is the most critical part of the system. This type of seal provides strong and even pressure along the edges, helping to prevent any water leakage during operation. In addition, O-rings were used to seal the camera casing, as they are effective and suitable for circular parts.

2.5 Bouyancy Table

Component	Quantity	Weight in Air	Weight in Water	Max Force	Net Buoyancy
Thruster T2000	6	427 G	239 G	2.92 Kgf	188 G
Lower Plate	1	1.5KG	500 G	2000 Kgf	1 KG
Thruster Holder	6	60 G	32 G	2.92 Kgf	28 G
Camera Case	4	80 G	38 G	3.71 Kgf	42 G
Shroud	6	50 G	10 G	3000 Kgf	40 G
Gripper	2	277 G	152 G	1500 Kgf	125 G
Cameras	4	25 G	10 G	3000 Kgf	15 G
Control Box	1	3 KG	1 KG	3000 Kgf	1.5 KG

Net Force=Buoyancy-Weight =4.514-8.696= **-4.182 kg**
[Negative Buoyancy]

• CFD



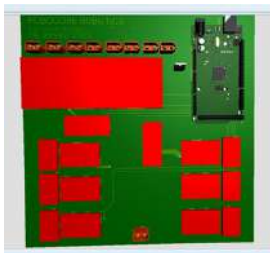
Computational Fluid Dynamics (CFD) was used to study how water flows around the ROV and to evaluate its overall hydrodynamic performance. The analysis is based on solving the fundamental fluid flow equations to understand velocity and pressure distribution around the structure. The results showed smooth water flow around the frame with limited turbulence, indicating an efficient design that helps reduce resistance. This analysis helps ensure that the ROV can move steadily underwater, achieve good diving performance, and operate efficiently during its tasks.

3-Electrical System

VEXEL's electrical system is designed to be modular, reliable, and easily maintainable, ensuring smooth operation of all mission-critical tasks. The system is organized into five main components:

3.1 Main Board

At the heart of Orca is a custom PCB board that organizes and integrates all electronic connections, with the Arduino Mega paired with an Ethernet Shield serving as the main control unit. It manages the thrusters, the pneumatic gripper, and the four cameras. The Arduino communicates with the external control station via Ethernet over the tether, allowing real-time commands from the pilot and ensuring smooth operation of all systems.



• FIGURE 13: EVO PCB



• FIGURE 14: Arduino Mega

3.2. Sensor Board

• Pressure & Temperature Measurement

The BMP180 sensor provides high-resolution barometric pressure readings that are translated into depth and altitude data for the ROV, allowing the pilot to continuously monitor the vehicle's vertical position in the water column. In addition to pressure, the sensor also measures ambient water temperature, which is important both for environmental research and for assessing the operational conditions of onboard electronics. The pressure and temperature data are transmitted to the Arduino Mega through UART communication ensuring

real-time feedback. These readings not only enable accurate depth estimation but also serve as an input for verifying the ROV's structural integrity under varying underwater conditions. By correlating pressure, depth, and temperature data, the system ensures reliable operation and provides valuable information for mission planning.

• IMU

The MPU6050 IMU combines a 3-axis accelerometer and gyroscope to measure motion and orientation (roll, pitch, yaw). Using its built-in processor with a Kalman filter, it provides accurate, low-noise data suitable for real-time control and navigation.



• FIGURE 15: IMU Sensor



• FIGURE 16: BMP 180 Sensor

3.3 Power Distribution

Power is supplied by a 48V, 30A (from 4 × 12V 30A power supply in series) and distributed through the Tether. A buck converter steps down to 5V to safely power the Arduino Mega. Thrusters, pneumatic valves, and the camera operate from 12V after using the buck to step down the 48 to 12. All high-current lines are properly fused, and Rozetta connectors ensure safe, modular, and easily maintainable wiring. Additionally, the system incorporates Escs to control the T200 Thrusters. These relays act as electronic switches, allowing safe and reliable activation of the pumps under pilot command while isolating the low-power control circuits from the high-current motor lines.



• FIGURE 17 : Buch Converter



• FIGURE 18: Dual Channel Relay



• FIGURE 19: EVO Thrusters

3.4- Topside control station

The control station serves as the interface between the operator and the ROV, integrating all necessary equipment into a compact and portable setup for quick deployment and organized operation. It consists of a pilot laptop, router, display screen, electrical socket, and power supply system, all arranged to ensure efficiency and ease of use. The laptop acts as the primary control unit, enabling the operator to send commands and receive real-time system feedback. Visual data, including live camera footage and system information, is presented on a dedicated monitor, connected via HDMI or VGA for clear and continuous observation.

3.5 Communication and Modularity

The ROV's two cameras transmit live video feeds via balun cables through the tether to the pilot screen, enabling precise navigation and better situational awareness. Modular wiring with WAGO connectors allows rapid troubleshooting and component replacement, ensuring minimal downtime and easy upgrades for future improvements.

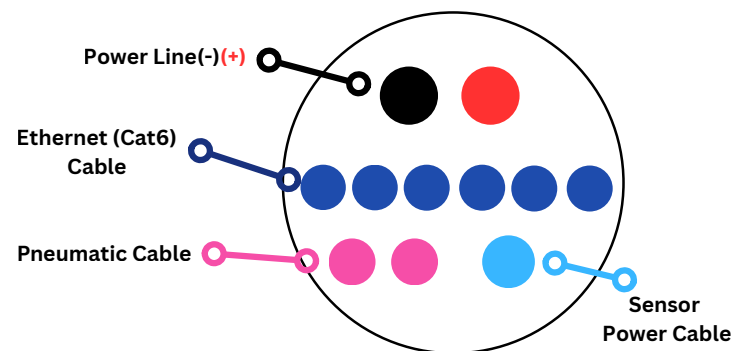


3.6 -Tether

The tether acts as the ROV's lifeline, carrying power, communication, and pneumatic lines in a single protective sheath. A 12V DC power cable delivers energy from the topside unit, which is stepped down to 5V inside the ROV to run the Arduino and electronics.

