



MATE ROV 2026

TECHNICAL REPORT

ELMAHROSA

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1. INTRODUCTION

1.1 Mission Overview

The **ELMAHROSA** project, developed by **Atlantic Robotics**, represents a sophisticated engineering response to the challenges of underwater exploration and environmental stewardship. Designed for the **MATE ROV 2026** competition, the ROV is a testament to the team's philosophy: merging technical simplicity and cost-effectiveness with high-performance autonomous capabilities. Named "ELMAHROSA" to reflect its resilient and protective nature, the vehicle is engineered to perform complex retrieval and monitoring tasks in demanding underwater environments.

1.2 Design Philosophy: The "Atlantic" Approach

Our team recognized that effective underwater robotics requires more than just raw power; it requires a balanced integration of mechanical stability, electrical reliability, and intelligent software. The development of ELMAHROSA followed a rigorous iterative design process, emphasizing:

Modular Innovation: Utilizing a ¾-inch PVC cube-frame (30×35×30 cm) that serves as both a structural backbone and an internal ballast system.

Economic Engineering: Retrofitting industrial **1100 GPH bilge pumps** with custom 3D-printed couplers to provide powerful propulsion at a fraction of the cost of commercial thrusters.

Advanced Perception: Integrating a distributed control architecture where an **ESP32-S3** handles real-time sensor fusion, while a surface computer executes **YOLO Nano** for object detection and **PPO Reinforcement Learning** for autonomous navigation.

1.3 Objectives and Scope

This technical report details the comprehensive lifecycle of ELMAHROSA, from initial CAD modeling and CFD simulations to final field testing. It covers the mechanical waterproofing of our custom **HDPE canisters**, the strategic layout of our **67mm circular PCB**, and the robust **50m CAT5 communication link**. By adhering to strict **FMEA (Failure Mode and Effects Analysis)** safety standards, Atlantic Robotics ensures that ELMAHROSA is not only a competitive tool but a safe and reliable underwater platform.



2) Design Rationale

2.1 Innovations

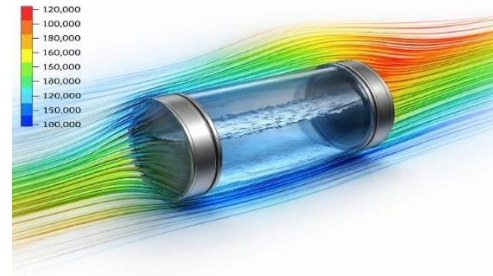
Overview

The innovations in **ELMAHROSA** reflect the team's philosophy of combining simplicity, affordability, and reliability with advanced functionality. Each subsystem was carefully designed to maximize efficiency while minimizing complexity, ensuring that the ROV remains easy to maintain and cost-effective without compromising performance. The innovations span the mechanical frame, propulsion system, vision units, and communication architecture, each contributing to a cohesive and distinctive design.

Frame

Innovation: The frame was constructed from $\frac{3}{4}$ -inch PVC pipes, chosen for their corrosion resistance, affordability, and natural buoyancy. Unlike traditional metallic frames, the hollow PVC pipes were cleverly used as ballast compartments, allowing weights to be inserted internally. **Result:** A compact cube structure with dimensions **30 × 35 × 30 cm**, providing strength and stability while reducing external drag.

Benefit: Lightweight, cost-effective, and easy to assemble; the frame integrates ballast, wiring channels, and mounting points for thrusters, cameras, and manipulators.



Computational Fluid Dynamics (CFD) simulation of the ROV's main canister, analyzing water flow and drag reduction for improved stability.

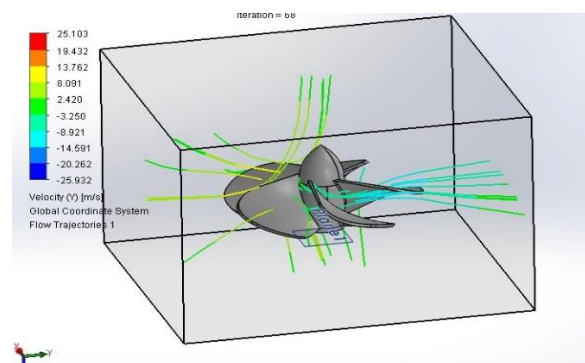
Thrusters

Innovation: Instead of expensive commercial thrusters, ELMAHROSA employs modified bilge pumps paired with bilge pump 1100 gph and nozzles.

Implementation: Custom 3D-printed couplers connect the pumps to the propellers, while HDPE nozzle holders ensure precise alignment and secure torque transfer.



Custom propulsion assembly showing bilge pump 1100 gph integrated with a modified bilge pump via a 3D-printed coupler & 3D-printed thruster holder and coupler assembly, designed for precise alignment and efficient torque transfer between the bilge pump and T100 propeller.



Computational Fluid Dynamics (CFD) simulation of the thruster nozzle design, validating efficient water flow and performance.



Result: A powerful yet low-cost propulsion system capable of controlling surge, sway, and yaw motions.

Benefit: Reliable maneuverability with reduced expenses, validated through CFD simulations and practical testing.

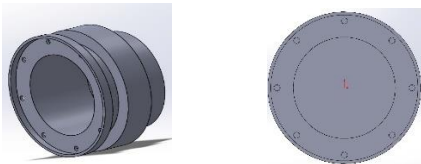
Cameras

Innovation: ELMAHROSA integrates USB cameras for high-definition, low-latency video, complemented by an ESP32-CAM for real-time streaming. This avoids the drawbacks of analog cameras (poor quality) and IP cameras (high latency).

Implementation: Cameras were enclosed in lathed HDPE housings, sealed with O-rings and acrylic plates to ensure waterproofing while maintaining visibility.

Result: Wide-angle mounting maximizes the field of view, aiding navigation and mission execution.

