

# GENSYS

Under The Supervision of

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**MIRA**  
robotics

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## Abstract

Established in 2011, M.I.A. Robotics is an interdisciplinary student company from Alexandria University. Celebrating our 13<sup>th</sup> year participating in the MATE ROV Competition, the company has cultivated extensive expertise in the realm of underwater robotics. With a steady pace towards improving the efficiency and environmental impact of our ROVs and in response to the 2026 MATE ROV request for proposal, we have engineered **GENSYS**. Engineered to dive through the toughest underwater currents with **active stability** for stable imaging over **Coral Gardens** combined with high-definition camera systems and advanced **photogrammetry software** for accurate **3D modeling**. By implementing modern Machine learning algorithms, **GENSYS** is capable of autonomously and accurately **identifying invasive crab species**. It is also equipped with specialized manipulator mechanisms to handle fragile **eDNA sensors** and underwater **power connectors** or sensitive **basket stars** and **corals**.

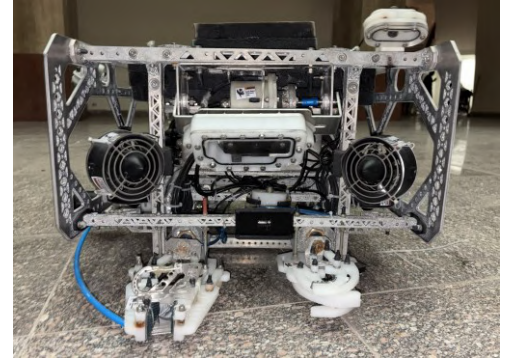


*Figure 1: Gensys ROV*

This technical document describes the design process and manufacturing of **GENSYS**, prioritizing **efficiency** and balancing trade-offs between different aspects of the ROV for optimal solutions while placing the highest priority on the **safety** and wellbeing of its team members. The team's **safety policy** follows a clear hierarchy: it begins with ensuring personal safety, extends to the safe construction of the ROV, and culminates in maintaining operational safety during deployment and testing. This structured and consistent focus on safety has empowered us to innovate with confidence, knowing that every step of our development process is grounded in **careful planning**, **situational awareness**, and **mutual respect**.



*Figure 2: M.I.A. ROV Team Members 2026*

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# Acknowledgments

We're very grateful to all these organizations and individuals for their help and support that enabled us to overcome all the challenges that we have faced:

**MATE Center** - for sponsoring this year's competition and for their generous awards.

**Arab Academy for Science and Technology (AAST)** - for hosting and organizing the regional competition.

**Alexandria University** - for supporting us with tensile tests for our materials.

**Synthesis 3D** - for providing discounts on 3D Printing.

**SolidWorks, Altium, Ansys, MATLAB** - for providing the team members with access to their products.

**Egypt Makes Electronics (EME)** - for providing us access to their workshop at a discounted rate.

**Makers Electronics** - for providing us with discounts and payment facilities on electric components.

**Team supervisor: Prof. Dr. Hassan Warda** - for his constant efforts in supporting the team.

**Our Families and Friends** - for their ongoing support and encouragement.



Figure 3: M.I.A. Sponsors and Partners

## 1. Design Rationale

### 1.1. Design Evolution

#### Making More With Less

This year marks the third consecutive year we have successfully reduced the electrical enclosure's volume. This reduction has significantly increased power density, and volumetric efficiency while fully preserving the ROV's core maneuvering and surveillance functionalities and lowering production costs.

The former internal dimensions were  $308 \times 162 \times 130$  mm, whereas the updated design measures  $260 \times 174 \times 110$  mm. This represents a **17% reduction in volume compared to the previous version**, and a **30% reduction relative to the 2024 season**.

This commitment is driven by our goal to continually challenge ourselves in developing our ROVs and minimizing the environmental impact of **GENSYS**.

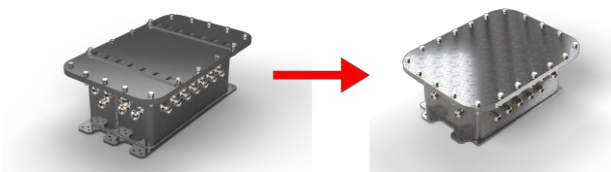


Figure 4: Evolution from 25' to 26'

#### Backward and Forward Compatibility

To ensure a smooth transition from ROS 1 to ROS 2 Humble, we implemented dual-stack architecture on our SBC that allows unit testing on the proven ROS 1 framework while enabling a seamless switch to ROS 2. This strategy extended to our embedded systems, where we migrated from the STM32 Blue Pill to the more robust Black Pill (**STM32F4xx**) to leverage its superior processing power and expanded memory (up to 256 KB Flash/64 KB SRAM). This hardware upgrade was essential to support the resource-intensive micro-ROS client libraries required for ROS 2 futureproofing, while maintaining full backward compatibility with our existing ROS 1 -which reached its end of life- codebase and Rosserial implementation. By keeping both firmware versions fully

operational, we have established a redundant system that allows for an instantaneous rollback if needed, mitigating the risks associated with the original ROS framework reaching its end of life.

#### Maneuverability

**GENSYS's** cuboidal design allows for the optimization of motion against a strong one-dimensional current, such as in flume tanks. Furthermore, this design provides improvements in maneuverability, **6 Degrees of freedom and 8 T200 Thruster configuration**.

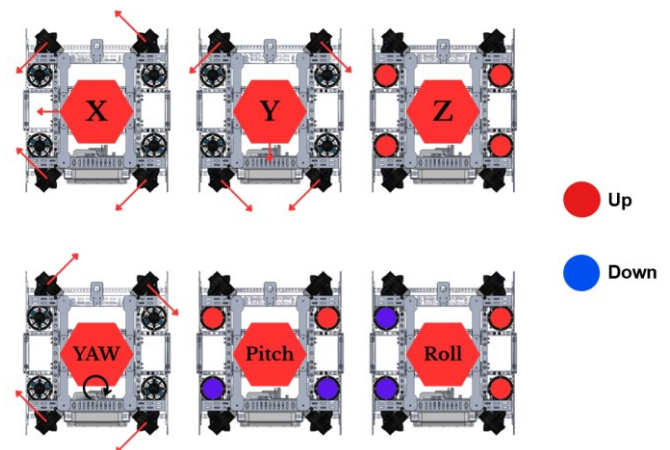


Figure 5: Gensys DoFs

#### Dynamic Power Management System

To ensure safe and reliable operation under constrained electrical budgets, the **Dynamic Power Management System (DPMS)** was developed to manage the significant current draw of operating eight thrusters simultaneously. By utilizing a polynomial curve fit derived from public T200 thruster performance data, the system calculates real-time current consumption and dynamically scales thruster commands to prevent overcurrent conditions, power supply overload, and DC-DC converter saturation. This approach allows the ROV to achieve higher speeds than static limits would permit while strictly maintaining the intended direction of motion and staying within safe **Full Load Amps (FLA)**. Additionally, the DPMS is highly configurable for various electrical architectures; for example, when recovering heavy objects like the **lobster pot (Task 2.3)**, it can prioritize the power for vertical thrusters to maximize lift without exceeding safety thresholds.

## Multi-Camera Streaming

A modular web interface was developed to enhance pilot situational awareness. Pilots can drag, resize, and save camera layouts for instant mid-mission switching without interrupting operations. Critical information – **such as vehicle state, depth and orientation**– is displayed in a header, keeping video feeds clear. Integrated camera controls, including dynamic auto-exposure, adjust in real time to subsea lighting.

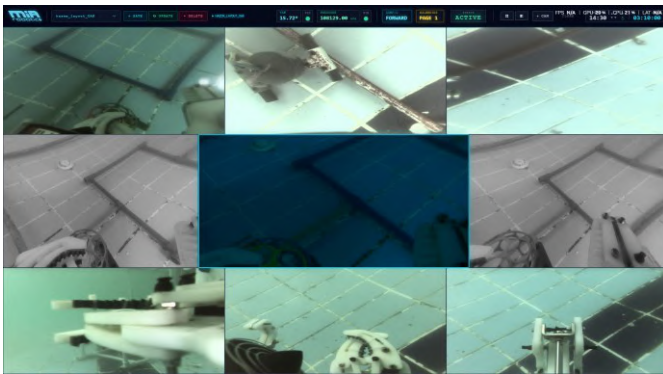


Figure 6: Cameras' GUI

## Sensor Fusion

Sensor fusion is widely regarded as a crucial technological advancement for enhancing control systems and addressing drifting problems that frequently occur in the data obtained from the IMU sensors. Since we are configuring multiple sensors, we used **Kalman Filter** to fuse the IMU sensor embedded within our OAK-D W stereo camera and the BN0055 9-DOF IMU sensor.

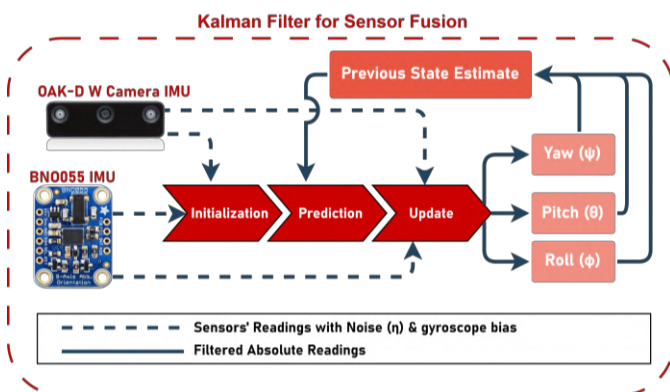


Figure 7: Sensors pipeline

## Automation Scripts

To ensure our system is **up and running** quickly with minimal manual input, we automated the launch of all critical systems on the **Jetson Nano**. **Camera streaming, thruster control, the**

**GUI**, and other essential scripts start automatically at system boot, eliminating the need for manual setup and improving system reliability.

## 1.2. Mechanical System

### Design Approach

The design process was the cornerstone of **GENSYS**. By adopting a structured methodology, the team ensured that errors were caught early, preventing "butterfly effect" failures in manufacturing or assembly.

- **Problem Identification:** Defining objectives based on regulations, previous design flaws, and safety requirements.
- **Brainstorming:** Generating diverse solutions through cross-disciplinary sessions (mechanical, electrical, and electromechanical).
- **Documentation:** Systematically recording and evaluating concepts based on feasibility, cost and reliability.
- **Simulation:** Using **CAD models** for stress analysis and scenario testing to validate performance before physical builds.
- **Integration:** Merging mechanical and electrical subsystems into a cohesive electromechanical unit.
- **Manufacturing:** Translating digital CAD designs into tangible physical components.
- **Testing and Debugging:** Rigorous verification of all subsystems to ensure the final product met all operational standards.

### Material Selection

Material selection was based on interdepartmental decisions between the mechanical, electrical, and software teams.

With emphasis on optimizing the legacy design features and rigorously testing new proposals for the ROV's structure, a decision matrix was implemented to inform design choices.

In turn, key factors such as strength, weight, material availability, cost decisions and long-term suitability were utilized in an intensive analysis.

Consequently, the mechanical team selected the 4mm Aluminum 7075 sheets as the

fundamental frame material due to its high strength-to-weight ratio, corrosion resistance and ease of fabrication.

A wide range of material classes were considered, including **ceramics, metals, plastics, and composites**. In addition, materials are available in different structural forms such as **tubes, cylinders, sheets, and rods**, as well as numerous alloy variations.

Among the candidate materials, **three aluminum alloys** were selected for use in the ROV structure. These alloys and their properties are presented in the material selection matrix.

*Table 1: Material selection Criteria*

| Criteria                 | Aluminum 5083 6mm | Aluminum 7075 4mm | Aluminum 5754 3mm | Ar-telon | Polyamide | PETG  |
|--------------------------|-------------------|-------------------|-------------------|----------|-----------|-------|
| Strength                 | 5                 | 4                 | 2                 | 3        | 3         | 2     |
| Weight                   | 3                 | 5                 | 4                 | 5        | 5         | 5     |
| Corrosion Resistance     | 3                 | 4                 | 3                 | 5        | 5         | 5     |
| Manufacturing Complexity | 4                 | 3                 | 4                 | 5        | 5         | 3     |
| Cost                     | 3                 | 3                 | 5                 | 4        | 2         | 3     |
| Flexibility              | 3                 | 4                 | 3                 | 4        | 3         | 5     |
| Thermal Conductivity     | 5                 | 5                 | 5                 | 1        | 1         | 2     |
| Overall Score            | 3.714             | 4.143             | 3.714             | 3.571    | 3.286     | 3.143 |

## Frame Design

**GENSYS** frame was designed to support all major components while ensuring structural integrity, modularity, ease of maintenance, and safe handling, with minimal interdependencies between subsystems.