For data transfer, Six Ethernet (CAT6) cables ensure reliable communication between the pilot station and the ROV, handling control signals, telemetry, and video feeds. Alongside these, Two pneumatic hoses support mechanism control, seal testing, and air exhaust.

All cables are bundled in a durable, flexible jacket with strain reliefs at both ends to prevent tension damage. Foam floats are attached along the tether to maintain near-neutral buoyancy, making it easier to manage during dives and ensuring smooth, dependable operation.



Cable type	Quantity	Purpose	Purpose	Diameter
CAT6 Ethernet Cable	6	Used for cameras and communication between the ROV and the topside station	Copper twisted pair (CAT6)	~6 mm
USB Cable	1	Used for Arduino programming, reset, and uploading code	USB shielded cable	~4–5 mm
Main Power Cable	1	Supplies electrical power from the topside power supply to the ROV	Thermo cable (4 mm / phase)	8 mm
Pneumatic Tubes	2	Used for pneumatic systems (air supply / actuators)	Flexible pneumatic tubing	~6–8 mm

• Fuse Table

Component	Quantity	Voltage (V)	Current (A)	Power / Component (W)	Total Power (W)
T200 Thruster	6	12	12	144	864
ESC	6	5	0.1	0.5	3
Camera	4	5	0.2	1	4
Arduino Mega	1	5	0.07	0.35	0.35
Sensors (BMP180 + MPU6050)	1	5	0.004	0.02	0.02
4ch Relay Module	1	5	0.1	0.5	0.5
Gripper	1	12	2	24	24
Total Power Consumption					895.87

- Max Power Consumption = 895.87
- Current from 48V Supply (A) = $895.87/48 = 18.7A$
- Fuse = 18.7×1.25 (Factor of Safety) = $23.4 A \approx 25 A$

4-Software System

4.1 Control System

The control system of EVO is designed to provide precise and reliable maneuverability across multiple directions, including horizontal, vertical, rotational, and mechanism control. The system is powered by an Arduino Mega 2560, chosen for its strong performance, ease of programming, and ability to handle multiple operations simultaneously. Motor control is achieved through Escs for propulsion and two relays for the grippers, ensuring smooth and coordinated actuation. A PS4 controller, integrated through the Pygame library, enables intuitive user input, translating joystick movements and button commands into responsive motor actions. This setup allows for fast, accurate responses to multiple commands at once, enhancing operational efficiency and user experience.

4.2 Communication Protocols

The communication system ensures seamless bidirectional data exchange between the client interface (GUI) and the server (Arduino Mega 2560). EVO employs the TCP/IP protocol, which provides a stable, high-speed connection capable of handling multiple commands in real time. This protocol not only ensures low latency in transmitting control inputs from the GUI to the ROV but also enables continuous feedback from the ROV to the operator, allowing for adjustments during operation. By combining robust hardware with efficient communication protocols, the system guarantees smooth coordination between user commands and ROV actions, ensuring precise and dependable underwater performance.

• Stability

This year marked a significant shift in how the ROV's stability was managed, moving from purely mechanical solutions to an advanced software-based approach. With the integration of an IMU, the system gained real-time awareness of its orientation, opening the door to more precise and dynamic control. Stability is now achieved using a **PID controller**, where the parameters were manually tuned through a trial-and-error process. Although this method was time-consuming, it resulted in a highly robust and flexible control system.

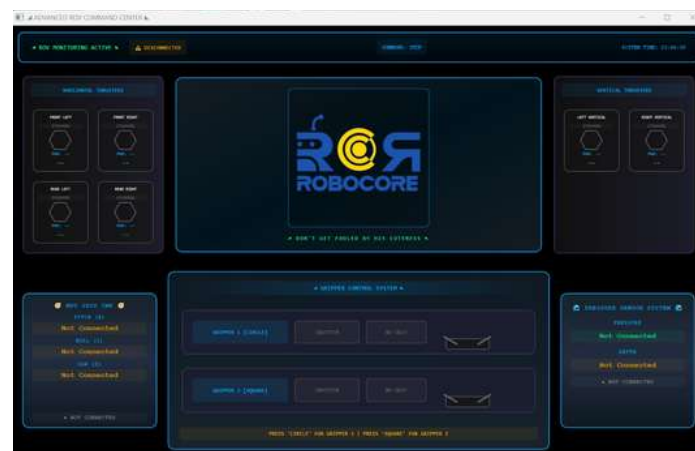
4.3 GUI

EVO ROV features a custom-designed GUI that enables real-time monitoring and control of all underwater operations. The interface displays four hexagonal thruster indicators—(left, right) horizontal thruster—(left, right) vertical thruster representing the T200 Blue Robotics Thrusters, with live power and temperature feedback.

Dual gripper controls are integrated, showing activation status (**active/inactive**) and grip state, triggered via the X and Z keys. The GUI supports 360° photosphere visualization and ruler-based measurement tools, allowing object analysis during missions.

A status bar displays: ROV connection state (**connected/disconnected**), active command (e.g., FORWARD, GRIP), and system time. The layout is organized into horizontal motors (right/left), vertical motors (right/left), and gripper panels for clear operational awareness.

Built with PyQt5, The design ensures low-latency control of the T200 motors, making the EVO ROV ideal for precision tasks in underwater environments.