Benefit: Clear, responsive visual feedback for operators, with video feeds processed by YOLO Nano for real-time object detection.



Custom-lathed HDPE camera housing features an acrylic viewing port and double O-ring sealing for waterproof integrity at depth.

Communication

Innovation: A 50-meter CAT5 cable was selected for robust, low-latency communication, supported by USB/CAT5 converters.

Implementation: A lightweight bidirectional protocol was designed: sonar data (df, dl, dr) transmitted from the ESP32 to the PC, while motion commands (v, w) are sent back.

Result: Stable, reliable data transfer over long distances, with redundancy checks to prevent loss.

Benefit: Seamless integration between low-level hardware control and high-level AI/RL processing, forming a continuous perception-decision-action loop.

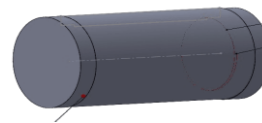
2.2 Design Process

The design process of **ELMAHROSA** was driven by the principle of combining simplicity with advanced functionality. From the earliest brainstorming sessions, the team focused on

creating a system that could be built, tested, and maintained with limited resources, while still

delivering high performance in underwater missions. Every stage of the design was iterative: concepts were modeled, simulated, tested in

controlled environments and refined until the final configuration was achieved.



3D CAD modeling of the main electronics enclosure, used to determine precise dimensions and Oring groove placements before the machining process.

Electrical and Control System

At the heart of the design lies the electrical and control system, centered around the **ESP32-S3 microcontroller**. This device was selected for its balance of computational power, low energy consumption, and compatibility with a wide range of sensors and drivers. The ESP32 was tasked with reading sonar data, applying filtering algorithms to reduce noise, and transmitting values to the onboard computer. The computer executed two high-level algorithms: the **YOLO Nano vision model** for real-time garbage detection, and the **PPO reinforcement learning controller** for autonomous navigation. This



distributed architecture separated real-time hardware control from computationally intensive AI tasks, ensuring reliability and scalability.

PCB Design

PCB design was a critical part of the process.

The **board diameter was reduced from 175 mm to 67 mm**, making the layout more compact and easier to fit inside the waterproof enclosure.

Sensors such as the **GT MS5837 pressure sensor** and **MPU6050 IMU** were deliberately placed away from high-power tracks and motor drivers to minimize electromagnetic interference.

Traditional XT60 connectors were replaced with **ESP32-based T-block connectors**, improving integration and reducing wiring complexity. An **LED indicator system** was added to represent

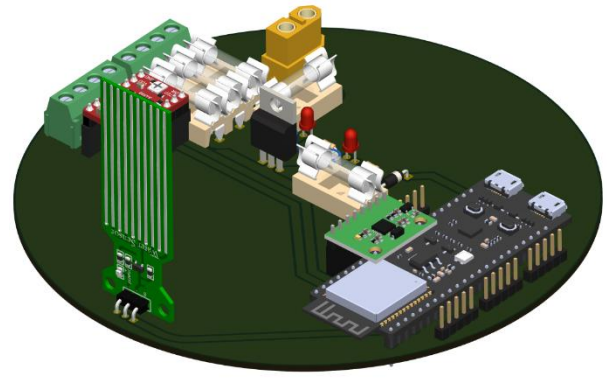
four operational stages, giving the team immediate feedback during testing.

Routing was carefully reviewed to minimize interference, and a **Design Rule Check (DRC)** was performed to verify compliance with spacing and manufacturability requirements.

Copper layers were used extensively for grounding and heat dissipation, while **heat sinks** were installed on the A4988 drivers to manage thermal loads.

Since the ROV operates in cold water, the surrounding environment naturally assisted in cooling, but current limits were also set below 2A to reduce stress on the drivers.

Track tinning was clarified as a **fabrication step**, not part of the design stage, ensuring proper solder quality during manufacturing.



3D render of the custom-designed circular PCB, showcasing the compact layout within a 67 mm diameter to fit the limited space of the HDPE enclosure, while integrating sensor placements to minimize interference.

Power System

The power system was designed to deliver stable voltages across all subsystems.

A **24V DC input** was supplied through an XT60 port.

12V was taken directly from the source (the LM7812 regulator was removed).

5V was generated via an LM7805 regulator, and the ESP32 itself regulated this input down to **3.3V** for sensors and reference signals.

Capacitors were paired with regulators to ensure voltage stability, while **Zener diodes** provided reverse current protection.

Two fuses were added: a **5A fuse** for the entire system and a **200mA fuse** dedicated to the ESP32, ensuring that any fault would be isolated before damaging critical components.

A **manual switch** was integrated, allowing operators to power the system on or off instantly.

Mechanical Design

Mechanical design was equally important.

The frame was constructed from **¾-inch PVC piping**, chosen for its corrosion resistance and affordability.



The hollow pipes doubled as **ballast compartments**, allowing weights to be inserted directly inside to achieve neutral buoyancy without external drag-inducing components.

Thrusters were mounted in a **differential configuration**, enabling steering by adjusting thrust between left and right units.

Bilge pumps were retrofitted with Bilge pump 1100 gph **and nozzles**, connected via custom 3D-printed couplers. This unconventional approach provided strong thrust at low cost, while **CFD simulations** confirmed efficiency in water flow.

Cameras were enclosed in **HDPE housings**, sealed with O-rings and acrylic plates, and mounted at wide angles to maximize field of view. Their feeds were transmitted to the PC via a USB hub, where YOLO Nano processed frames for object detection in real time.

Communication System

Finally, the communication system was designed for robustness and clarity.

A **50-meter CAT5 cable** was selected for data transmission, supported by USB/CAT5 converters.

The protocol was lightweight: sonar data was transmitted in the format `df, dl, dr`, while motion commands were sent as `v, w`.

Redundancy checks were included to prevent data loss, and all converters and hubs were securely mounted inside the ROV to withstand vibration.