During the early stage of design, several existing ROV designs were studied to gain insight into different structural configurations. Based on this research, multiple conceptual sketches were developed to explore frame layouts and component placement. The most promising concept was then modeled in **SolidWorks**, enabling improved system visualization and early identification of potential design issues.

After evaluating multiple configurations, the final design adopted a hybrid structure

consisting of 7075-T6 aluminum side sheets and 6063-T6 aluminum square hollow tubes. This configuration was selected to meet the key objectives and achieve a high strength-to-weight ratio.

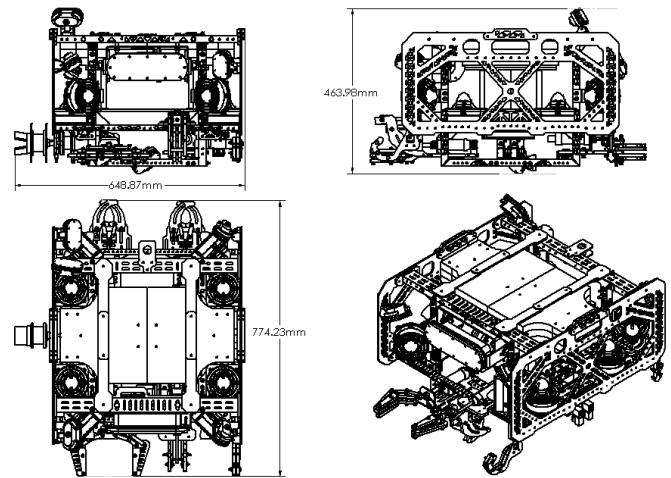


*Figure 8: Gensys dimensions*

The frame was divided into two primary sections: The internal structure that houses the enclosure and thrusters, forming the main load-bearing backbone of the ROV and the outer frame that consists of side sheets and horizontal members protecting the internal components and providing mounting interfaces for external subsystems such as cameras and mechanisms.

Truss-inspired cutouts were incorporated in the **GENSYS** frame to improve stress distribution, while multiple fixation points were added for structural support. Loads on each part were then analyzed to ensure that the selected profiles could safely withstand the expected stress.

**GENSYS** frame was designed as an open frame to minimize hydrodynamic drag caused by water currents and vehicle motion.

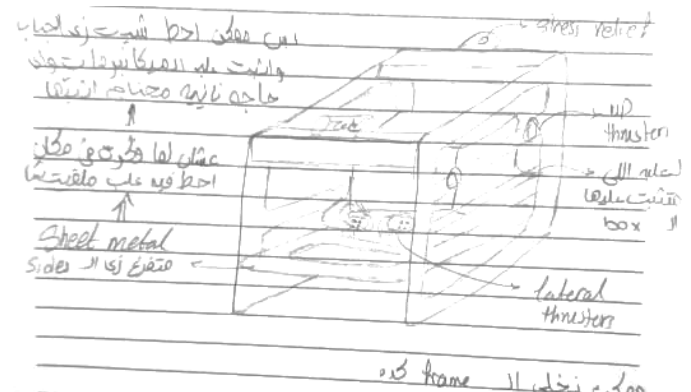


*Figure 9: Early Design Sketches*

## Manipulators and Mechanisms

### Main Manipulator

A **four-bar mechanism-based manipulator** is used by the ROV to clamp objects underwater. The mechanism is **pneumatically actuated** with a **30 mm bore - 20 mm stroke piston**. The end effectors of the mechanism can hold various cross-section objects up to **109 mm in diameter**. This manipulator is mounted on Gensys for general gripping, for retaining multiple objects within the ROV during a single dive, and for **carrying and attaching the carabiner** used to recover the buoy anchor for **Task 2.4**.

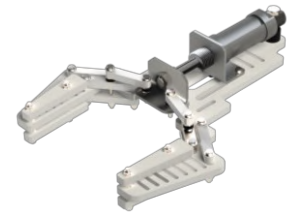


*Figure 10: Main Gripper*

### Static Hook

A **simple, rigid hook** was developed for **lobster pot retrieval**, providing a simple and reliable load-engagement solution. The hook profile is primarily formed from two **HDPE plates**, resulting in a lightweight structure with good durability.



*Figure 11: Hook*

### Non-Parallel Mechanism

A **non-parallel gripper** was selected for its effectiveness in handling **small and irregular objects**. The gripper features **circular-shaped end effectors**, allowing the jaws to partially surround the object and improve grip stability while reducing the risk of slipping during manipulation. Within the mission, this mechanism is used for **Task 1.1**, where its geometry enables reliable grasping of delicate and irregular components.



*Figure 12: Non-Parallel Gripper*

### Jaw Mechanism

This jaw mechanism has proven reliability and adaptability over **several seasons of use**. It consists of two moving end-effectors actuated by a **pneumatic piston**, working against two fixed ones to grip objects with different cross-sections.



*Figure 13: Jaw Gripper*

### Spool Mechanism

To accomplish **Task 2.4** and **Task 2.5**, a **modular mechanism** was designed with an emphasis on ease of attachment and detachment while maintaining operational effectiveness. Since both tasks required rotational movement, a motorized mechanism was integrated into a unified design; developed to perform both functions, reducing weight and overall system cost.

The mechanism was divided into four main subassemblies: **(1)** The upper subassembly acts as the end effector, responsible for rotating the camera and connecting to the rest of the mechanism; **(2)** a removable spool is positioned between the upper and lower subassemblies, allowing easy installation or replacement; **(3)** The lower subassembly includes a coupler and a flange that transmits motion from the motor; **(4)** final subassembly consists of the motor casing. A **ceramic bearing** is incorporated to support the shaft and ensure smooth operation.

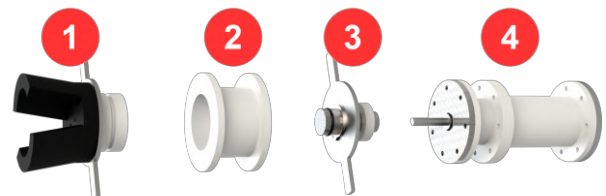


*Figure 14: Motor Exploded View*

### Basket Star Arrow

A **non-actuating end-effector** for **basket star collection**. It functions as a **non-return mechanism** that penetrates with a 3D-printed (TPU) interface, whose elasticity allows O-ball entry and retention.

## Electrical Enclosure

The enclosure is made of **6 mm thick annealed 5083 aluminum sheets**, which help dissipate heat from internal electrical components. The sheets are bent and welded using gas tungsten arc welding (TIG), creating a strong and durable structure that can withstand underwater conditions.

The enclosure box is sealed with a **dual O-ring face seal**, and all cable entries are sealed with cable penetrators to prevent water ingress and protect the ROV's electrical connections. The box's sealing system is designed to withstand pressures of up to **800 kPa** (equivalent to 80 meters underwater). This ensures the ROV can operate reliably at significant depths.

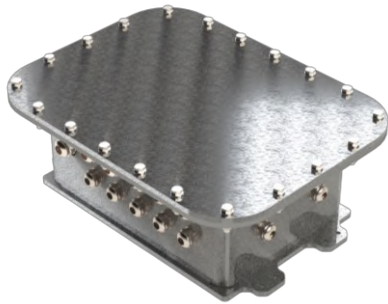


Figure 15: Electrical Enclosure

## Camera Casing

The casing was CNC-milled from HDPE for its high strength-to-weight ratio, featuring an acrylic cover for optical clarity. To ensure system integrity, the assembly is sealed with an O-ring and a cable gland. Additionally, an integrated servo motor allows for vertical camera adjustment, expanding the field of view for **3D modeling** and supporting the future development of a multi-DOF robotic arm.



Figure 16: OAK-D W camera casing

## Propulsion

Utilizing eight T200 Blue Robotics thrusters, **Gensys** is characterized by high thrust output, rapid response, and reliable performance.

Albeit their high efficiency, the primary drawback of the T200 Thrusters is elevated power consumption, particularly during high-speed operation.

This is indicated by the drag force dynamic equation below:

$$F_D = \frac{1}{2} \rho v^2 C_D A$$

$F_D$ : Drag force

$\rho$ : Density of the fluid

$v$ : Speed of the vehicle relative to the fluid

$C_D$ : Coefficient of Drag

$A$ : Cross Sectional Area

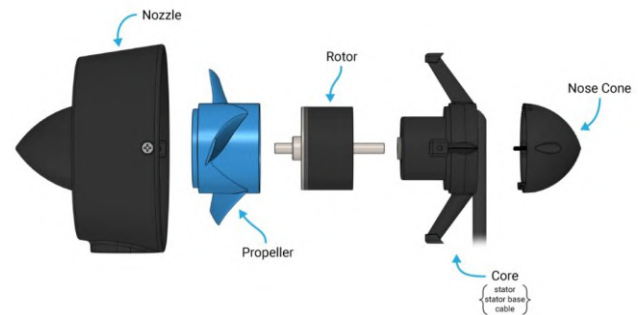


Figure 17: T200 thruster disassembled

## Virtual Prototyping

### Computational Fluid Dynamics (CFD)

With a heavy emphasis on currents and opposing forces in tanks and controlled environments, a (CFD) study was performed on **GENSYS** to evaluate flow around its hull, assess its resistance to pressure forces, and calculate drag. **Figure 18** illustrates streamlines around the GENSYS design. The CFD results indicate a drag force of **18.54 Newtons** at an ROV velocity of **0.75 m/s**; to compare these results to past ROVs, this is a **32.92% decrease** in drag force over the last two MATE seasons.

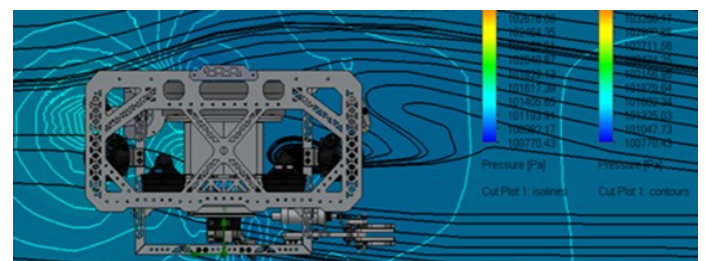


Figure 18: Gensys's CFD

## Buoyancy and Stability System

Gensys's buoyancy system was designed to enhance hydrostatic stability while also maintaining ease-of-access to the electrical enclosure as a secondary design priority.

The design calculations were based on Archimedes' principle, where each component of the ROV (*Table 2*) was analyzed to determine three key parameters: **mass**, **volume**, and the **resulting buoyancy force**. The analysis showed that Gensys undergoes a total negative buoyancy of **-89.51 N**, which establishes the theoretical buoyant force required to achieve **neutral buoyancy**.

Consequently, the required volume of flotation material was deduced to achieve **near-neutral buoyancy** and configure the **internal distribution of the flotation elements**.

Table 2: Gensys's Buoyancy Table

| Item                  | Qty. | Actual Mass(kg) | Weight (N) | total Disp. Vol.(m3) | Buoyant Force (N) | Net Fb (N) |
|-----------------------|------|-----------------|------------|----------------------|-------------------|------------|
| Internal Structure    | 1    | 10.438          | 102.392    | 0.0082               | 80.71             | -21.67     |
| Outer Structure       | 1    | 3.174           | 34.6       | 0.0017               | 17.07             | -17.54     |
| Cameras               | 6    | 0.082           | 4.824      | 0.0006               | 6.044             | 1.22       |
| OAK-D W               | 1    | 1.227           | 12.5146    | 0.000846             | 9.251             | -3.26      |
| Thrusters             | 8    | 3.41            | 33.51      | 0.0015               | 15.24             | -18.2      |
| Main-Gripper          | 1    | 0.882           | 8.654      | 0.0003               | 3.698             | -4.88      |
| Non-parallel Gripper  | 1    | 0.598           | 5.866      | 0.0006               | 6.542             | -3.20      |
| Jaw                   | 1    | 0.845           | 8.297      | 0.0003               | 3.686             | -3.59      |
| Fasteners             | N/A  | 1.687           | 17.491     | 0.2256               | 2.213             | -15.2      |
| Hook                  | 1    | 0.114           | 1.115      | 7E-05                | 0.708             | -0.40      |
| O-Ball Arrow          | 2    | 0.059           | 0.577      | 40354                | 0.395             | -0.18      |
| Spool                 | 1    | 0.651           | 6.395      | 0.00048              | 4.72              | -1.66      |
| Claw                  | 1    | 0.601           | 5.899      | 0.000368             | 3.609             | -2.22      |
| Negative buoyancy (N) |      |                 |            |                      | -89.51            |            |

## Simulation and Stress Analysis

As the engineering design process entails, the integrity of our structure was to be tested through performing various stress analyses on the main components of the structure.