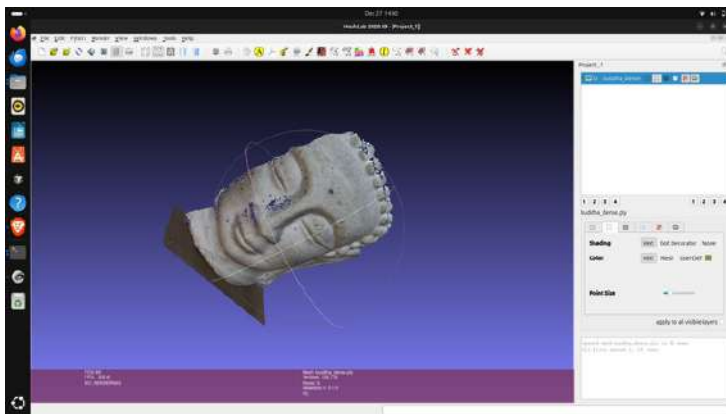


• FIGURE 20 : EVO GUI

4.4 Image Processing

1. Task 1.2 – Photogrammetric 3D Reconstruction (Coral Garden)

This task generates a 3D model of the underwater structure using a photogrammetry pipeline. First, the ROV captures multiple overlapping images (60–80% overlap) from different angles. These images are processed using COLMAP, which applies SIFT (Scale-Invariant Feature Transform) to detect and match keypoints between images, allowing reconstruction of a sparse 3D model using Structure from Motion (SfM). The model is then densified using Multi-View Stereo (MVS) to produce a detailed point cloud. Since the model has no real-world scale, colored reference squares (10×10 cm) are used as Ground Control Points to compute a scaling factor. Finally, Open3D is used to apply scaling and extract accurate measurements such as the structure height.



• FIGURE 21 : 3D photogrammetric test

2. Task 2.1 – Invasive Species Detection (Green Crab Detection)

This task detects and counts European Green Crabs using a robust three-stage computer vision pipeline. First, HSV color masking is applied to isolate green regions in the image, filtering out non-target species and background. Next, ORB/SIFT feature matching is used to verify the crab's shape and structure, ensuring detection is invariant to rotation and scale. Finally, template matching with a pre-rotated image library confirms the detection with high precision. Additional techniques like Watershed segmentation are used to separate overlapping crabs, and Non-Maximum Suppression (NMS) removes duplicate detections. This hybrid approach ensures high accuracy with least false positives.

3. Task 2.2 – Iceberg Number Recognition (OCR System)

This task identifies numbers placed around the iceberg using an image-based recognition system. The captured image is first preprocessed using adaptive thresholding to isolate the digit under varying lighting conditions. The region of interest is then resized and normalized before being passed to a Convolutional Neural Network (CNN) trained on the MNIST dataset. The CNN extracts features and classifies the digit with high accuracy (>95%), enabling reliable identification of all required numbers during the mission.

4. Task 2.2 – Keel Depth Measurement (Pixel-Based Scaling)

This task measures the iceberg keel depth using a pixel-ratio scaling method. A known reference—the diameter of the PVC pipe (2.13 cm)—is used to convert pixel measurements into real-world values. By measuring the pipe's width and the vertical depth in pixels, the system calculates depth using a ratio, making the method independent of camera distance or zoom. If the full keel is not visible, multiple frames are combined using image stitching, and overlapping regions are subtracted to avoid duplication. This provides an accurate and efficient non-contact depth measurement.

5. Task 2.2 – Risk Assessment (Geodetic Analysis)

This task evaluates the risk posed by the iceberg using geometric analysis based on image-derived measurements. After obtaining the keel depth and iceberg position, the system calculates the Closest Point of Approach (CPA) between the iceberg trajectory and offshore platforms using a point-to-line distance formula. A grounding rule is first applied to determine if the iceberg will stop before reaching the platform. Risk levels (Green, Yellow, Red) are then classified based on CPA distance and depth ratio analysis, which compares keel depth to ocean depth, enabling accurate and reliable decision-making.

5- Safety

5.1 Safety Philosophy

At Robocore, we view safety as the foundation of every successful mission. Protecting our teammates comes before all other priorities, and this principle guides every stage of our ROV's development. From the workshop to the test site, we follow MATE's safety regulations with precision, applying protective equipment, enforcing clear procedures, and conducting routine checks on tools and systems. We also conduct safety briefings before operations to ensure every member understands potential risks and knows how to respond effectively. By fostering a safe and mindful environment, we empower our members to innovate confidently while minimizing risk.

5.1 Safety Training

During our training sessions, we followed strict safety protocols under the guidance of our lab assistants. They provided us with detailed instructions on proper lab conduct and demonstrated the correct way to handle specific tools and equipment. With their supervision, we practiced safe usage techniques to ensure we could operate the tools confidently and responsibly. This hands-on guidance reinforced the importance of following safety measures at all times, creating a secure and supportive environment for learning.

5.1 Safety Features

Fuses

A suitable fuse is installed near the main power connection to provide overcurrent protection. This ensures that in case of abnormal current draw, both the ROV and operators remain protected.

Sheathed Tether

The tether is securely sheathed and strain-relieved at both ends to prevent damage to the connectors. This protective covering also increases durability and safety during handling.

Shrouded Thrusters

All thrusters are equipped with protective shrouds over the intake and exhaust. These covers prevent accidental contact with moving blades and reduce the risk of injury, while maintaining proper thrust flow for optimal performance.

Sealing System (O-Rings)

O-rings are incorporated into all enclosures to ensure reliable waterproofing of electronics and cameras. This prevents short circuits, protects sensitive components, and guarantees safe operation during underwater missions.

Warning Labels

Warning labels are placed on thrusters, electrical housings, and other critical areas to alert team members and operators to potential hazards. These visual cues serve as constant reminders of safe handling practices during both testing and operation.