Together, this communication link bridged the ESP32 low-level control with the PC for high-level AI/RL processing, forming a continuous **perception-decision-action loop**.

2.3 Manufacturing Process

2.3.1 Build vs Buy

The team adopted a hybrid approach, balancing in-house fabrication with commercially available components.

In-house fabrication: Critical structural parts such as the PVC frame, HDPE enclosures, manipulators, and custom PCB boards were manufactured internally. This reduced cost and allowed full control over design specifications, ensuring waterproofing, ballast integration, and enclosure dimensions tailored precisely to ELMAHROSA's requirements.

Purchased components: Certain parts were acquired to save time and guarantee quality, including buck converters, motor drivers (ZK-BM1 and A4988), and thruster accessories such as Bilge pump 1100 gph and nozzles.

Benefit: This build-versus-buy strategy optimized both performance and efficiency, keeping the ROV cost-effective while maintaining professional-grade reliability.

2.3.2 Mechanical

Mechanical manufacturing focuses on precision, durability, and ease of maintenance.

Enclosures: The main electronics enclosure, camera housing, and pneumatic valve box were machined from HDPE using a lathe, ensuring watertight sealing.



Custom-lathed HDPE electronics enclosure before final assembly and sealing.



Manipulators: CNC routers were employed to cut manipulator arms from HDPE sheets, producing strong and accurate components capable of withstanding underwater forces.

Couplers and mounts: 3D printing was used extensively for custom couplers and mounts, particularly to connect bilge pumps with Bilge pump 1100 gph. This ensures perfect fit and efficient torque transfer.

End plates: Laser cutting was applied to fabricate acrylic end plates for enclosures, providing transparent inspection windows while maintaining waterproof integrity.

Frame assembly: The PVC frame was assembled using adhesive bonding, creating a rigid cube-like structure (30 × 35 × 30 cm). Ballast weights were inserted directly into hollow PVC sections, achieving neutral buoyancy without external drag.



initial assembly of the PVC frame, showcasing the basic cube-like geometry and internal ballast compartments.

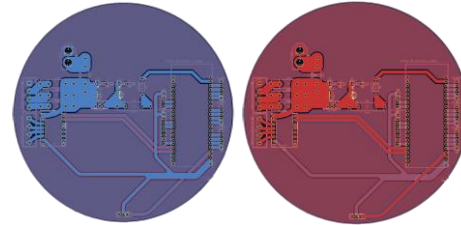
Outcome: This combination of lathe machining, CNC cutting, 3D printing, and laser fabrication ensured that each mechanical subsystem was optimized for strength, precision, and reliability.

2.3.3 Electrical

Electrical manufacturing was conducted entirely in-house to maintain quality control and integrate the design modifications.

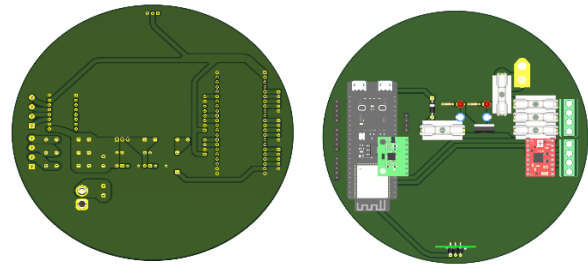


PCB redesign: The PCB layout was reduced to **67 mm diameter**, integrating ESP32-based T-block connectors and relocating sensors away from high-power tracks and drivers to minimize interference.



layer routing of the custom circular PCB, showing the primary signal traces and component pads & layer routing, optimized to minimize electromagnetic interference (EMI) and ensure stable power delivery.

Routing and checks: Routing was carefully reviewed to minimize noise, and a **Design Rule Check (DRC)** was performed to ensure compliance with spacing and manufacturability standards.



3D model of the custom circular PCB, highlighting the integrated safety fuses and water leak detection sensor for internal monitoring.

Grounding and cooling: Copper layers were used extensively for grounding and heat dissipation, while heat sinks were installed on the A4988 drivers to manage thermal loads.

Indicators: LED indicators were added to represent four operational stages, giving immediate feedback during testing.

Power system:

24V DC input supplied through XT60 port.

12V taken directly from the source (LM7812 removed).

5V generated via LM7805 regulator, then ESP32 regulates internally to 3.3V.

Capacitors paired with regulators ensure stability.

Zener diodes provide reverse current protection.

Two fuses installed: 5A for the entire system and 200mA dedicated to the ESP32.

A manual switch is integrated for operator control.

Fabrication notes: *Track tinning* clarified as a **fabrication step**, not part of the design, ensuring solder quality during production.

Outcome: This comprehensive electrical manufacturing process ensured that ELMAHROSA's control system was compact, efficient, and fully optimized for underwater operation.

2.4 Vehicle Structure

The structure of **ELMAHROSA** was designed to be simple, stable, and easy to maintain, while integrating all subsystems into a cohesive and compact layout. Each element of the structure was carefully chosen to balance affordability, durability, and performance in underwater missions.

Frame

Constructed from **¾-inch PVC pipes**, selected for their strength, corrosion resistance, and affordability.

The hollow pipes were used as **ballast compartments**, allowing weights to be inserted directly inside to achieve neutral buoyancy without external drag.

The frame dimensions are **30 × 35 × 30 cm**, forming a cube-like geometry that provides rigidity and stability.

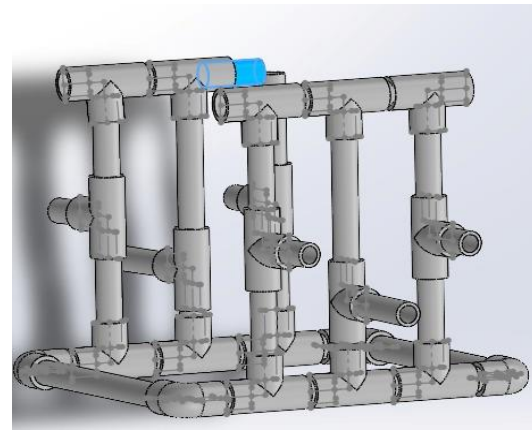
Serves as the backbone of the ROV, offering secure mounting points for thrusters, cameras, manipulators, and wiring channels.