A fundamental tool in our design choices was **SolidWorks Simulation**, whereby **dividing our structure into smaller sub-assemblies**, we maintained **result consistency**.

Amongst the results, the extrusion bar supporting the weight of the OAK-D W Camera and Servo motor displayed reasonable deformation as a response to bending stress. (*Figure 19*)

Another simulation run on Gensys's side sheets showed a maximum deformation of **0.025 mm** (*Figure 20*) as a response to uniform static tension.

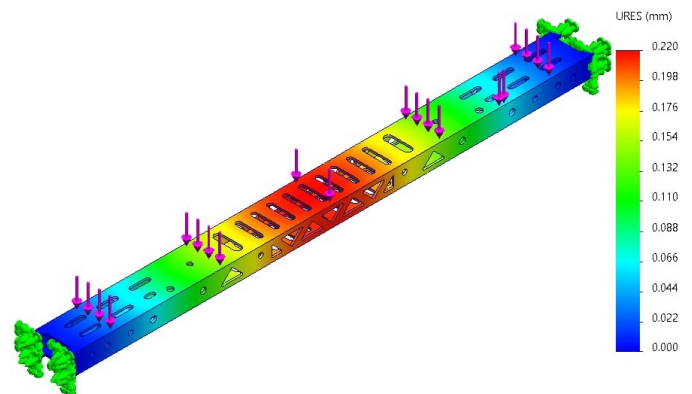


Figure 19: Extrusion Bar Disp.

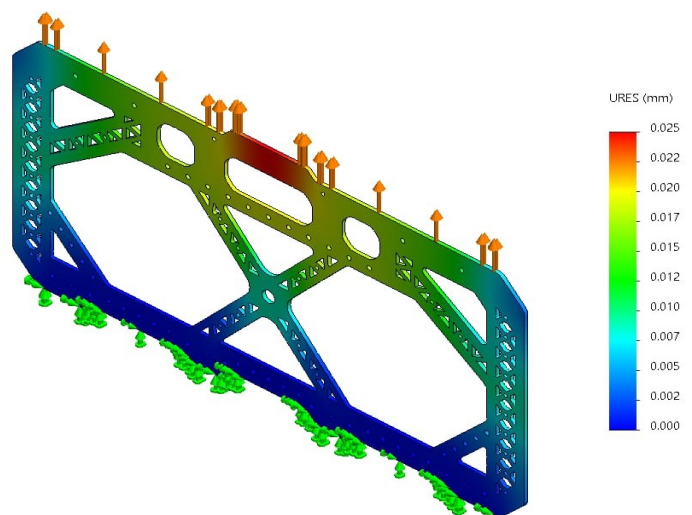


Figure 20: Side Sheet Disp.

## 1.3. Electrical System

Gensys's electrical system is organized into a **three-layer vertical stack** that prioritizes both accessibility and electromagnetic compatibility (EMC). By **isolating** the SBC and sensitive sensors from high-power, noisy DC-DC buck converters, the design simplifies debugging and protects signal integrity. All hardware was developed in **Altium Designer** using a **hybrid fabrication strategy**: **in-house boards** (e.g., Actuators PCB and Jetson Hat) are used for **rapid, cost-effective prototyping** despite being limited to two layers and lower copper thickness. In contrast, complex boards like the ESCs board utilize **outsourced** multi-layer PCBs to support high-current tracks, through-hole electroplating, and professional solder masking, accepting longer fabrication lead times in exchange for superior process reliability.

### Tether

Gensys is linked to the surface via a high-tensile umbilical integrating power, data, and pneumatic supply. Low-resistance **10 AWG conductors** deliver DC power with 85% efficiency verified in [Section 3.1.1](#). **CAT6e Ethernet** cable supports 1000 Mb/s throughput for low-latency telemetry. **Redundant high-pressure tubing** provides compressed air to actuators, all encased in a **braided sleeve** to enhance mechanical

durability. To ensure neutral buoyancy and minimize drag, cylindrical foam elements are positioned at specific intervals, preventing entanglement and reducing twists during complex maneuvers.

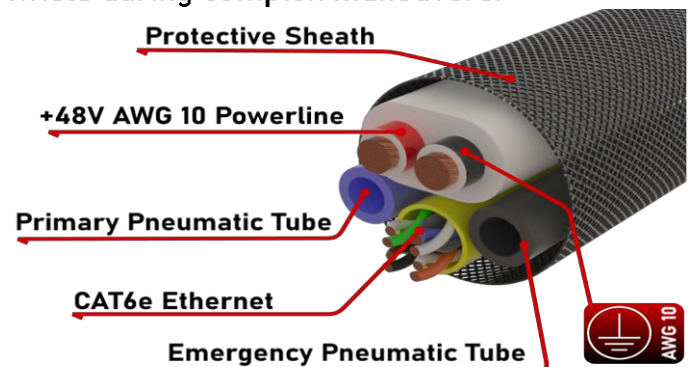


Figure 22: Tether composition

### Tether Management Protocol

**Preparation:** Conduct pre-deployment checks on the tether, ensuring it is free from damage and properly connected.

**Deployment:** Deploy the tether carefully, avoiding tangles, while maintaining communication with the control station.

**Monitoring:** Continuously monitor tether tension during operation to prevent overloading.

**Adjustment:** Make dynamic adjustments to tether length and tension as needed to accommodate changes in conditions.

**Retrieval:** Retrieve the tether systematically at the end of the mission, avoiding twists.

**Inspection:** Inspect the tether post-mission for any signs of wear or damage.

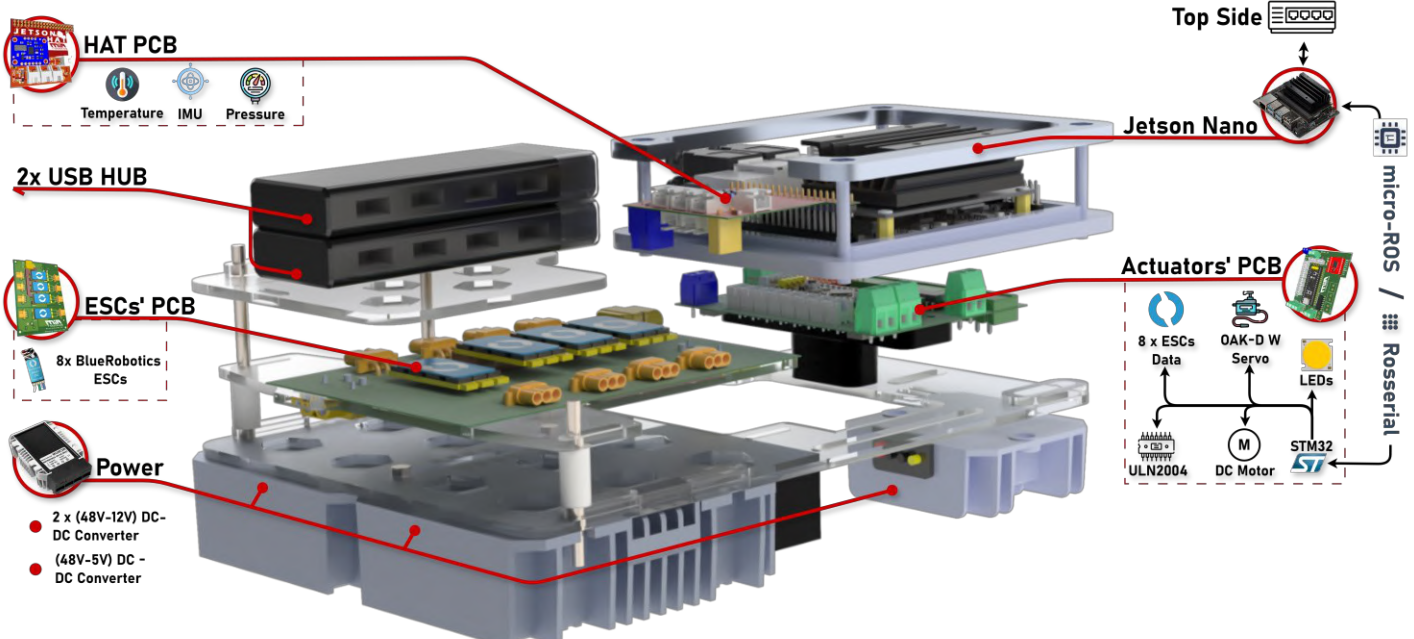


Figure 21: Gensys internal hardware structure

## Power Management and Connectors

Building from the bottom up, our main power management layer receives 48V through the **XT150** power connector, which offers sliding **interlocking housing** allowing it to pass through the enclosure's cable penetrator rather than previously used fixed-block connectors like XT90, it also provides lower power loss and higher thermal performance. This choice aligns with our design requirements for **modularity and optimal power delivery**.

Secondly, this year **Gensys** utilizes two (48V to 12V) 720W DC-DC buck converters to supply high power loads and a (48V – 5V) 50W DC-DC buck converter with smart chip protection, anti-overheating, overcurrent safeguards, and **96% efficiency at high load**, to safely power the SBC and 8 Rapoo cameras. In total, **only three** buck converters are used which is **three fewer** than previous year.



*Figure 23: XT150 Connector*

features custom CNC-machined **5x5mm copper bus bars** soldered to both the top and bottom layers, effectively combining the high current-carrying capacity of the bus bars with the heat dissipation characteristics of the large copper PCB planes.

For connecting the thrusters to the ESCs, two methods were used in previous years Both of which presented significant drawbacks:

**Direct soldering:** While providing a stable connection, this method was highly inflexible, making disconnection and reconnection of the ESCs cumbersome.

**Screw terminals:** These offered a non-permanent connection but were bulky, occasionally resulted in unreliable connections, and the screws were difficult to access within the electrical enclosure.

Consequently, a more compact and flexible alternative was necessary. After surveying available options and shortlisting leading candidates, a decision was made, as detailed in the accompanying table, that the **MR30** connector was the optimal solution. This choice was subsequently subjected to extensive testing using the test rig described in [Section 3.1.1](#).

## ESCs Layer Board

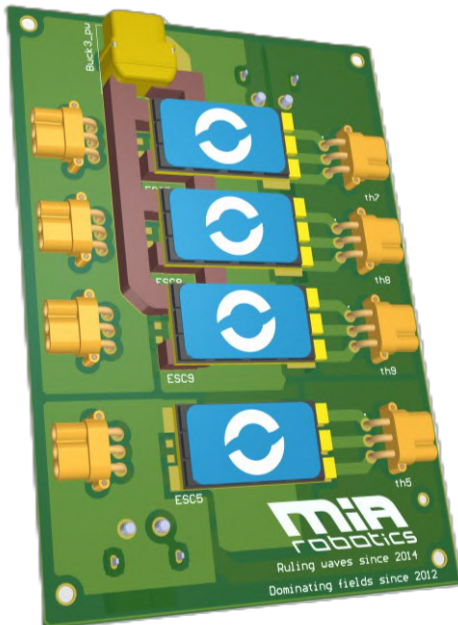


*Figure 24: ESCs PCB*

A custom high-current PCB was developed to manage power distribution among the 8 Electronic Speed Controllers (ESCs). This PCB

*Table 3: connectors comparison*

|             | Size when connected (mm) |       |       | Volume (mm <sup>3</sup> ) | Continuous Current rating (A) |
|-------------|--------------------------|-------|-------|---------------------------|-------------------------------|
|             | L                        | W     | H     |                           |                               |
| <b>MR30</b> | 23.8                     | 4.9   | 11.9  | 1387.78                   | 15                            |
| <b>MT30</b> | 30.5                     | 10.25 | 10.78 | 3370.10                   | 15                            |
| <b>MT60</b> | 45.5                     | 12    | 12.5  | 6825.00                   | 30                            |
| <b>MR60</b> | 34.5                     | 20.2  | 9.8   | 6829.62                   | 30                            |

This board significantly reduced wire clutter inside the electrical enclosure and simplified the debugging process while also reducing the disassembly and downtime.