6-Mission Tools

Float (Autonomous Vertical Profiler)

The float used in this mission is an autonomous vertical profiling system designed to achieve precise depth control through dynamic buoyancy adjustment. The system is built around a transparent PVC cylindrical body, which functions as both the structural frame and the buoyancy chamber. This design ensures uniform pressure distribution while allowing visual inspection of internal components during operation and testing.

Design and Dimensions

The float features a compact cylindrical geometry optimized for vertical stability and reduced hydrodynamic drag. The internal configuration is carefully arranged to maintain a centralized center of mass, improving balance and minimizing tilting during motion. The structure consists of three main sections:

Top housing: Contains the electronics and actuation system, sealed using O-rings and bolted interfaces to ensure full waterproofing

Main cylindrical body: Serves as the variable buoyancy chamber

Bottom end cap: Reinforced with a cross/star support structure to hold the lead screw and allow controlled water flow

Buoyancy Control Mechanism

The float utilizes a piston-driven buoyancy engine instead of conventional pump-based systems.

The mechanism includes:

- Lead screw
- Linear plunger (piston)
- Stepper motor (NEMA 17)

The operating principle is based on variable displacement:

The stepper motor rotates the lead screw, causing the plunger to move linearly inside the chamber. As the plunger moves, water is either drawn into or expelled from the chamber, enabling controlled adjustment of the float's buoyancy.

The system's density changes while the external volume remains constant



Electrical System

The float is powered by a **12V, 3Ah rechargeable battery**. The 12V supply drives the NEMA 17 stepper motor through a TB6600 motor driver, which controls the buoyancy mechanism. A 12V to 5V buck converter is used to power the ESP32 microcontroller and the pressure sensor.

The ESP32 acts as the main controller, handling motor control, sensor readings, and communication. It reads data from the pressure sensor to measure depth and uses a closed-loop control system to compare the actual depth with the desired value, adjusting the motor position to achieve the required buoyancy.

The ESP32's built-in Wi-Fi is used to transmit real-time data to the surface station. This allows continuous monitoring of depth versus time and enables the float to operate autonomously while executing multiple depth profiles.

5- Safety

5.1 Safety Philosophy

At Robocore ,we view safety as the foundation of every successful mission. Protecting our teammates comes before all other priorities, and this principle guides every stage of our ROV's development. From the workshop to the test site, we follow MATE's safety regulations with precision, applying protective equipment, enforcing clear procedures, and conducting routine checks on tools and systems. We also conduct safety briefings before operations to ensure every member understands potential risks and knows how to respond effectively. By fostering a safe and mindful environment, we empower our members to innovate confidently while minimizing risk.

5.1 Safety Training

During our training sessions, we followed strict safety protocols under the guidance of our lab assistants. They provided us with detailed instructions on proper lab conduct and demonstrated the correct way to handle specific tools and equipment. With their supervision, we practiced safe usage techniques to ensure we could operate the tools confidently and responsibly. This hands-on guidance reinforced the importance of following safety measures at all times, creating a secure and supportive environment for learning.

5.1 Safety Features

Fuses

A suitable fuse is installed near the main power connection to provide overcurrent protection. This ensures that in case of abnormal current draw, both the ROV and operators remain protected.

Sheathed Tether

The tether is securely sheathed and strain-relieved at both ends to prevent damage to the connectors. This protective covering also increases durability and safety during handling.

Shrouded Thrusters

All thrusters are equipped with protective shrouds over the intake and exhaust. These covers prevent accidental contact with moving blades and reduce the risk of injury, while maintaining proper thrust flow for optimal performance.

Sealing System (O-Rings)

O-rings are incorporated into all enclosures to ensure reliable waterproofing of electronics and cameras. This prevents short circuits, protects sensitive components, and guarantees safe operation during underwater missions.

Warning Labels

Warning labels are placed on thrusters, electrical housings, and other critical areas to alert team members and operators to potential hazards. These visual cues serve as constant reminders of safe handling practices during both testing and operation.

7- Logistics

7.1 Team Work

RoboCore Robotics, representing Benha National University's Faculty of Engineering, brings together students across electrical, mechanical, computer, and media disciplines to pioneer innovative robotic solutions through our flagship project EVO.

Our organizational structure features an Executive Board comprising a Team Leader, Technical Manager, Financial Officer, and Operations Coordinator, who collectively oversee strategic planning, resource allocation, team development, and project management.

Each technical division is led by dedicated Section Heads responsible for onboarding new members, decomposing complex projects into manageable tasks, and ensuring effective skills transfer.

In addition, a specialized Research and Development (R&D) Department drives innovation by scouting new technologies, testing novel concepts, and providing forward-looking solutions that enhance system performance and give the team a competitive edge.

Complementing our student leadership, our Faculty Advisory Board—consisting of professors and industry mentors—provides critical technical guidance, quality assurance, and real-world perspective to strengthen our engineering decisions and project execution.