Thrusters

Mounted symmetrically on the frame to ensure balanced maneuverability.

Based on **bilge pumps retrofitted with Bilge pump 1100 gph and nozzles**, connected via custom 3D-printed couplers and HDPE holders.

Their placement enables efficient control in **surge, sway, and yaw motions**, validated through CFD simulations and practical testing.



Final assembly of ELMAHROSA's structural framework.

Electronics and Enclosures

Electronics are housed in **HDPE canisters**, lathed for precision and sealed with O-rings and acrylic plates to guarantee waterproofing.

The **main canister** contains the redesigned PCB (67 mm diameter), ESP32 microcontroller, and power distribution circuits.

Camera housings protect USB cameras and ESP32-CAM modules, ensuring clear visibility while maintaining watertight integrity.

Sensors were deliberately positioned away from high-power tracks and drivers to minimize interference.



Mission Tools

Dual pneumatic manipulators (one horizontal and one vertical), CNC-machined from HDPE for strength and reliability.

Powered by compact air cylinders, capable of performing gripping and retrieval tasks.

A **static hook** was added for specific retrieval missions, positioned to avoid seabed contact.

Tether System

Integrates both **power and data transmission**.

Power: 24V DC supply, stepped down directly to 12V (LM7812 removed), 5V via LM7805, and 3.3V regulated internally by the ESP32.

Data: A **50-meter CAT5 cable** supported by USB/CAT5 converters ensures robust

communication between the ESP32 and the surface computer.

Secure routing and XT60 connectors ensure vibration resistance and reliable operation.

2.5 Core Systems

2.5.1 Mechanical

Frame

Constructed from **¾-inch PVC pipes**, forming a cube-like geometry with dimensions **30 × 35 × 30 cm**.

Hollow pipes act as **ballast compartments**, allowing weights to be inserted internally to achieve neutral buoyancy without external drag.

Provides secure mounting points for thrusters, cameras, manipulators, and wiring channels.

Propulsion

Based on **bilge pumps retrofitted with Bilge pump 1100 gph and nozzles**.



Mounted symmetrically to deliver control in **surge, sway, and yaw motions**.

Custom **3D-printed couplers** and **HDPE nozzle holders** ensure secure torque transfer and alignment.

Canisters

Electronics, solenoids, and cameras are housed in **HDPE canisters**, lathed for precision and sealed with O-rings and acrylic plates.

Transparent covers allow inspection while maintaining waterproof integrity.

Mission Tools

Dual pneumatic manipulators (horizontal and vertical), CNC-machined from HDPE and powered by compact air cylinders.

Designed for gripping, lifting, and retrieval tasks.



CNC-machined HDPE pneumatic gripper mechanism, designed for efficient underwater object manipulation and retrieval.

Static Hook Design

A fixed hook was added for specific retrieval missions.

Positioned carefully to avoid seabed contact and interference with thruster flow.

Buoyancy & Ballast

Ballast weights are distributed inside PVC sections to achieve neutral buoyancy.

Testing ensured even distribution, keeping the ROV level stable during operations.

Component	Material / Design	Function
Frame	PVC cube (30×35×30 cm)	Provides structure & ballast compartments
Propulsion	Bilge pump 1100 gph	Surge, sway, yaw control
Canisters	HDPE + acrylic + O-rings	Waterproof housing for electronics/cameras
Mission Tools	HDPE manipulators + static hook	Object interaction & retrieval
Buoyancy/Ballast	Internal PVC ballast distribution	Neutral buoyancy & stability

2.5.2 Electrical

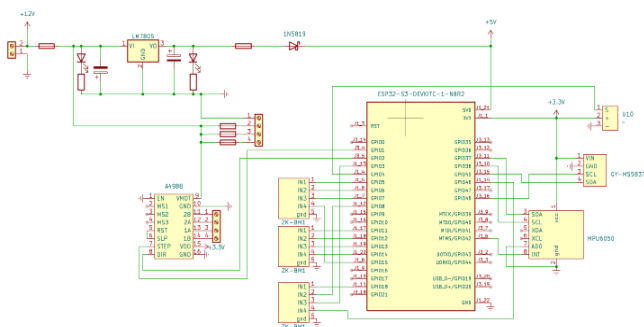
Control

Central unit: **ESP32-S3 microcontroller**, responsible for reading sonar data, filtering noise, and transmitting values to the PC.

Generates PWM signals for ESCs to control thrusters.

Integrates sensors (**GT MS5837 pressure sensor**, **MPU6050 IMU**) deliberately placed away from high-power tracks and drivers to minimize interference.

PCB was redesigned with **67 mm diameter** for compactness and better enclosure fit.



Detailed electrical schematic for ELMAHROSA's control system, illustrating the precise interconnections between the ESP32-S3 microcontroller, pressure and motion sensors, and the critical voltage regulation stages required for subsystem power



Power

Input: **24V DC** supplied through XT60 port.

12V taken directly from the source (LM7812 removed).

5V generated via LM7805 regulator, ESP32 regulates internally to **3.3V**.

Capacitors ensure voltage stability; Zener diodes provide reverse current protection.

Fuses: **5A fuse** for the system, **200mA fuse** dedicated to ESP32.

Copper layers and heat sinks manage thermal loads, assisted by natural water cooling.

Track tinning clarified as a **fabrication step**, not part of design.

Tether

50-meter CAT5 cable transmits data, supported by USB/CAT5 converters.

Parallel **50-meter power cable** connected via XT60 ports.

Secure route ensures vibration resistance and reliable communication.