## Actuators PCB

The transition to the **STM32F4xx** microcontroller as mentioned in [Section 1.1.2](#) came with the added benefit of having a floating-point unit (FPU) accelerating floating-point operations, significantly improving performance for math-intensive ROV features like **PID control** and **DPMS**. Additionally, it offers **8 Independent Timers** allowing **GENSYS** to control up to:

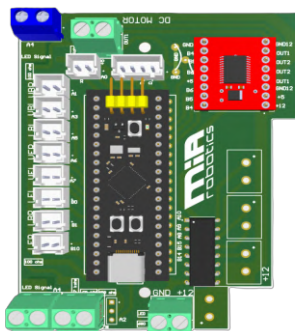


Figure 25: Actuators PCB

1. 8 thrusters for movement with 6 DoF
2. DC motor to control mechanisms used in: **Recovering buoy anchor (Task 2.4)** and **Removing biofouling from observatory camera (Task 2.5)**.
3. Servo port for controlling a 12 V servo motor, used for tilting the OAK-D W camera, providing precise angles; due to its half-duplex asynchronous serial communication. This helps us in **3D modelling of coral garden (Task 1.2)**. This servo has been chosen over the old 8.4V servo after fault simulation test and based on the following criteria.

Table 4: Old vs New Servo

| Features      | 12V Servo Motor                                                                                                                    | Previously Used 8.4V Servo Motor |
|---------------|------------------------------------------------------------------------------------------------------------------------------------|----------------------------------|
| Communication | Supports half duplex UART.                                                                                                         | Pulse Width Modulation (PWM)     |
| Safety        | <ul style="list-style-type: none"> <li>Overcurrent</li> <li>Overload</li> <li>Overvoltage</li> <li>Overheat protection.</li> </ul> | No protection                    |

In addition, removing the 8.4 V servo eliminated an entire voltage level and therefore removed a buck converter from our system, which helped downsize the electrical enclosure.

Lastly, our PCB supports up to 4 high power LEDs. Since our team's main goal is **protecting marine life** and providing **environmental safety**, these LEDs improve the pilot's ability to clearly observe the surroundings in the flume tank,

helping avoid contact with and disturbance to coral organisms.

## Single Board Computer (SBC)

In the uppermost layer, the ROV's central computing unit exists, which was required to fulfill the need for video encoding, high Ethernet bandwidth, and USB3.0 for interfacing with **7 Rapoo cameras** and Minimum 1.1GHz Quad Core CPU ensuring low-latency data processing for smooth operation.

As shown in [Table 5](#), **Jetson Nano** showed eminence in our software engineers' requirements in comparison to **Raspberry Pi 4B**.

Table 5: SBC comparison

| Features | Jetson Nano 4GB                              | Raspberry Pi 4B                                        | Required                                     | Decision    |
|----------|----------------------------------------------|--------------------------------------------------------|----------------------------------------------|-------------|
| CPU      | ARM Cortex-A57 (quad-core) @ 1.43 GHz        | Broadcom BCM2711, quad-core Cortex-A72 (ARM v8) 64-bit | ~1.1GHz Quad Core System                     | Both        |
| GPU      | 128-core NVIDIA Maxwell @ 921MHz             | Broadcom VideoCore VI                                  | GPU accelerated encoders                     | Jetson Nano |
| Memory   | 4GB 64-bit LPDDR4 @ 1600 MHz   25.6 GB/s     | 2GB, 4GB and 8GB LPDDR4-3200 SDRAM with on-die ECC     | At least 4GB RAM                             | Both        |
| Storage  | MicroSD card                                 | MicroSD card                                           | Expandable Storage                           | Both        |
| Encoder  | 4Kp30   4x 1080p30   9x 720p30 (H.264/H.265) | H.264 (1080p30)                                        | Approx. 7x 720p30 Cameras                    | Jetson Nano |
| Ethernet | 10/100/1000 BASE-T Ethernet                  | Gigabit Encoder                                        | >800 MB/s                                    | Both        |
| USB      | 4x USB 3.0 A   1x USB 2.0 Micro-B            | 2x USB 3.0 A   2x USB 2.0 A                            | Min. 4 USB 3.0 ports (OAK-D W & 3 USB 3.0 A) | Jetson Nano |
| Power    | 5V / 10-20W                                  | 5V / 10-15W                                            | Not more than 20W                            | Both        |

Stress testing the Jetson Nano revealed high temperatures increasing data processing latency. To maximize performance, a thermoelectric cooler cools down the SBC and dissipates the heat in the enclosure's ceiling. This setup **lowers the nominal temperature to 20°C**, enhancing computational efficiency.

## Jetson HAT

Our custom-made Hardware on Top (HAT) PCB is equipped with a 5V power distribution base, for powering the on-board and out-board 5V loads. It supports a **depth-sensing unit**, a **temperature sensor**, and a **9-axis Inertial Measurement Unit (IMU)**.

The HAT provided smoother interface compared to the **previously used sensors' PCB** by eliminating the MCU layer between the sensors and the SBC, resulting in fewer potential points of failure. Furthermore, IMU readings were improved due to its fixation on SBC at the topmost layer of the electrical enclosure, minimizing electromagnetic interference.

## Control Station

M.I.A.'s station is the collection of equipment the pilot uses to operate the ROV. The surface station computer, router, monitors, controller, and all other equipment are enclosed in a single grab-and-go package for rapid deployment and easy setup with minimal clutter. In order to make it suitable for movement, the router and the power supply have been secured in the downstage box. The monitor has been mounted on the other half of the station for easy access and viewing.



Figure 26: M.I.A. Control station

## 1.4. Software System

### Communication System

The **Robot Operating System (ROS)** facilitates communication with the ROV, including **pilot commands**, **sensor feedback**, and the OAK-D W camera stream. The system utilizes **micro-ROS**

for STM32-based communication while also supporting **Rosserial** for backward compatibility.

### Web Communication between SBC and TCU

Although ROS simplifies inter-node communication, it requires direct network access, which conflicts with our platform-independent web-based TCU. To address this, we implemented a middleware layer with **Rosbridge** at its core. Rosbridge dynamically converts ROS topics to lightweight **JSON** and uses a WebSocket server over the Ethernet tether, enabling persistent, low-overhead, real-time communication between the SBC and the TCU's web interface.

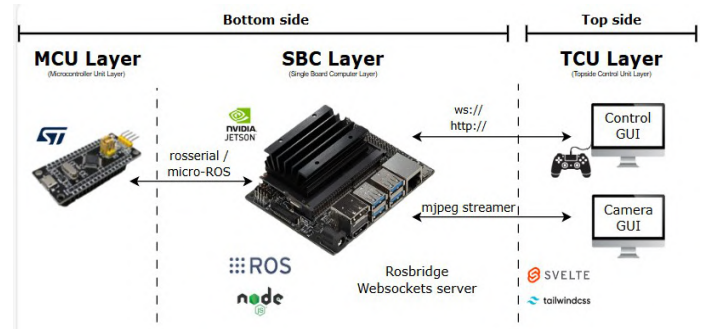


Figure 27: Communication system

### Software Control System

#### Kinematic Model

To convert pilot propulsion commands to thruster speeds, a kinematic model was developed based on the thrusters' **vectored configuration**. This allows navigation in the **6 degrees-of-freedom** while keeping the ROV inherently **stable**.

#### Precision Mode

During testing, it was observed that the T200 thrusters exhibit a **dead zone at low speeds** around **300 RPM**, where small command changes produce little or no thrust. This behavior can cause unstable or inconsistent motion during delicate maneuvers. To address this, a feature developed for our software control system is **precision mode**. When thruster commands fall within the dead-zone

region, a small offset is applied to ensure the command exceeds the minimum effective thrust level. This allows the vehicle to maintain smooth and predictable motion at low speeds, improving **precision** against strong **Transect Currents**.

## Soft Start

Rapid changes in thruster commands can produce high current spikes, sudden torque changes and mechanical stress on the propulsion system. To reduce these effects, a **Soft Start filter** is applied to thruster commands. This filter gradually transitions thruster speeds instead of applying abrupt changes, resulting in **smoother** vehicle motion, reduced electrical transients, and **improved stability** during rotations and maneuvering.

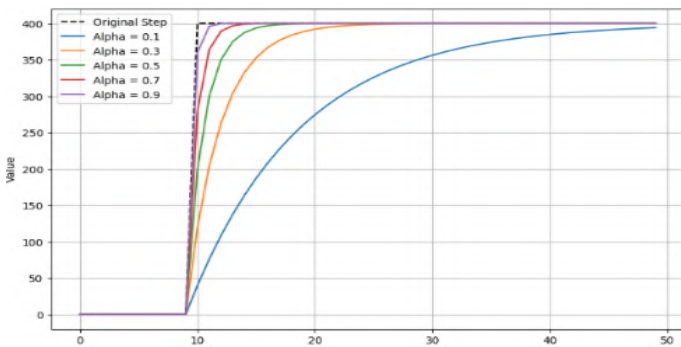


Figure 28: Effects of Exponential Smoothing

## Depth Hold

The **Depth Hold** feature assists the pilot in maintaining a constant underwater depth. The PID controller continuously compares the measured depth from the pressure sensor with the desired depth and generates a corrective command that adjusts the vertical thrusters to bring the vehicle back to the desired depth. This is beneficial in tasks requiring stable depth control like **Flying a transect over the coral garden (Task 1.3)**.

## Heading Hold

Another feature is **Heading Hold** which maintains the ROV's orientation around the vertical axis (**yaw**) using a **cascaded control system** with two loops:

**Outer loop (Heading):** Computes the error between desired and current heading to determine the required yaw rotation rate.

**Inner loop (Rate):** Uses gyroscope data to regulate the vehicle's rotation rate and achieve the commanded motion smoothly.

Separating heading and rate control improves disturbance rejection and stability, which is beneficial during **coral garden photogrammetry (Task 1.2)** where precise orientation is required for accurate 3D reconstruction.

## Technology Stack and Software Architecture

### Technology used



For rapid development, modularity, and accessibility, **Svelte** and **Tailwind** were chosen once again for the frontend due to Svelte's reactive, efficient compiler and straightforward development workflow. **Node.js** serves as the backend, leveraging its similarity to JavaScript and enabling seamless integration with **roslibjs** for ROSBridge communication. During development, the GUIs followed the **MVC architecture**, dividing the application into three distinct components to simplify modular development.

## Control GUI

To leverage the **low-level** control system, a top side web-based interface provides full control of **Gensys** via a **gaming joystick**, allowing real time **parameter tuning**, **status monitoring**, and version controlled **low level code uploads**. Key features include automatic **high level** PID activation after a customizable inactivity interval, toggling low-level modes such as **precision** and **DPMS**, and visualization of PID parameters using **ECharts**, which supports zooming and pausing for detailed analysis. The transition to a web-based GUI three years ago eliminated the need for dedicated software, significantly **improving accessibility and usability**. By using a **browser-based interface**, the system can be accessed from any device connected to the SBC without additional setup.



Figure 29: Control GUI

## Vision System

### Video Streaming

Delivering a **low latency** video feed is critical for subsea teleoperation. To optimally allocate the Jetson Nano's computer resources across all active ROS nodes and vision systems, we required a streaming architecture with minimal CPU overhead. This ensures a low latency stream while preserving essential processing power for ROV control

Table 6: Camera Streaming Comparison

| Evaluation   | Weight | Mjpeg Streamer | Web RTC | GStreamer | FFmpeg |
|--------------|--------|----------------|---------|-----------|--------|
| CPU utility  | 5      | 5              | 2       | 3         | 2      |
| Latency      | 4      | 4              | 5       | 3         | 2      |
| Bandwidth    | 3      | 2              | 5       | 5         | 5      |
| Total weight | -      | 47             | 45      | 42        | 33     |

Based on (Table 6), mjpeg-streamer was selected to strictly conserve Jetson Nano's processing resources. While H.264 alternatives (like WebRTC or FFmpeg) offer excellent compression, their software encoding introduces unacceptable CPU spikes and latency.