• FIGURE 22 : Robocore Team Members

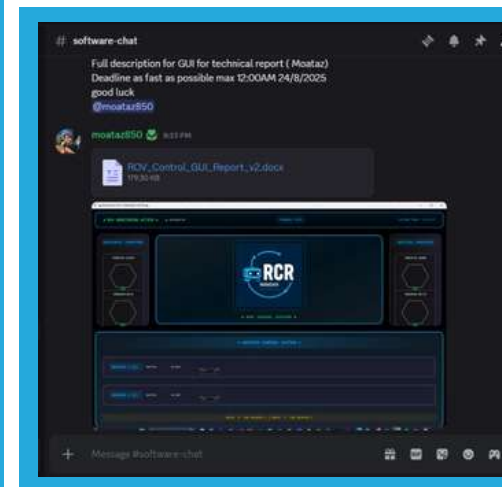
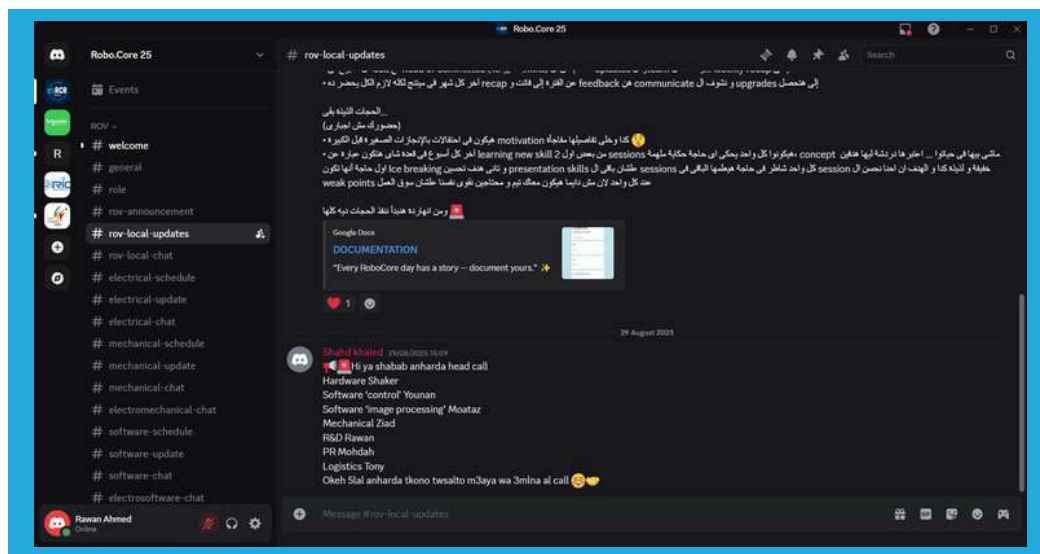
7.2 Project Managment

At RoboCore Robotics, project management is not treated as an administrative necessity, but as a strategic driver of success. We operate under a clear governance structure designed to ensure accountability, efficiency, and seamless collaboration. At the top level, the CEO and Vice CEO oversee vision and direction, while the CTO and Vice CTO ensure technical excellence. Below this leadership tier, four core divisions — Mechanical, Hardware, Software, and Non-Technical execute their mandates with precision. The non-technical division itself integrates specialized sub-teams in HR, R&D, PR, Logistics, and Documentation, ensuring that both engineering and operational functions are completely done with high efficiency and less time.

- Strategic Workflow & Planning

We follow a structured, stage-gated development process, beginning with an intensive Research & Development (R&D) phase to identify requirements, assess feasibility, and forecast risks. Cross-functional alignment is achieved through structured coordination meetings, after which the project advances through Design, Prototyping, Testing, and Final Integration. Each stage has defined deliverables, approval checkpoints, and embedded quality assurance standards.

Our planning relies on a blend of Agile adaptability and Waterfall discipline, supported by digital collaboration platforms such as Discord, GitHub and Zoom. This hybrid methodology allows us to adapt to unforeseen challenges while maintaining a disciplined progression towards milestones.

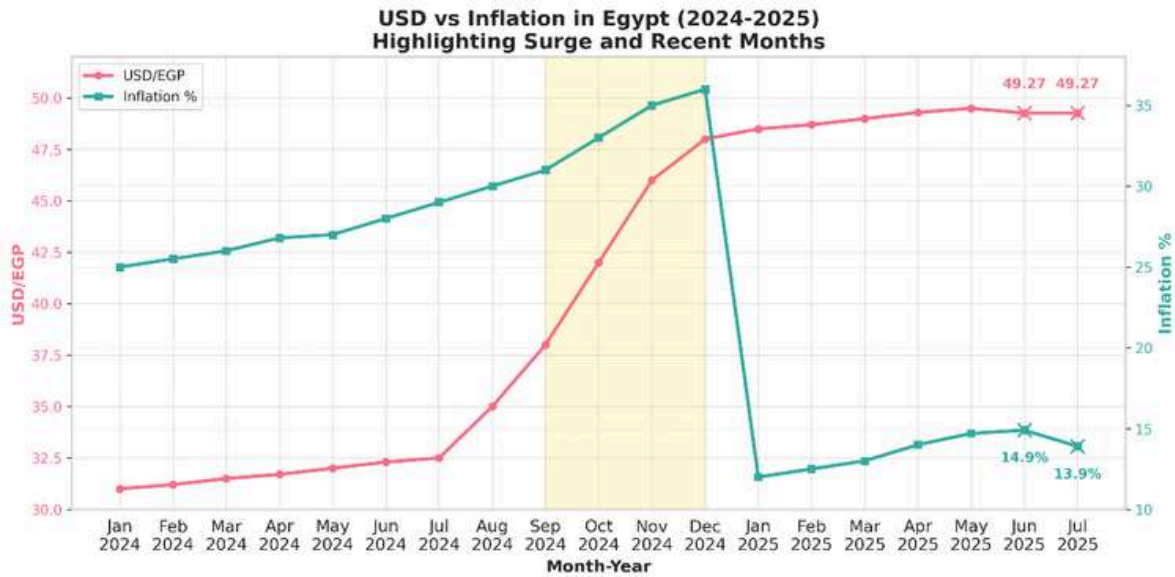


• FIGURE 23 : Robocore Team Discord Channel

7.3 Accounting

At the inception of our team, establishing a clear and realistic seasonal budget was a key priority. This plan was based on anticipated operational needs, competition requirements, and logistical expenses. Our funding structure combined partial financial support from the University Innovation Center with contributions from team members, ensuring a stable starting point for our activities.