Cameras

USB cameras + ESP32-CAM modules provide HD, low-latency video.

Enclosed in HDPE housings with O-rings and acrylic plates for waterproofing.

Mounted at wide angles to maximize field of view.

Video feeds are transmitted to PC via USB hub, processed by YOLO Nano for real-time detection.

Subsystem	Components / Design Changes	Function
Control	ESP32-S3, sonar, MS5837, MPU6050, ESCs, PCB 67 mm	Hardware control & sensor integration
Power	24V → 12V direct (LM7812 removed), LM7805 → 5V, fuses, Zener diodes	Stable voltage & overload protection
Tether	50m CAT5 + USB converters, XT60 ports	Data & power transmission
Cameras	USB + ESP32-CAM, HDPE housings	HD video, real-time detection

2.5.3 Software

Station

The surface computer executes high-level algorithms:

YOLO Nano for vision-based garbage detection.

PPO reinforcement learning for autonomous navigation.

Communication

Lightweight bidirectional protocol implemented:

Sonar data transmitted as df , dl , dr .

Motion commands sent as v , w .

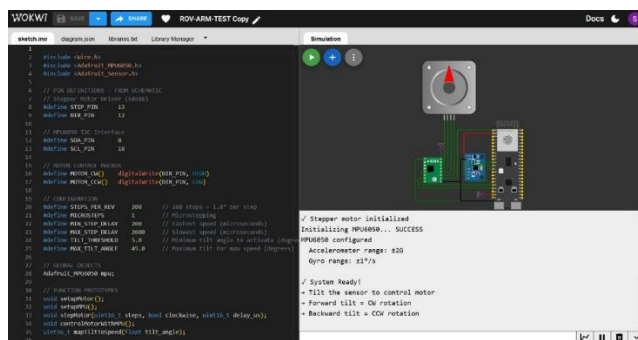
Redundancy checks ensure clarity and minimize parsing errors.

Motion

ESP32 runs a continuous control loop at ~ 10 Hz.

Reads sonar values, filters noise, checks commands, and updates thruster outputs.

Fail-safe conditions set thrusters to neutral if commands are not received within 500 ms.



Virtual simulation of the ROV's control logic using Wokwi, demonstrating the integration between the MPU6050 inertial measurement unit (IMU) and the motor driver for real-time response.

Thruster Model

Thruster outputs are modeled to translate velocity and steering commands into PWM signals.

Ensure precise control of surge, sway, and yaw motions.



Firmware

Embedded firmware on ESP32 integrates sensor readings, communication protocol, and thruster control.

Designed for reliability, with watchdog timers and fail-safe overrides.

Mission Algorithms

YOLO Nano detects underwater garbage in real time.

PPO RL generates velocity and steering commands based on sonar inputs.

A **safety layer** overrides RL actions if obstacles are detected within critical distance, ensuring collision avoidance.

Module	Function
Station	Runs YOLO Nano & PPO RL for detection and navigation
Communication	Bidirectional protocol (df , dl , dr / v , w)
Motion	ESP32 control loop, thruster updates, fail-safe timeout
Thruster Model	Converts velocity/steering commands into PWM signals
Firmware	Embedded ESP32 firmware, watchdog timers, fail-safe overrides
Mission Algorithm	Object detection + RL navigation with safety override

3) Safety

Mechanical Safety

The mechanical design of **ELMAHROSA** was developed with a strong focus on operational safety, structural reliability, and water isolation to ensure safe underwater operation up to a maximum depth of **15 meters**. All subsystems were designed to minimize risks to operators and ensure long-term durability in harsh marine environments.

Structural Safety

The frame is constructed from **¾-inch PVC pipes**, which provide a lightweight, corrosion-resistant, and electrically insulating structure.

PVC reduces the risk of electrical conduction in case of internal faults and ensures safe handling during deployment and maintenance.

The frame edges were designed with **smooth surfaces and rounded corners** to minimize the risk of injury to team members during transportation, assembly, and operation.

Internal ballast distribution ensures stability without external protrusions, reducing hazards during handling.

Pressure Housing Safety

The electronics enclosure is manufactured from **HDPE/Ertalyte**, high-strength engineering Plastics with excellent dimensional stability and resistance to water absorption.

These materials maintain structural integrity under hydrostatic pressure and protect sensitive internal components such as the **ESP32-S3 microcontroller** and the redesigned **67 mm PCB**.

All enclosure joints are sealed using **Nitrile (NBR) O-rings**, which provide reliable waterproof sealing and resistance to compression underwater pressure conditions.

Water Sealing Mechanisms

To prevent water ingress into the electronics housing, multiple sealing layers were implemented:

All threaded connections are sealed using **PTFE tape** to eliminate leakage paths.

Electrical cables enter the housing through **waterproof cable glands**, ensuring both strain relief and sealing against water intrusion.

The rotating shaft used to transmit motion to the gripper mechanism passes through a **mechanical seal**, allowing rotation while maintaining a watertight barrier between the internal electronics and the external environment.

These sealing methods create **redundant layers**

of protection against water leakage during operation.



Waterproof cable glands used to provide secure, watertight entry points for power and data tethers into the HDPE enclosures.

Moving Parts Safety

The gripper actuation system and other moving components are designed to operate smoothly without exposing hazardous mechanisms.

Mechanical parts are securely mounted to prevent loosening due to vibration during operation.

Shafts and moving elements are properly aligned to reduce mechanical stress and prevent premature wear of seals and bearings.

Thrusters (bilge pumps + Bilge pump 1100 gph) are mounted symmetrically with protective housing to avoid accidental contact during handling.

Pre-Deployment Inspection

Before each mission, the ROV undergoes a **mechanical safety inspection** that includes:

Checking the condition and lubrication of the **Nitrile O-rings**.

Verifying the tightness of all threaded connections.

Inspecting cable glands for proper sealing.