### OAK-D W Stereo Camera

This year, M.I.A. selected the **OAK-D W** as its primary stereo camera due to its **4K** streaming capability, wide **150°** field of view, integrated **BN0085** IMU, and **RVC2** chip with onboard processing capabilities. Its monochromatic

stereo cameras also provide improved performance in **low light** conditions, making them well suited for operation in the **offshore engineering basin**. The RVC2 enables **onboard sensor fusion**, **stereo depth-map** generation, and **MJPEG encoding**, significantly reducing computational requirements compared to the previously used **ZED2** camera. These features enable accurate **iceberg keel depth estimation (Task 2.2)** and **high-res 3D coral garden reconstruction (Task 1.2)**. The camera was calibrated using a **ChArUco** board with multi-view images to estimate **intrinsic and extrinsic parameters**, achieving a 0.4-pixel reprojection error for reliable stereo rectification

### Coral Garden Reconstruction

To ensure high quality 3D reconstruction, comprehensive research was conducted to evaluate the most suitable **Photogrammetry** software as well as evaluating the latest research on **NeRF** techniques. For instance, **Instant-ngp** learns a scene with a compact neural network and hash encoding, while **Gaussian Splatting** models it as optimized 3D Gaussians rendered direct. Meanwhile, **RealityScan**, though slightly lower in visual quality, provides more reliable results with an efficient SfM and dense point cloud pipeline, and lower VRAM usage.

**Scaling:** RealityScan converts models from arbitrary units to real-world scale using known distance constraints (e.g. measurements from the **OAK-D W**), enabling accurate object and spatial measurements within the scene.

*Table 7: Photogrammetry software comparison*

| Software           | Processing Time Weight = 4 | Model Quality Weight = 4 | Reliability Weight = 5 | Total Weight |
|--------------------|----------------------------|--------------------------|------------------------|--------------|
| RealityScan        | 5                          | 4                        | 5                      | 61           |
| 3DF Zephyr         | 4                          | 3                        | 5                      | 53           |
| Instant NGP        | 4                          | 5                        | 4                      | 56           |
| Gaussian splatting | 5                          | 5                        | 3 (High Vram)          | 55           |
| Metashape          | 4                          | 4                        | 5                      | 57           |

## Dockerization

To avoid compatibility issues, the software system has been **containerized**. This helps maintain a uniform environment across different hardware platforms like the Jetson Nano and the topside computer and allows users to run complex applications such as the **3D Coral Garden Reconstruction** simply by downloading and running the container, without manually installing dependencies or configuring the environment.

## Image Preprocessing

### Automatic Camera adjustment:

To handle varying underwater lighting, a script was developed to monitor each camera's stream and automatically adjust the gain whenever **overexposure** or **underexposure** was detected, ensuring consistent image quality.

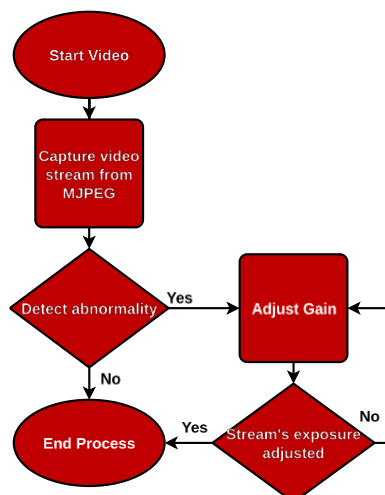


*Figure 30: Dynamic Gain Adjustment*

**Color correction:** Underwater computer vision suffers from color **distortion** and **attenuation**, which can hinder tasks such as **Task 2.1 (Invasive Crabs)** and **Task 1.2 (3D coral garden reconstruction)**. To address this, we reused the

previous year's C++ classical algorithm. It applies the **Gray World algorithm** to balance color intensities by assuming the scene's average color is neutral gray, followed by **red-blue compensation** to restore lost red tones and improve visibility. Finally, **CLAHE** is applied to each RGB channel to enhance contrast while reducing color imbalance, improving visual clarity with minimal computational overhead.

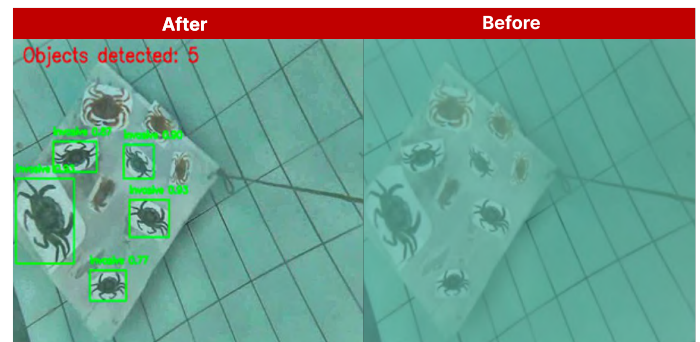


*Figure 31: Enhanced Image*

## Invasive Crabs Detection

Extensive testing was performed using several object detection AI models. Each model was evaluated on the same underwater datasets with the same preprocessing algorithm, allowing for a direct comparison of their performance through standard evaluation metrics such as precision, recall, and mean Average Precision (**mAP**).

**Model Selection:** Each model was tested on the same dataset to ensure fair evaluation. Based on the comparative evaluation, **YOLOv11** was selected due to its effective balance between real-time performance, detection accuracy, and implementation simplicity. This advantage is largely attributed to its improved architecture, which incorporates C3K2 blocks, SPFF (Spatial Pyramid Pooling Fast), and advanced attention mechanisms such as C2PSA.

*Table 8: Model comparison results*

| Category/Model | YOLO 11   | Faster-rcnn        | YOLO 26             | SSD      |
|----------------|-----------|--------------------|---------------------|----------|
| Accuracy       | Moderate  | Very high accuracy | worse than yolov11  | Mediocre |
| Speed          | Real time | Not real time      | Faster than yolov11 | Fastest  |

## 2. Safety

### 2.1. Safety Philosophy

At M.I.A. Robotics, safety is a cornerstone of our operations. We are committed to creating a secure and comfortable work environment for all company employees by proactively identifying and mitigating risks before they escalate into unsafe situations.



Figure 32: Safety Measures Taken While Working

### 2.2. Awareness Training and Standards

Safety is a foundational priority at M.I.A. overseen by a dedicated **Safety Director**, requiring all personnel -especially freshmen- to undergo mandatory hazard training, take part in **workspace organization**, adhere to a strict **workspace code of conduct**, and wear proper **Personal Protective Equipment (PPE)**.

This includes verifying that all employees follow the detailed safety checklist (refer to **Appendix C**) during pool tests and other activities. Additionally, consistent execution of task-specific safety procedures (refer to **Appendix D**) safeguards underwater environment and ROV assets.

By fostering a culture of **respect** and professionalism, we create an environment where everyone can thrive and contribute to our shared success.

### M.I.A. Workspace Code

Given the persistent disorder in our workspace, which poses challenges and impedes productivity, it is wise to make some strategic decisions aimed at addressing and enhancing the current situation.

- 1- At the conclusion of each workday, during the last **20 minutes**, all individuals in the workspace are required to **temporarily** set aside their tasks and participate in the collective effort to reorganize the workspace, restoring it to its original configuration.  
(Exceptions to this rule may only be granted by a board member, and in the absence of a board member, by designated leaders).
- 2- On one designated **cleaning day** within the final seven days of each month, a **mandatory cleaning day** will be observed. All team members are expected to participate, unless they have a valid excuse.
- 3- All borrowed items must be promptly **returned to their original containers**, adhering to the labeled instructions. In cases of uncertainty, team members are encouraged to seek guidance from one of the mentors.
- 4- After finishing your work, you must leave your space clean and return everything to its original place.
- 5- The configuration of the Warshe will be as shown in the figure, and the **traffic area should always be kept clear for passage.**

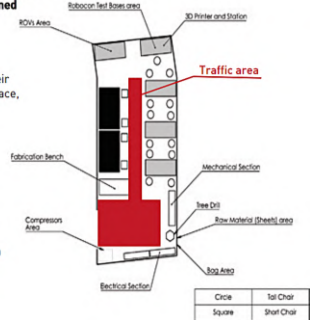


Figure 33: Workspace Code

### 2.3. Safety Features

Physically, **GENSYS** incorporates comprehensive safety integrations, including meticulously sanded frames, covered bolts, protective thruster shrouds, and strain-relief tether mechanisms.



Figure 34: T200 shrouded thruster

Electrical hazards are mitigated by properly sized fuses installed near the power-pole connectors and easily accessible kill-switches on both the main power supply and the Topside Control Unit (TCU). Additionally, a properly sized **fuse** is installed 30cm from the **Anderson** Power-pole connectors to prevent electrical hazards.

## 3. Testing and Troubleshooting

### 3.1. Testing Strategy

To ensure the ROV's reliability and performance, a thorough and systematic testing process was implemented across all subsystems to allow us to validate functionality, identify potential issues, and optimize the system for both normal and extreme operating conditions. By conducting rigorous tests, we ensured the ROV was mission-ready and capable of handling the challenges of underwater environments.

## External Test Rig

To ensure hardware reliability and architectural integrity, a dedicated **validation test rig** was engineered. This platform facilitates the evaluation of system modifications and R&D topics, specifically **Electronic Speed Controller (ESC)** board iterations, and allows for rigorous **stress testing of buck converters**. By isolating these components, we can verify thermal and electrical stability under load prior to integration into the primary system.

The test rig evaluates system resilience by simulating **peak operational loads**, specifically by driving thrusters to maximum output. This allows for the precise characterization of **thermal and power stability** across the ESC bus bars and buck converters under worst-case scenarios. Additionally, the rig served as a diagnostic tool to quantify **maximum power loss across the ROV tether to be 216 W**, this ensures that power delivery remains within nominal tolerances during high-amperage draws.

By utilizing a dedicated fluid tank and isolated electrical bench, all over-current tests are performed in a contained environment. This protocol ensures that any component failures, such as thermal damage or circuit interruptions, occur under supervision, protecting both the operators and the primary ROV system.



Figure 35: Portable T200 thrusters test rig

## Mission Specific Testing

We ensured competition readiness through mission-specific tests, which led to refinements in camera angles, navigation, stability, and manipulator designs. Simulations of tasks such as **3D modelling, object retrieval, and navigation** also enhanced pilot performance. In addition, we prepared **two complete crews** for the competition to ensure operational readiness,

each consisting of trained pilots, co-pilots, and tether men.

After developing a new component, whether a software module, mechanical payload, or electrical subsystem—it was first tested on our **mini-ROV test platform**. This step allows us to verify the component's functionality, performance, and integration feasibility in a controlled environment before incorporating it into the main **GENSYS** system. By validating each module on the mini-ROV, we ensure reliability, minimize risks during deployment. The mini-ROV is also used for collecting underwater datasets for missions such as **Invasive Crabs** while the main system is being developed.

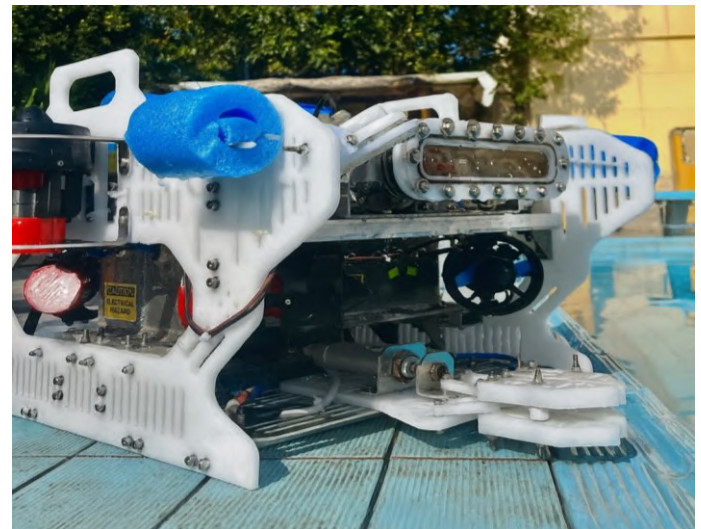


Figure 36: mini ROV

## Full System test

Table 9: Full system test Criteria

| Full System Test         |                                                 |
|--------------------------|-------------------------------------------------|
| Dry Test                 |                                                 |
| <input type="checkbox"/> | Power The control station                       |
| <input type="checkbox"/> | Connect the tether to the power supply          |
| <input type="checkbox"/> | Verify the tone of the ESCs                     |
| <input type="checkbox"/> | Connect the Ethernet cable from the SBC and TCU |
| <input type="checkbox"/> | Verify Cameras' Feed                            |
| <input type="checkbox"/> | Confirm all readings are read by the GUI        |
| <input type="checkbox"/> | Connect the joystick                            |
| <input type="checkbox"/> | Test the thrusters with low speeds              |
| <input type="checkbox"/> | Test the solenoids (grippers)                   |
| <input type="checkbox"/> | Test the OAK's servo and motor functionalities  |
| <input type="checkbox"/> | Initiate underwater test                        |
| Underwater Test          |                                                 |
| <input type="checkbox"/> | Adjust floatation                               |
| <input type="checkbox"/> | Test motion and ensure the ROV moves            |
| <input type="checkbox"/> | Test and adjust PID settings if necessary       |

## Software Testing

**HTTP and WebSocket Server Testing:** Our APIs were tested using endpoint testing software like Postman to ensure valid communication with our APIs, ensuring seamless data exchange and enabling reliable mission execution.