However, as a new team in 2025, we quickly faced significant economic challenges. The Egyptian pound experienced a sharp depreciation of over 40% against the US dollar, driving inflation rates beyond 30% in certain months. This currency volatility had a direct impact on the cost of imported equipment, specialized components, and even some local services, pushing actual expenses far above our initial projections.



• FIGURE 24 : USD vs Inflation in egypt

In response, we implemented a proactive financial strategy:

- Resource Optimization – Reusing existing assets and materials wherever possible to reduce reliance on imports.
- Diversified Funding – Expanding beyond self-funding to include targeted fundraising campaigns and sponsorships to stabilize cash flow.
- Transparent Accounting – Tracking all transactions in a centralized digital ledger, ensuring real-time visibility and accountability.

These measures enabled us to adapt quickly, control costs effectively, and maintain operational continuity despite external economic pressures. The following figure illustrates the month-on-month increase in projected costs over the last two months, driven primarily by currency exchange rate fluctuations.

• Company TimeLine



• FIGURE 25 : Robocore 2025 - 2026 Time plan

8-Lessons Learned

Although RoboCore Robotics is a relatively young team, our journey builds on prior experience in ROV competitions, where we achieved a 4th place nationally. This foundation allowed us to approach this season with greater confidence and clearer goals. Over the course of the project, we enhanced our technical expertise across several domains: in mechanics, we deepened our skills in CAD design, 3D printing, and machining; in electronics, we progressed in PCB design, wiring, and troubleshooting; and in software, we grew in programming with Python and C++, version control using Git, and developing web-based control systems. Alongside the technical side, the team gained valuable soft skills such as time management, teamwork, and adaptability—skills that helped us stay aligned under pressure and overcome unexpected challenges. Together, these experiences have strengthened our capabilities and prepared us to compete at higher levels in the future.

10-Challenges

We faced several challenges that tested our determination. One of the main obstacles was finding the required hardware components, which were often difficult to source or unavailable when needed. This was further complicated by currency fluctuations between the US dollar and the Egyptian pound, which significantly increased costs. At times, the team relied on self-funding to keep the project moving forward, pushing us to actively and persistently seek sponsorships. Despite these challenges, along with software integration issues, tight schedules, and communication gaps, our resilience and problem-solving mindset enabled us to adapt and continue delivering innovative solutions under pressure.

9- Future Plans

- **Integrate a Depth Camera:**

Add a depth or stereo camera to enable 3D vision, improving underwater mapping, object detection, and navigation in low-visibility environments.

- **Manipulator Arm Addition:**

Design and integrate a robotic arm for performing tasks such as object retrieval, valve turning, or sample collection.

- **Adopt ROS (Robot Operating System):**

Implement ROS to manage communication between sensors, controllers, and actuators more efficiently. This will enable scalable development, easier debugging, and integration of advanced features like autonomy and computer vision.

11- Troubleshooting & Testing

1 Mechanical Testing

A PVC prototype was first built to test the basic design and identify early issues. Based on these results, a stronger rectangular frame was developed to improve stability.

Buoyancy and balance were adjusted to ensure stable underwater movement. The thrusters and structure were also tested to achieve smooth and controlled motion.

2 Electrical Testing

The electrical system of the EVO ROV was tested to ensure safe and reliable operation. Tests were carried out to check voltage levels, current distribution, and component performance.

Protection systems were verified to prevent damage from overcurrent or voltage changes. The communication between the ROV and the control station was tested, and the full system was checked to ensure proper integration and performance.

12- Appendix

12.1 Company Structure



• FIGURE 26 : Robocore Company Structure

12.2 Safety Checklist

• Pre-Launch

- ☐ Ensure tether is secured with strain relief on both ROV and control side.
- ☐ Inspect seals, cables, and connectors for damage or leaks.
- ☐ Verify thrusters and moving parts are free of obstructions.
- ☐ Confirm all team members are wearing PPE.

• Launching and In Water

- ☐ Test thrusters, cameras, and sensors before full operation.
- ☐ Monitor tether for knots, strain, or kinks.
- ☐ Watch for bubbles or water leaks —if detected, surface immediately.
- ☐ Pilot gives clear commands; communication must remain loud and clear.

• Post-Mission

- ☐ Power down system before lifting ROV from water.
- ☐ Retrieve ROV with at least two members and tether handler.
- ☐ Rinse thrusters and components with fresh water.
- ☐ Inspect for damage, leaks, or loose fittings.