Ensuring the mechanical seal is functioning correctly.

Inspecting the PVC frame for cracks or structural damage.

Confirming sensor placement remains isolated from high-power tracks to avoid interference.

This inspection process ensures that the mechanical system maintains safe and reliable operation underwater.



Electrical Safety

To enhance system safety, several measures were implemented:

High-current tracks were widened, mirrored on both PCB sides, and reinforced with solder coating.

Sensitive components such as sensors and the ESP32-S3 microcontroller were positioned away from high-current paths and actuator drivers.

A general 25 A fuse was added for the system, with dedicated fuses for each ZK-BM1 (15 A) and for the ESP32 (200 mA).

A Zener diode was integrated to protect the ESP32 supply against reverse current.

Motors were configured to start sequentially, preventing simultaneous inrush currents.

A water leakage sensor was included to automatically shut down the system in case of leakage.

4) Testing & Troubleshooting

4.1 Testing Methodology

As the ATLANTIS team, we followed a structured and step-by-step testing process to make sure that our ROV *ELMAHROSA* is reliable, safe, and ready for operation.

We started with **component-level testing**, where we tested each electrical component individually, including sensors, motor drivers, power modules, and the ESP32 microcontroller. This helped us ensure that every part was working correctly before moving to the next stage.

After that, we moved to **PCB testing**. We checked for short circuits, verified all connections between tracks and components, and made sure power was distributed properly across the board.

We also designed high-current tracks to be wider and double-sided to improve conductivity and reduce losses. In addition, we performed a Design Rule Check (DRC) to confirm that the PCB met safety and manufacturing requirements.

Once we were confident in the individual parts, we carried out **system integration testing** by connecting all components together, including the control system, thrusters, sensors, and communication modules. At this stage, we focused on making sure everything worked smoothly together, especially signal flow and motor response.

We then tested the **power system** under real conditions using a 24V DC supply, which we regulated to 12V for the motors and 5V for the control system. We also checked protection components such as fuses and Zener diodes to make sure the system is safe during operation.

Before putting *ELMAHROSA* in the water, we performed **waterproofing tests**. We sealed the enclosures and applied compressed air inside them to check for leaks. If the pressure dropped, we knew there was a problem, so we fixed it by tightening cable glands or improving the seals. This allowed us to test safely without risking damage to our electronics.

We also tested the **water leakage sensor** to make sure it can detect any internal water entry and respond properly.

Finally, we conducted **underwater testing** to evaluate the real performance of the ROV. We tested its movement, stability, buoyancy, and overall behavior underwater. We also observed how heat from components like motor drivers was dissipated through heat sinks and the surrounding water.



We repeated testing after every modification, which helped us continuously improve the system and ensure that *ELMAHROSA* performs reliably during competition.

4.2 Troubleshooting Strategies

As the ATLANTIS team, we followed a systematic approach to troubleshoot and solve problems during testing and operation of *ELMAHROSA*.

Electrical Troubleshooting

When dealing with electrical issues, we followed these steps:

Visual Inspection:

We first checked for obvious problems such as burnt components, loose wires, or blown fuses.

Measurement and Diagnostics:

We used tools like multimeters to measure voltage, current, and resistance, and compared the readings with expected values.

Subsystem Isolation:

We divided the system into smaller sections (power, control, motor drivers, and sensors) to identify exactly where the problem was coming from.

Circuit Review:

We reviewed wiring connections and control logic to make sure everything was correct.

Protection Check:

We verified that safety components like fuses and Zener diodes were working properly. Once we identified the issue, we repaired or replaced the faulty component and tested the system again to confirm that the problem was solved.

Mechanical Troubleshooting

For mechanical issues, we used practical and straightforward methods:

Leak Detection:

We used air pressure testing to detect leaks. Most issues were due to loose cable glands or sealing problems, which we fixed and tested again.

Frame Inspection:

We checked the PVC frame for cracks or weak joints and made sure the internal weights were stable.

Thrusters:

We inspected the thrusters for debris or damage and ensured that the mounts were secure.

Manipulator System:

We tested the gripper to make sure it operates smoothly and checked for leaks using soapy water when needed.

Thermal Management:

We monitored components like motor drivers for overheating and used heat sinks while limiting current when necessary.

5) Logistics

5.1 Company

The ATLANTIS team was founded in 2026 at Capital University by a group of engineering students interested in robotics. This is our first year competing, and our focus is on building an organized, efficient, and collaborative team to develop our ROV, **ELMAHROSA**.

5.1.1 Structure

ATLANTIS is organized to ensure clear responsibilities, accountability, and smooth collaboration. The team is divided into several key departments:

Executive Leadership: Oversees the overall project vision, technical strategy, and resource allocation.

Mechanical Department: Responsible for the ROV frame, thrusters, buoyancy systems, and manipulator design.



Hardware Department: Handles electronics, PCB design, power distribution, and system integration.

Software & AI Department: Develops control software, AI models, and autonomy features for the ROV.

Media & Outreach Department: Manages documentation, media content, and communication with stakeholders. Each department is led by a **Head** and supported by an **Assistant Head**, ensuring clear supervision, task distribution, and communication

5.1.2 Management

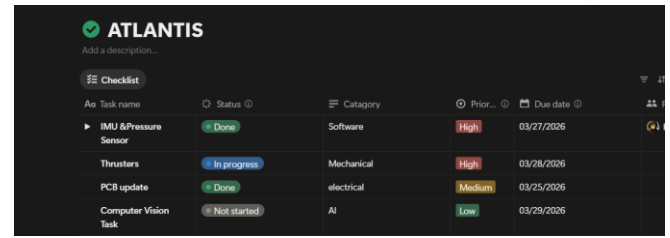
At ATLANTIS, we follow a structured project management approach to keep the team coordinated and on track.