### Performance Testing:

- **Latency Testing:** **GENSYS** response has been measured relative to the pilot's input, ensuring real-time control.
- **Resource Usage Testing:** Monitor CPU, memory, and network usage to ensure the software runs without overloading the system.

**ROS-Based Testing:** ROS was utilized for live logging, debugging, and communication between system nodes. Its extensive libraries and packages simplified testing, while our custom GUI provided easy access to logs for real-time monitoring.

## 3.2. Troubleshooting Strategy

**Gensys** followed a structured and methodical troubleshooting process to ensure the ROV operated reliably before any dry or underwater testing. Throughout development and testing, we encountered various challenges, which we addressed using an effective "**isolate, divide, and conquer**" strategy. Each issue was first categorized as mechanical, electrical, or software-related, then broken down into smaller components to pinpoint the root cause and implement a targeted solution.

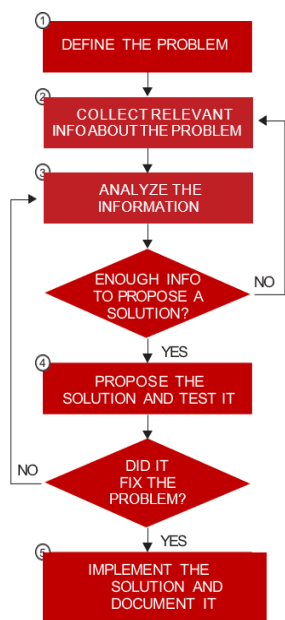


*Figure 37: Systematic Problem-Solving Logic*

## Notable Troubleshooting Incidents

**Case 1:** During early testing of **Gensys**, thrusters exhibited erratic motion at random intervals while at rest. The STM32F4, responsible for generating the PWM signal, was tested in

**isolation** using an Arduino UNO to verify pulse width output, revealing inconsistent widths with an error of  $\sim 30\mu s$ , indicating software-emulated PWM rather than hardware timers. This was traced to a missing code modification required when migrating from the F1 to the F4 MCU. Applying the fix resolved the problem entirely.

**Case 2:** Another issue encountered was a thruster spinning significantly slower than the others or not spinning at all. Checking the ROS topic logs confirmed that the commanded thruster values were nominal, **eliminating** software as a cause. Using the T200 diagnostic tones as a guide, the troubleshooting followed a systematic elimination process: the three-beep startup tone confirmed ESC power and phase wire continuity, and the two-beep response to a  $1500\mu s$  arming signal confirmed MCU signal integrity. With software, electrical, and signal sources all verified, the problem was **isolated** to a mechanical cause. Disassembling the thruster revealed that the propeller screws had come loose and fallen into the rotor, which was resolved by refastening them securely.

## 4. Logistics

### 4.1. Teamwork

M.I.A. Robotics, part of Alexandria University's Faculty of Engineering, unites students from electrical, mechanical, software, AI, and media teams to develop cutting-edge robotic solutions, culminating in the **Gensys** ROV project. Our organizational structure consists of Board Members, including a **CEO**, **CTO**, **CFO**, and **ESG**, who oversee strategy, budgeting, recruitment, and project execution. Each subteam is led by a **leader**, with some teams also having a **vice-leader** to facilitate operations, ensuring smooth onboarding of new members and breaking down major tasks into manageable assignments. Additionally, our Advisory Committee, composed of supervisors and mentors, provides invaluable guidance, aiding in decision-making and catalyzing the process. Refer to [Appendix A](#) for the complete team structure.

## 4.2. Project Management

At M.I.A. Robotics, maintaining and building upon our technical expertise is a top priority. To ensure a seamless transfer of knowledge and continuous innovation, we allocate substantial time at the start of each season to recruiting and training new members. Our workflow is structured, as in [Appendix F](#), into five key phases:

- **Training and R&D Phase:** This initial phase focuses on equipping new members with essential skills while conducting research and development to improve our robotic capabilities.
- **Application and ROV Design Phase:** In this stage, findings from Phase 1 are applied to the design and development of the ROV, refining its core systems.
- **Mission Specification Brainstorming Phase:** Following the release of the Request for Proposal (RFP), this phase is dedicated to defining mission objectives and aligning them with MATE competition requirements.
- **Intensive Testing Phase:** The final phase subjects the ROV to rigorous testing to verify its electrical and mechanical stability, ensuring optimal performance before the competition.
- **Post-Competition Review and Strategic Planning Phase:** After the competition, the team assesses challenges, analyzes performance, addresses design flaws, and refines strategies for future improvements. Insights from other teams contribute to continuous learning and optimization.

### Resources, Procedures, and Protocols

To enhance efficiency and collaboration, we have adopted Agile methodologies for project management and software development. This approach allows for greater flexibility, continuous improvement, and iterative development. We utilize the following tools to streamline our workflow:

- **Notion:** Used for sprint planning and documentation, with **Kanban boards** to track progress and organize tasks efficiently.

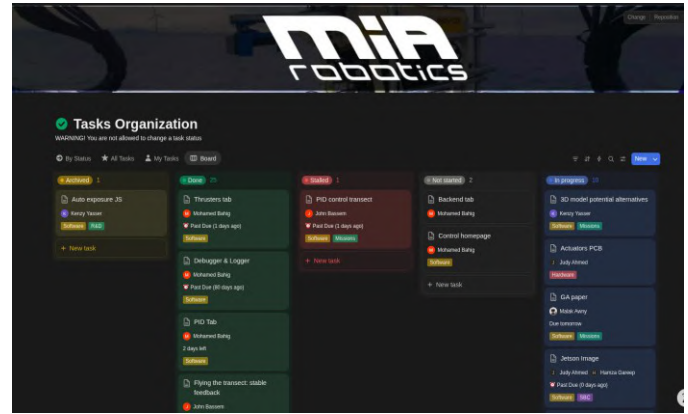


*Figure 38: M.I.A. Notion Kanban Chart*

**Software Version Control:** Our software development follows a methodological approach that leverages GitHub's **CI/CD**, **version control**, and **issue tracking** to ensure seamless integration and early problem detection. By utilizing Git's **branching capabilities** for modular development, new features are thoroughly tested on land before being deployed to a prototype ROV, such as the Mini ROV, via a dedicated integration branch and eventually merged into the main codebase. This technical workflow is complemented by transparent team meetings where members present project updates, including **achievements**, **current tasks**, and **blockers**. These open forums facilitate immediate feedback and insight sharing, allowing the team to rapidly resolve operational challenges and strengthen overall efficiency.

• **Discord:** Selected for its real-time communication capabilities, automation features, and integrated voice/video calls, facilitating biweekly team meetings and live updates.

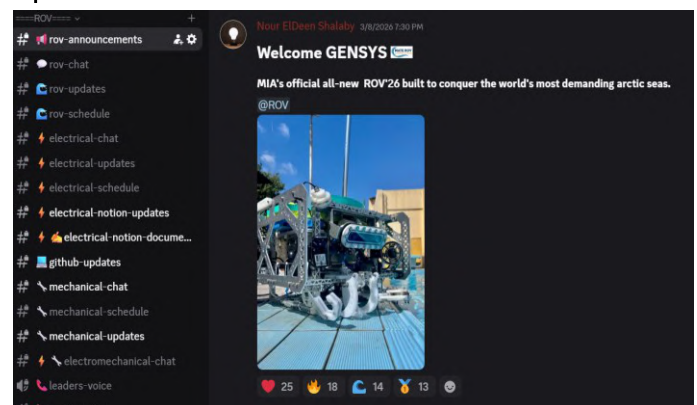


*Figure 39: M.I.A. Discord server*

## 4.3. Accounting

Creating an estimated budget for the season marks one of the initial responsibilities shouldered by the company's board, essential for strategic planning throughout the project. With ten years of experience in MATE ROV, each season's budget reflects a combination of past expenditures and anticipated new costs.

Due to global and local inflation, we adopted a cautious budget estimation approach, intentionally overestimating certain costs by a small percentage to account for potential price increases. Additionally, our company has implemented strategic fundraising initiatives, getting discounts from our partners and cost-management measures to mitigate financial risks and ensure budget stability.

For a comprehensive breakdown of the budget, refer to [Appendix B](#) for a detailed analysis.

## 5. Conclusion

### 5.1. Build vs Buy, New vs Used

M.I.A. follows a **strategic reuse approach**, repurposing ROV components that meet performance requirements without creating bottlenecks. This reduces costs, improves reliability, and lets us focus on critical upgrades.

#### Reused Components

*Table 10: Reused Components*

| Component             | Purpose        | Reason for Reuse                                                       |
|-----------------------|----------------|------------------------------------------------------------------------|
| <b>T200 Thrusters</b> | Propulsion     | High performance, fully compatible with this year's design             |
| <b>Jetson Nano</b>    | Microprocessor | Provides sufficient <b>GPU processing power</b> for this year's system |

Some components from previous years were retained for their **compatibility and cost-effectiveness**. See [Appendix H](#) for more details.

#### Custom-Built Components

When off-the-shelf solutions were cost-effective, like the **3D modelling software** (Task

1.2), we **used** them; otherwise, we built in-house alternatives for better compatibility and value.

#### Leveraging Past Designs

We maintain an **archive** of all mechanisms from our 11 years of participation in MATE, refining and reusing designs with lessons learned. For instance, our **Spool Mechanism** (Task 2.4, Task 2.5) was enhanced based on past iterations, improving efficiency. This approach ensures continuous improvement while balancing cost, performance, and innovation.

*Table 11: Custom Built Components*

| Component                     | Purpose                  | Reason for Build                                                                                                                    |
|-------------------------------|--------------------------|-------------------------------------------------------------------------------------------------------------------------------------|
| <b>Topside Control System</b> | Software/Vision          | Fully custom-built <b>GUI, streaming, and color correction</b> for tasks like Task 2.1 (invasive crabs) and Task 1.2 (3d modelling) |
| <b>Pressure Sensor</b>        | Motion Control           | Provides <b>precise depth-based motion</b> at a fraction of the cost of commercial alternatives                                     |
| <b>Sealed Servo Motor</b>     | OAK-D W Camera Actuation | Cost-effective alternative to expensive underwater servo motors                                                                     |