		Expenses	Type	Description	quantity	unit price	total	Total per category (EG)		
Mechanical	Categories	1	Stainless steel plate	Purchased	Control Box Body	1	£1,300.00	£1,300.00	£35,690.00	
		2	artelon sheet 8mm	Purchased	ROV Chassis	1	£1,500.00	£1,500.00		
		3	acrylic sheet	Purchased	Control BOX	1	£500.00	£500.00		
		4	rubber	Purchased	Control Box Sealing	1	£500.00	£500.00		
				Machining						
			Machining provided free of charge by Qader Factory	non-Purchased						£0.00
				Pneumatic System components						
		1	Air Compressor	Re-Used		1	£8,000.00	£8,000.00		
		2	Pneumatic Regulators	Re-Used	Fluid Power Supply	-	£1,000.00	£1,000.00		
		3	Pneumatic Hoses	Re-Used		-	£2,200.00	£2,200.00		
		4	Pneumatic Fittings and Connections	Re-Used	Fluid Transportation Lines	-	£1,200.00	£1,200.00		
		5	5/2 Solenoid Actuated valve	Purchased		2	£890.00	£1,780.00		
		6	Pneumatic Cylinders	Re-Used	Actuators	-	£2,550.00	£2,550.00		
		7	Non-Return Valve	Re-Used	Safety Valve	1	£320.00	£320.00		
				Sealing Components						
		1	Epoxy A-B Glue 14g	Purchased	Wires sealing	18	£15.00	£270.00		
		2	Wire Glands	Purchased	thread sealing	-	£500.00	£500.00		
		3	Teflon	Re-Used	Chemical Seal	-	£240.00	£240.00		
				Miscellaneous						
		1	Fasteners	Purchased		-	£1,500.00	£1,500.00		
		2	Tie Wrap	Purchased		3	£200.00	£600.00		
		3	table collector	Re-Used		1	£900.00	£900.00		
				3d Printing						
		1	shrouds for t200 thrusters	Purchased		6	£91.67	£550.00		
		2	control box guides	Purchased		-	£300.00	£300.00		
		3	grippers	Purchased		2	£1,000.00	£2,000.00		
		4				-	£0.00	£0.00		
		5				-	£0.00	£0.00		
				Tools						
		1	BK203T Soldering Iron 60W With Variable Temperature Selector (200-4500C)	Purchased		2	£350.00	£700.00		
		2	WL901 Welding Soldering Iron Tip Cleaner	Purchased		1	£75.00	£75.00		
		3	Empty Tools Box 17" with Hang & Shelf - DWI 7C	Purchased		1	£550.00	£550.00		
		4	INGICO 30V Cordless Drill	Purchased		2	£900.00	£1,800.00		
				Accessories						
		1	Additional Accessories for ROV	Purchased	Mechanical Equipment	-	£3,250.00	£3,250.00		
		2	Additional Accessories for ROV	Purchased	Hardware Equipment	-	£2,505.00	£2,505.00		
		Electrical	categories			Vision System				
1	305m lan cable			Purchased		1	£1,175.00	£1,175.00		
2	2mp expif			Purchased		2	£355.00	£710.00		
3	12V 1 A A+			Purchased		2	£50.00	£100.00		
4	12v 2A halvision			Purchased		1	£100.00	£100.00		
5	balloon			Purchased		2	£65.00	£130.00		
6	Tapo C211 - 2K 3MP Pan.			Purchased		1	£1,250.00	£1,250.00		
7	Xur4108hs DVR 2016			Re-Used		1	£4,500.00	£4,500.00		
				Sensors						
1	bmp180 sensor			Purchased		1	£95.00	£95.00		
2	Ir sensor			Purchased		1	£35.00	£35.00		
3	Oled screen			Purchased		1	£160.00	£160.00		
4	Mpu6050 sensor			Purchased		1	£175.00	£175.00		
							£0.00	£0.00		
							£0.00	£0.00		
				Electrical components						
1	Liquid Pump - 2000GPH (12Vdc) Bilge Pump			Purchased	for ROV Movement	6	£1,750.00	£10,500.00		
2	MD20A Cytron 20Amp ov-30V DC Motor Driver (1 Channel)			Purchased		8	£1,300.00	£10,400.00		
3	Arduino Mega2560 Rev3 Original Chips - Clone			Purchased		1	£1,450.00	£1,450.00		
4	Arduino Shield - Ethernet Shield W5100 + SD Card			Purchased		1	£475.00	£475.00		
5	Kit Resistor 1/4W - 450 Carbon Resistors 5% Tolerance 1/4W			Purchased		1	£75.00	£75.00		
6	ESP-01S WiFi Serial TTL Module - Updated Version			Purchased		1	£145.00	£145.00		
7	DC-DC step Down Voltage Converter Adjustable 3A LM2596S			Purchased		5	£45.00	£225.00		
8										
9	Rel15-Relay 5V-10A spin			Purchased		6	£10.00	£60.00		
10	PCB17 = EL817C-F			Purchased		10	£2.00	£20.00		
11	LED 5mm Red Color			Purchased		20	£0.50	£10.00		
12	LED 5mm Green Color			Purchased		20	£0.50	£10.00		
13	LED 5mm Blue Color - super Bright W8			Purchased		20	£0.50	£10.00		
14	2 Pin PCB Screw Terminal Block Pitch 5mm (R.3)			Purchased		10	£4.00	£40.00		
15	3 Pin PCB Screw Terminal Block Pitch 5mm (R.4)			Purchased		20	£0.75	£15.00		
16	Transistor 2N2222			Purchased		20	£0.50	£10.00		
17	IN4007 General Purpose Silicon Diode 1A - 1000V			Purchased		10	£2.00	£20.00		
18	PHI - Pin Header Male 1x40 Straight 2.54mm			Purchased		1	£340.00	£340.00		
19	Brushless Motor EMAX 1400KV			Purchased		1	£75.00	£75.00		
20	Servo Tester			Purchased		-	£5,100.00	£5,100.00		
21	bilhelix 6s esc			Purchased		1	£19,000.00	£19,000.00		
	T 200 thrusters			Purchased				£19,000.00		
				PCB Fabrication						
1	Solder Wire RAM High Quality 250gm Sn70/Pb30			Purchased		1	£800.00	£800.00		
2	105 Rotary Tool Set - Work With Any Driller			Purchased		1	£150.00	£150.00		
3	Drill Bits (0.8 mm)			Purchased		20	£3.00	£60.00		
4	Drill Bits (1.0 mm)			Purchased		4	£100.00	£400.00		
5	Flux liquid solution bottle 75mL			Purchased		1	£100.00	£100.00		
6				Purchased		1	£45.00	£45.00		
7	Pcb						£0.00	£0.00		
8							£0.00	£0.00		
				Top Side Control Unit						
1	Station BOX			Purchased		-	£2,000.00	£2,000.00		
2	Screen Monitor			Re-Used		-	£1,500.00	£1,500.00		
3	DualShock Controller			Re-Used	Station Components	-	£1,000.00	£1,000.00		
4	Toplink router			Re-Used		-	£590.00	£590.00		
5	Power Supply			Re-Used		-	£1,500.00	£1,500.00		
6	Power Switch Connector			Purchased						
7	Fuse Holder			Purchased						
8	30A-fuses	Purchased	for Safety	-	£500.00	£500.00				
General	Categories			Safety				£38,450.00		
		1	Life jacket	Purchased		2	£450.00		£900.00	
		2	Water resisting Shoes	Purchased	For Terthermen Safety	2	£900.00		£1,800.00	
		3	Non-Slip gloves	Purchased		2	£100.00		£200.00	
		4	Ear Plugs	Purchased		4	£50.00		£200.00	
		5	glasses	Purchased		2	£150.00		£300.00	
		6	first aid kit	Purchased	For Workshop	2	£800.00		£1,600.00	
				Marketing Purposes						
		1	Banner	Purchased		3	£1,200.00		£3,600.00	
		2	Flyers	Purchased		300	£2.50		£750.00	
		3	T-shirts	Purchased		40	£350.00		£14,000.00	
		4	Neck brace	Purchased		40	£35.00		£1,400.00	
		5	caps	Purchased		40	£100.00		£4,000.00	
		6	gifts	Purchased		100	£15.00		£1,500.00	
		7	stickers	Purchased		200	£12.00		£2,400.00	
		8	flag	Purchased		1	£800.00		£800.00	
		1	Villa Rent			8	£500.00		£4,000.00	
		2	Transportation			10	£100.00		£1,000.00	
								Total		
								£138,885.00		