Season Phases:

1. **Learning & Research Phase:** New members get familiar with tools, techniques, and past projects.
2. **Design & Prototyping Phase:** Mechanical, electronic, and software designs are developed and tested.
3. **Mission Planning Phase:** The ROV is adapted to meet specific competition challenges.
4. **Testing & Optimization Phase:** All subsystems are rigorously tested and improved based on performance results.

Task Management and Workflow Tools:

We use **Notion** to assign tasks, set priorities, track progress, and manage deadlines. **GitHub** is used for software version control and collaborative coding. This ensures transparency and allows the team to work efficiently together.



Task name	Status	Category	Prior...	Due date
IMU & Pressure Sensor	Done	Software	High	03/27/2026
Thrusters	In progress	Mechanical	High	03/28/2026
PCB update	Done	electrical	Medium	03/25/2026
Computer Vision Task	Not started	AI	Low	03/29/2026

Managing Resources & Workflow:

Checkpoints & Reviews: Weekly meetings review progress, solve issues, and adjust plans as needed.

Budget & Materials: The finance team works with department leads to ensure all materials are available on time.

Documentation: Design files, meeting notes, and technical specifications are stored on Notion and Google Drive for easy reference.

This structured yet flexible approach ensures the team works efficiently, collaborates effectively, and can handle any challenges while continuously improving ELMAHROSA.

5.2 Logistics

5.2.1 Budget

The project budget outlines the planned financial resources required for the development, testing, and preparation of ELMAHROSA. Each department—Mechanical, Hardware, Software, AI, and Media—was allocated a portion of the budget to ensure all tasks could be completed on schedule.:



Category	Weight (%)	Scope & Components
Mechanical System	30%	ROV frame, thrusters, manipulator, buoyancy systems
Electrical System	25%	Controllers, motor drivers, PCBs, power supply, sensors
Registration & Fees	15%	Competition entry and event registration fees
Workshop & Tools	10%	Hand tools, soldering stations, drills, consumables
R&D & Testing	10%	Prototypes, upgrades, material/pool testing, spare parts
Contingency Fund	5%	Unexpected expenses, emergency repairs, last-minute buys
Branding & Media	5%	Documentation, banners, stickers, media equipment

This budget plan allowed ATLANTIS to organize resources efficiently while preparing for all aspects of the competition.

5.2.2 Costing

This section reports the actual expenditures for ELMAHROSA during development and testing.

All purchases were tracked in real time using shared Google Sheets, with expenses categorized according to the planned budget. Receipts and invoices were uploaded to a structured Google Drive folder, ensuring full transparency.

This careful tracking helped the team manage resources efficiently, avoid overspending, and provide each department with the materials and tools necessary to complete their tasks on time.

All planned cost items and their estimated costs are documented for transparency and are available in Appendix 8.3.

6) Conclusion and Future Directions

6.1 Conclusion

The development of ELMAHROSA by the ATLANTIS team demonstrates a successful integration of mechanical design, electronics, and software into a fully functional ROV system. Despite being our first year, we were able to plan, build, test, and refine a complete engineering solution under real-world constraints.

Throughout the project, several key outcomes were achieved:

System Integration:

All subsystems—including the mechanical structure, electrical components, and control systems—were successfully combined to operate as one reliable unit.

Design Efficiency:

The ROV was designed to be simple, cost-effective, and easy to maintain while still meeting performance requirements.

Testing and Reliability:

A structured testing approach helped us identify issues early and improve system performance, resulting in a stable and dependable ROV.

Team Collaboration:

Clear task distribution and effective communication allowed all team members to contribute and meet deadlines efficiently.

Problem-Solving Approach:

Challenges such as limited resources, budget constraints, and system adjustments were handled through practical solutions and continuous improvement.



This project provided valuable hands-on experience in engineering design, system integration, and teamwork, and it forms a strong foundation for the future development of the ATLANTIS team.

6.2 Future Improvements

While ELMAHROSA achieved its main objectives, several improvements can be considered in future versions to enhance performance and reliability:

Enhanced Sealing:

Using higher-quality sealing materials and improved enclosure designs could further reduce the risk of leakage under higher pressure.

Cable Management:

Better organization of internal and external wiring would simplify maintenance and improve overall system reliability.

Power Optimization:

Improving power efficiency and reducing losses in motor drivers and components could minimize heat generation and enhance system stability.

Advanced Monitoring System:

Adding more sensors, such as temperature or current monitoring, would provide better real-time feedback and safer operation.

Mechanical Improvements:

Further refinement of the frame design and weight distribution could improve maneuverability and stability underwater.

Manipulator Enhancement:

Improving the gripper mechanism and potentially increasing its degrees of freedom would allow more precise and flexible object handling.

Camera System Improvement:

Mounting the camera on a servo mechanism would allow adjustable viewing angles, improving visibility and task accuracy during missions.

Control System Upgrade:

Using multiple microcontrollers instead of a single unit could improve system performance, reduce processing load, and increase reliability.

Extended Testing:

Performing tests under more varied underwater conditions would help identify hidden issues and improve overall system performance.