## 5.2. References

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## 6. Appendix

### A- Company Structure

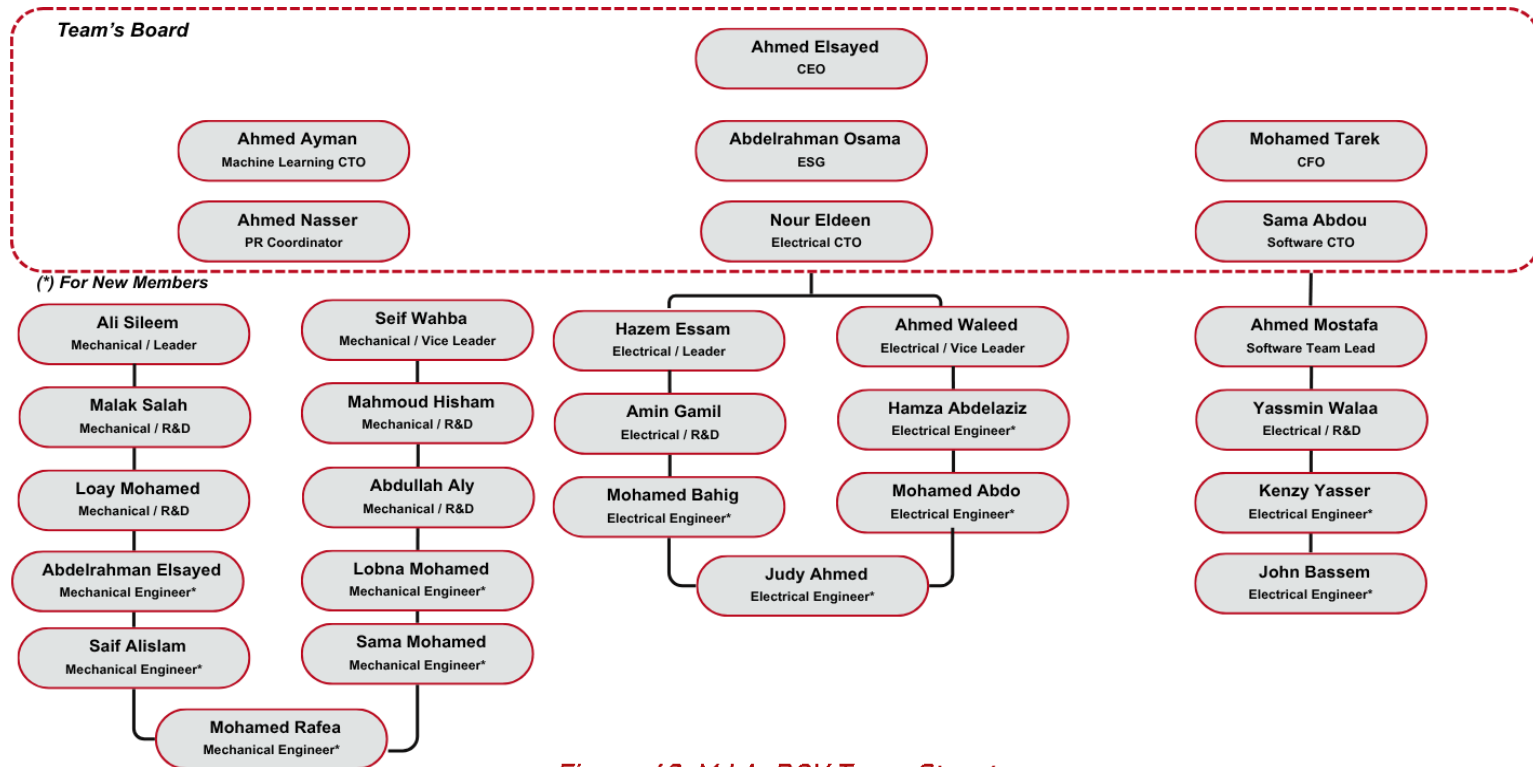


Figure 40: M.I.A. ROV Team Structure

### B- Budget Planning

Table 12: Budget Planning

| Budget Planning (From 1/8/2025 to 1/4/2026) |                        |           |                                                                                                                                            |                      |                        |                                   |                           |
|---------------------------------------------|------------------------|-----------|--------------------------------------------------------------------------------------------------------------------------------------------|----------------------|------------------------|-----------------------------------|---------------------------|
| 1 USD ≈50 EGP                               |                        |           |                                                                                                                                            |                      |                        |                                   |                           |
| INCOMES                                     | Donated/Raised         |           | Funds From The Last Year / Donations From Our Alumni                                                                                       | \$1,000.00           |                        |                                   |                           |
|                                             | Raised                 |           | Employee Dues                                                                                                                              | \$3,200.00           |                        |                                   |                           |
| Main Category                               | Sub Category / Purpose | Type      | Description                                                                                                                                | Projected Cost (USD) | Allocated Budget (USD) | Projected Cost Per Category (USD) | Budget Per Category (USD) |
| Administration                              | Marketing              | Re-used   | Ex: Poster, Flags, Banners                                                                                                                 | \$50.00              | -                      | \$1,935.00                        | \$1,885.00                |
|                                             | Marketing              | Purchased | Ex: Flyers, T-Shirts, Posters                                                                                                              | \$230.00             | \$230.00               |                                   |                           |
|                                             | Registration           | Purchased | Ex: MATE ROV Registration Fees, Fluid Power Quiz Fees                                                                                      | \$705.00             | \$705.00               |                                   |                           |
|                                             | Testing Logistics      | Purchased | Ex: Villa Rent, Transportation                                                                                                             | \$950.00             | \$950.00               |                                   |                           |
| Electrical                                  | Electrical Components  | Purchased | Ex: 30m CAT6 Ethernet Cable, Connectors and Cables, DC Motors, Servo Motors, Water Pump, etc.                                              | \$130.00             | \$130.00               | \$3,268.70                        | \$233.00                  |
|                                             | Electrical Components  | Re-used   | Ex: DC-DC Converters (48V to 12V), DC-DC Converter (48V to 5V), 30m Power Cable 10AWG, 8x Blue Robotics T200 Thrusters and ESCs, USB Hubs. | \$2,100.00           | -                      |                                   |                           |
|                                             | Microprocessors        | Purchased | Ex: Microcontrollers                                                                                                                       | \$25.00              | \$25.00                |                                   |                           |
|                                             | Microprocessors        | Re-used   | Ex: Jetson Nano                                                                                                                            | \$291.10             | -                      |                                   |                           |
|                                             | Sensors                | Purchased | Ex: Water Presure Sensor, etc.                                                                                                             | \$20.00              | \$20.00                |                                   |                           |
|                                             | Sensors                | Re-used   | Ex: IMU Sensor, Gas Pressure Sensor                                                                                                        | \$17.00              | -                      |                                   |                           |
|                                             | Vision System          | Purchased | Ex: 3x Digital Mono Camera                                                                                                                 | \$58.00              | \$58.00                |                                   |                           |
|                                             | Vision System          | Re-used   | Ex: Stereo ZED Camera, 5x Digital Mono Camera                                                                                              | \$627.60             | -                      |                                   |                           |
| General                                     | Equipment              | Purchased | Ex: Circclip Pliers, Crimpers, Etching Solution Acid, Soldering Paste Flux, Fiber glass PCB Boards, etc.                                   | \$40.00              | \$40.00                | \$456.00                          | \$80.00                   |
|                                             | Equipment              | Re-used   | Ex: Electric Screw Driver, Crimpers, Wire Cutters/Strippers, Driller, Grinder, Tree Drill, Desoldering Pump , Soldering Iron, Hot Gun      | \$376.00             | -                      |                                   |                           |
|                                             | Prototyping            | Purchased | Ex: Aluminum Extrusion Welding, Wood For Prototypes, Floatation Boards, etc.                                                               | \$40.00              | \$40.00                |                                   |                           |
| Mechanical                                  | Fabrication            | Purchased | Ex: Laser Cutting, Machining Services, Milling, Turning, etc.                                                                              | \$150.00             | \$150.00               | \$945.58                          | \$805.00                  |
|                                             | Miscellaneous          | Purchased | Ex: Bearings & Couplers, Fasteners, T200 Propellers, etc.                                                                                  | \$120.00             | \$120.00               |                                   |                           |
|                                             | Pneumatic              | Purchased | Ex: Pneumatic Hoses, Pneumatic Fittings and Connections, Solenoids                                                                         | \$124.00             | \$122.90               |                                   |                           |
|                                             | Pneumatic              | Re-used   | Ex: Air Compressor, Pneumatic Regulators, Pneumatic Actuators                                                                              | \$139.58             | -                      |                                   |                           |
|                                             | Raw Material           | Purchased | Ex: Aluminum Sheets, PLA+ Filament, Acrylic Sheet, Aluminum Extruded Links, etc.                                                           | \$325.00             | \$325.00               |                                   |                           |
|                                             | Sealing                | Purchased | Ex: O-rings, Wire Glands, Teflon, Mechanical Seals, etc.                                                                                   | \$87.00              | \$87.00                |                                   |                           |
| Operation                                   | Propbuilding           | Purchased | Ex: PVC, Extra Items (O-balls and Carbiners), etc.                                                                                         | \$35.00              | \$35.00                | \$865.80                          | \$48.00                   |
|                                             | Propbuilding           | Re-used   | Ex: PVC                                                                                                                                    | \$40.00              | -                      |                                   |                           |
|                                             | Safety                 | Purchased | Ex: First Aid Kits                                                                                                                         | \$13.00              | \$13.00                |                                   |                           |
|                                             | Safety                 | Re-used   | Ex: Life Jackets, Water Resisting Shoes, Safety Goggles, Non-slip Gloves, Ear Plugs                                                        | \$33.00              | -                      |                                   |                           |
|                                             | TPU                    | Re-used   | Ex: Station Box, 2K Screen Monitor, PS5 Controller, Power supply, 30A - Fuse, setc.                                                        | \$744.80             | -                      |                                   |                           |
| Total Income:                               |                        |           |                                                                                                                                            | \$4,200.00           |                        |                                   |                           |
| Total Purchased/Budget:                     |                        |           |                                                                                                                                            | \$3,051.00           |                        |                                   |                           |
| Total Reused/Donated:                       |                        |           |                                                                                                                                            | \$4,420.08           |                        |                                   |                           |
| Total Estimated Cost of The Project:        |                        |           |                                                                                                                                            | \$7,471.08           |                        |                                   |                           |

## C- Safety Checklist

Table 13: Safety Checklist

| Construction                                                                                | Operation                                                                  |                                                                           |
|---------------------------------------------------------------------------------------------|----------------------------------------------------------------------------|---------------------------------------------------------------------------|
|                                                                                             | Pre-Power Test                                                             | In Water                                                                  |
| <input type="checkbox"/> Keep the workspace clean and free of debris.                       | <input type="checkbox"/> Area safe (no tripping hazards, items in the way) | <input type="checkbox"/> Check for bubbles, if large, pull ROV to surface |
| <input type="checkbox"/> Store materials properly to prevent tripping hazards               | <input type="checkbox"/> Verify switches and circuit breakers are off      | <input type="checkbox"/> Visual inspect for water leaks                   |
| <input type="checkbox"/> Use safety goggles or face shields when cutting and grinding.      | <input type="checkbox"/> Tether flaked out on deck secured to ROV          | <input type="checkbox"/> Engage thrusters and begin operations            |
| <input type="checkbox"/> Use appropriate gloves for handling materials                      | <input type="checkbox"/> Strain relief connected to ROV                    | <b>Loss of Communication</b>                                              |
| <input type="checkbox"/> Inspect all machinery for any damage or wear before use.           | <input type="checkbox"/> Electronics housing sealed                        | <input type="checkbox"/> Cycle power on TCU to reboot ROV                 |
| <input type="checkbox"/> Ensure all guards and safety devices are in place and functioning. | <input type="checkbox"/> Visual inspection for damaged wires               | <input type="checkbox"/> If no communication, power down ROV              |
| <input type="checkbox"/> Follow manufacturer's instructions and safety guidelines.          | <input type="checkbox"/> Nuts tight on electronics housing                 | <input type="checkbox"/> If communication is restored, resume operation   |
| <input type="checkbox"/> Ensure all energy sources are properly isolated before servicing.  | <input type="checkbox"/> Thrusters free from obstructions                  | <b>Pit Maintenance</b>                                                    |
| <input type="checkbox"/> Store materials securely to prevent falls or spills.               | <input type="checkbox"/> Set compressor output to 2.75 bar Power Up        | <input type="checkbox"/> Verify thrusters are free of foreign objects     |
| <input type="checkbox"/> Inspect electrical cords for damage before use.                    | <input type="checkbox"/> Power source connected to TCU                     | <input type="checkbox"/> Visual inspection for any damage                 |
| <input type="checkbox"/> Ensure proper grounding of electrical equipment.                   | <input type="checkbox"/> TCU receiving 48 Volts nominal                    | <input type="checkbox"/> Ensure that all cables are neatly secured        |
| <input type="checkbox"/> Disconnect power when changing accessories or making repairs.      | <input type="checkbox"/> Control computers up and running                  | <input type="checkbox"/> Verify tether is free of kinks                   |
|                                                                                             | <input type="checkbox"/> Ensure deck crew members are attentive            | <input type="checkbox"/> Visual inspect for leaks                         |
|                                                                                             | <input type="checkbox"/> Power on TCU                                      | <input type="checkbox"/> Test onboard tools                               |
|                                                                                             | <input type="checkbox"/> Verify thrusters are working properly             | <input type="checkbox"/> Verify camera positions                          |
|                                                                                             | <input type="checkbox"/> Verify video feeds                                | <input type="checkbox"/> Washdown thrusters with water                    |