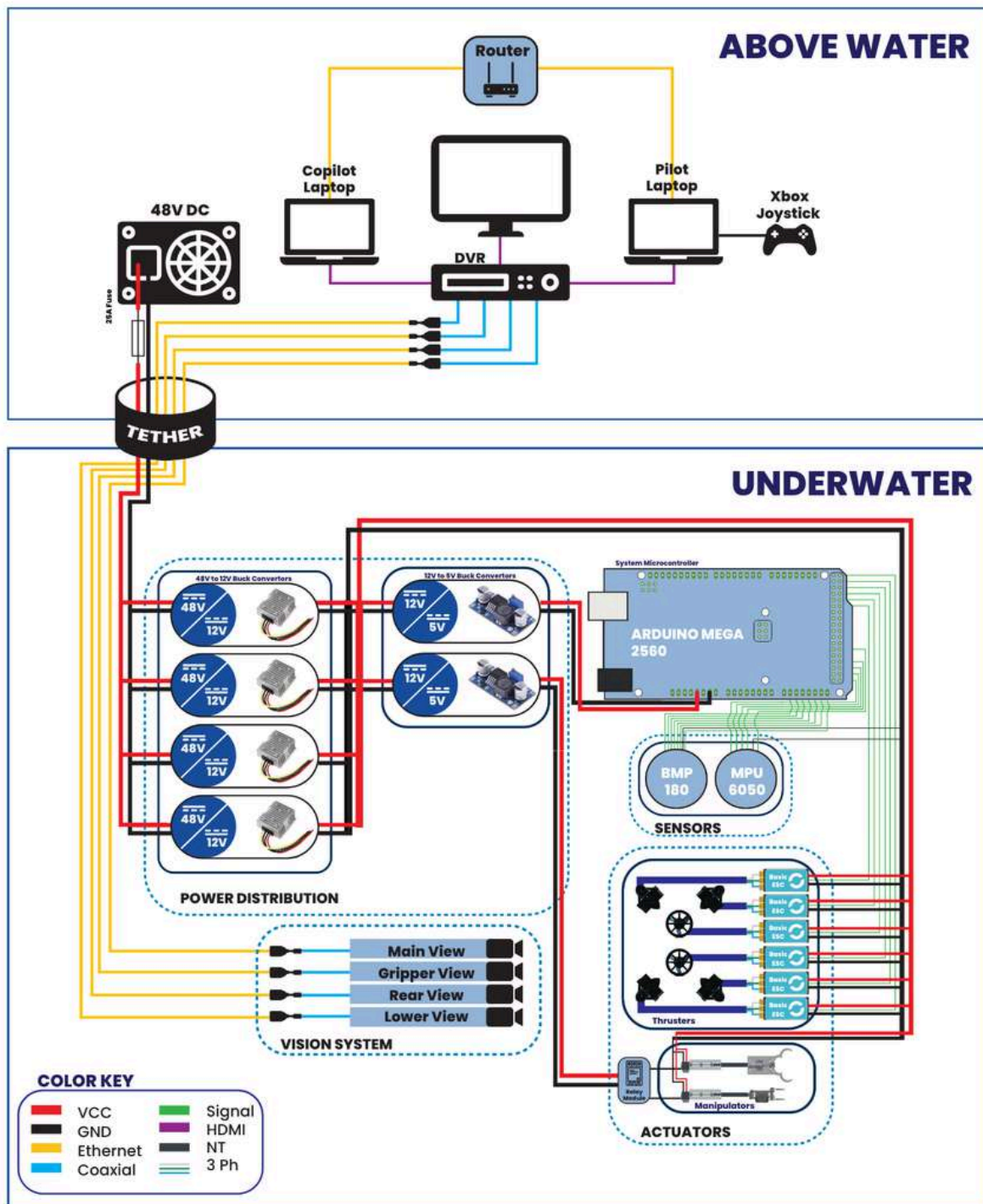
€35,690.00

€64,745.00

€38,450.00

12.3 SID

12.3.1 Hardware SID



12.3.3Pneumatic SID