7) References

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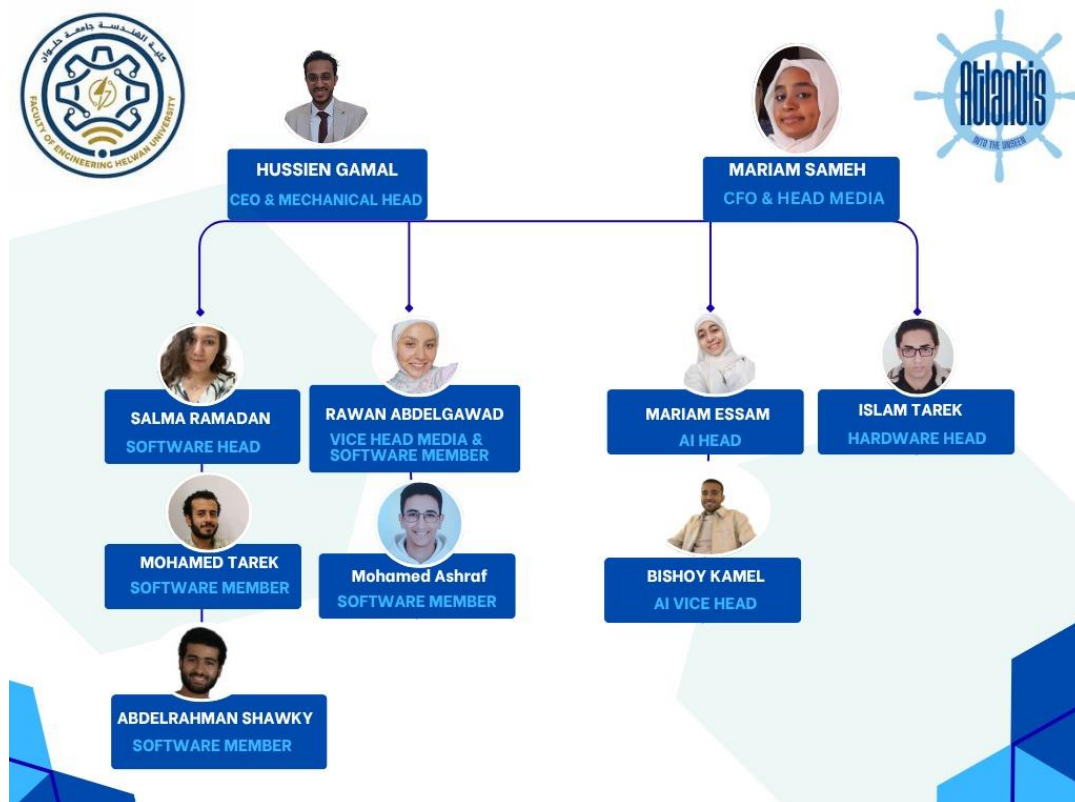


8) Appendices

8.1 Safety Checklist

Pre-Operation	Start-Up Checks	In-Water Ops	Post-Operation	Workshop Safety
Clear pool-side area	Check battery (14.8V)	Test before diving	Pilot surfaces ROV	Keep workspace clean
Secure tether line	Verify ESP32-S3 link	Maintain tether control	Power off thrusters	Trained members only
Wear proper PPE	Check ESP32-Cam feed	Monitor sensor data	Retrieve by frame	Handle tools safely
Inspect wiring & fuses	Test thruster response	Team communication	Visual leak check	Power off before work
Ensure system ready	Confirm GUI response	Visual bubbles watch	Fresh water rinse	Store tools after use
Check propeller guards	Verify sensor offsets	Stay in mission zone	Coil tether properly	Remove sharp hazards

8.2 Company Structure & Job Description



8.3 Project Costing

Category	Item Description	Status	Total Cost (USD)
Mechanical	1x 3m PVC Pipes & Connectors (3/4")	Purchased	\$16.20
	Artillon turning	Purchased	\$28.41
	ESP32-CAM Mount	Purchased	\$3.50
	1x 22kg Artillon Frame Material	Purchased	\$62.50
	6x Swimming Pool Noodles (Floats)	Purchased	\$11.36
	1x Acrylic Sheet (6mm x 144mm)	Purchased	\$8.52
	1x Custom 3D Printed Gripper	Purchased	\$71.97
	1x 3D Printed Thruster Holders	Purchased	\$90.91
	6x Bilge Pump 1100 GPH 12V (Thrusters)	Purchased	\$102.30
	1x Nema 16 Stepper Motor	Purchased	\$12.31
	1x Aluminum Rod & 2x Couplers	Purchased	\$11.93
	6x Cooling Fans (Internal)	Purchased	\$5.70
	8x Waterproof Wire Glands	Purchased	\$4.55
Electrical	1x GY-MS5837 Pressure Sensor	Purchased	\$26.52
	1x MPU6050 Gyro/Accel Sensor	Purchased	\$2.27
	1x ESP32-S3 DevKit	Purchased	\$8.52
	1x ESP32-Cam Module	Purchased	\$7.20
	3x ZK-BM1 Motor Drivers	Purchased	\$22.74
	1x A4988 Stepper Driver	Purchased	\$2.84
	1x LiPo Battery (14.8V 5000mAh)	Purchased	\$53.03
	1x 50m Power Wire Reel	Purchased	\$75.76
	1x 50m CAT5 Ethernet Cable	Purchased	\$17.05
	1x USB Hub + RJ45 Adapter Combo	Purchased	\$8.52
	2x Voltage Regulators (7805/7812)	Purchased	\$1.90
	3x Aluminum Heat Sinks & Thermal Pads	Purchased	\$1.98
	2x Fuses (3A & 200mA) & Holders	Purchased	\$0.94
	5x 1N5819 Diodes & Capacitors	Purchased	\$0.95
	1x Set of Pin Headers & XT60 Connectors	Purchased	\$6.65
Workshop	1x Copper Board & Solder Wire	Purchased	\$11.36
	1x Flash Lights (Underwater)	Purchased	\$16.10
	2x USB Data Cables	Purchased	\$3.78
	1x Workshop Space Access	Donated	\$0.00
	1x Tools Usage (Soldering/Multimeter)	Donated	\$0.00
R&D Cost	1x Epoxy, Sealants & Consumables	Purchased	\$15.15
	1x Prototyping & Spare Components	Purchased	\$66.29
General	1x Local Registration Fee	Purchased	\$208.33
	1x International Registration Fee	Purchased	\$329.55
	10x Transport (Cairo-Alex RT)	Purchased	\$132.58
	10x Team T-Shirts	Purchased	\$28.40
	1x Marketing Banner & Materials	Purchased	\$23.67
TOTAL			\$1,483.60