## D- Task-Specific Safety Procedures

Table 14: Task-Specific Safety Procedures

| Task                          | Potential Hazard                                                                                                                                     | Mitigation Procedures                                                                                                                                                                                                                    |
|-------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Buoy Anchor Recovery</b>   | Recovery line entangling in thrusters or external objects, overrunning (backlashing) during fast spool-out or dangerous and uncontrolled unspooling. | Continuously monitor the recovery line.<br>Encase exposed line sections in a frictionless pneumatic tube.<br>Use a TPU [Thermoplastic Polyurethane] cover on the spool.<br>Ensure the spool mechanism is correctly coupled to the motor. |
| <b>New eDNA Installation</b>  | The New eDNA cable looping around external objects or entering the thrusters.                                                                        | Securely hold the eDNA cable alongside the sensor using the non-parallel gripper.                                                                                                                                                        |
| <b>Micropile Installation</b> | Accidental dropping of the micropile pin, leading to underwater environmental pollution.                                                             | Stage auxiliary magnet at poolside for immediate retrieval.                                                                                                                                                                              |
| <b>Lobster Pot Retrieval</b>  | The weight of the pot restricts ROV maneuverability, causing unnecessary collisions with the underwater environment.                                 | Strictly execute this as the absolute last task in the dive sequence.                                                                                                                                                                    |
| <b>General Navigation</b>     | Unseen proximity hazards causing the ROV to damage the underwater environment or its own frame.                                                      | Co-pilots continuously monitor secondary cameras to verbally warn pilot of very near objects or pool sides.                                                                                                                              |

## E- Pneumatic SID

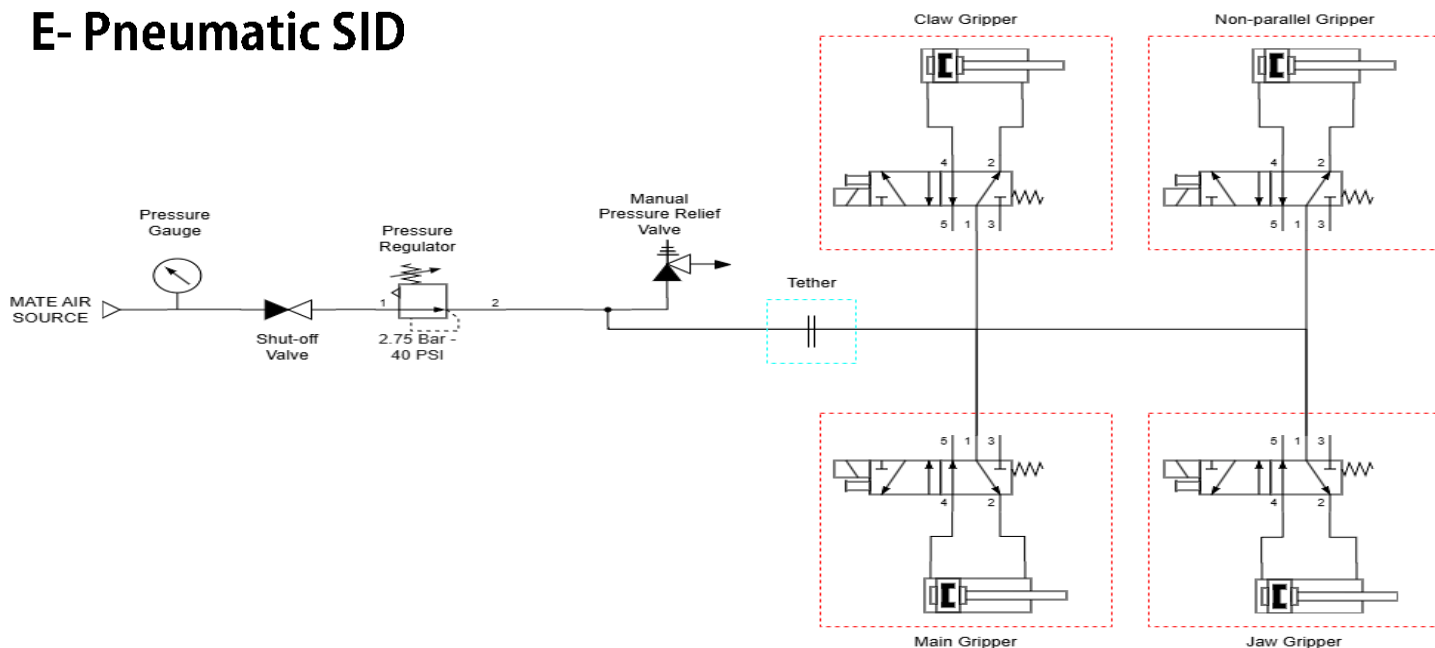


Figure 41: Gensys's Pneumatic SID

## F- Project Timeline

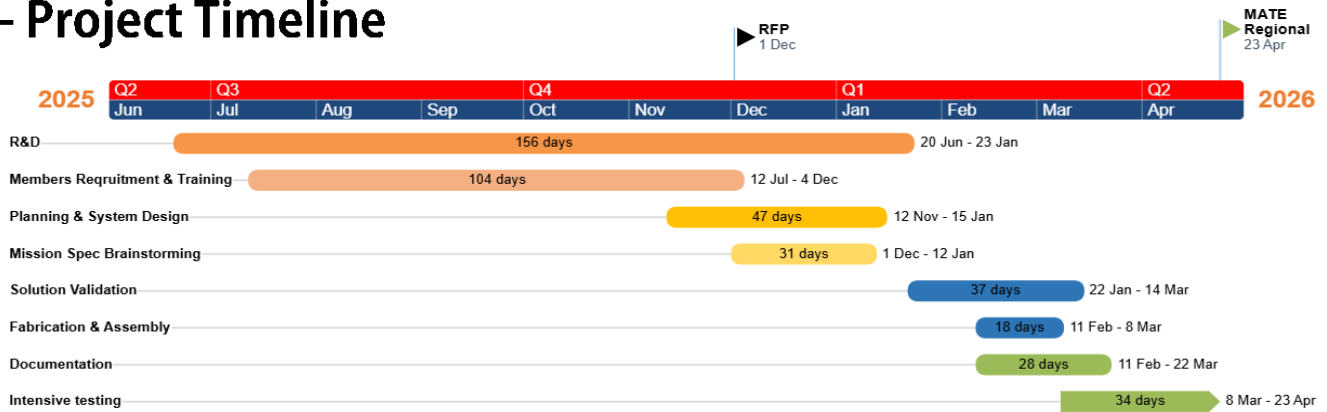


Figure 42: Timeline for MATE 2026

## G- Electrical SID

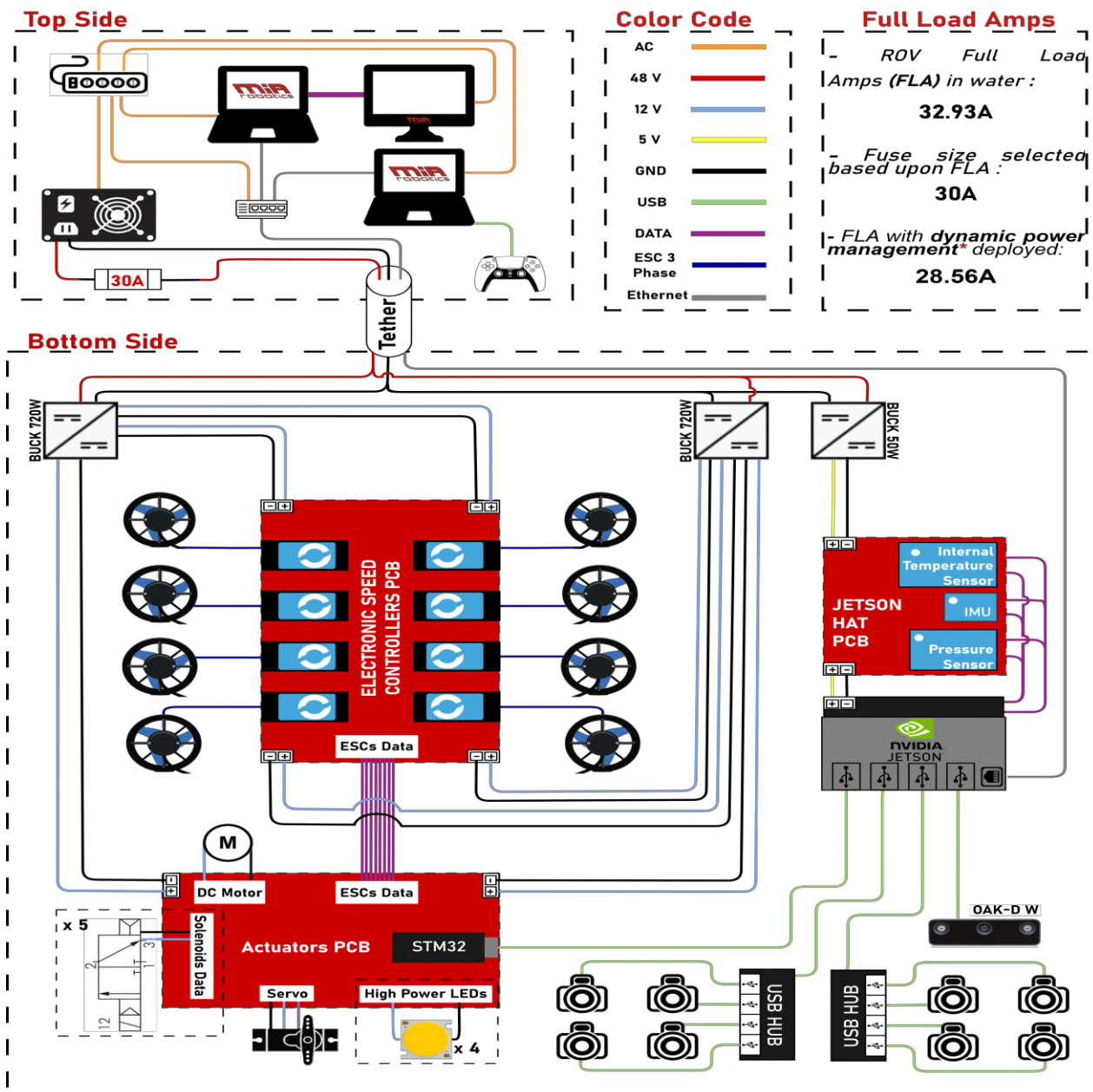


Figure 43: Gensys's Electrical SID

\* Our system's maximum power consumption exceeds the allowed power budget. Therefore, the system is equipped with a Dynamic Power Management System (DPMS) ([Section 1.1.4](#)) to keep the total nominal power consumption within the allowed range.

## H- Project Costing

Table 15: Project Costing

| Project Costing (From 1/8/2025 to 1/4/2026)<br>1 USD ≈ 50 EGP |                       |                                            |                                                |                                                                  |                                                          |                       |                              |                                     |       |
|---------------------------------------------------------------|-----------------------|--------------------------------------------|------------------------------------------------|------------------------------------------------------------------|----------------------------------------------------------|-----------------------|------------------------------|-------------------------------------|-------|
|                                                               | Type                  | Item(s)                                    | Description                                    | Amount (USD)                                                     | Project Cost (USD)                                       | Running Balance (USD) | Cost Paid Per Category (USD) | Budget Allocated Per Category (USD) |       |
|                                                               | Incomes               |                                            |                                                |                                                                  |                                                          |                       |                              |                                     |       |
|                                                               | 1                     | Donated/Raised                             |                                                | Funds From The Last Year / Donations From Our Alumni             | 100.0                                                    |                       | 100.0                        |                                     |       |
|                                                               | 2                     | Cash Raised                                | Employee Dues                                  |                                                                  | 320.0                                                    |                       | 420.0                        |                                     |       |
| Mechanical                                                    | Raw Material          |                                            |                                                |                                                                  |                                                          |                       |                              |                                     |       |
|                                                               | 1                     | Purchased                                  | Aluminum Sheets 4mm                            | External Frame Material                                          | 74                                                       | 74                    | 412.6                        |                                     |       |
|                                                               | 2                     | Purchased                                  | Aluminum Sheets 6mm                            | Enclosure Material                                               | 176                                                      | 250                   | 395.0                        |                                     |       |
|                                                               | 3                     | Purchased                                  | 3D Printing and Material                       | 3D Printing Material, Camera Rolls                               | 48                                                       | 298                   | 390.2                        |                                     |       |
|                                                               | 4                     | Purchased                                  | Acrylic Sheet                                  | Camera's Casing Cap, Mechanisms, Enclosure Electrical Structure  | 24                                                       | 322                   | 387.8                        |                                     |       |
|                                                               | 5                     | Purchased                                  | Aluminum Extruded Links                        | Frame Material                                                   | 32                                                       | 354                   | 384.6                        |                                     |       |
|                                                               | 6                     | Purchased                                  | HDPE and POM                                   | Mechanisms Material                                              | 62                                                       | 416                   | 378.4                        |                                     |       |
|                                                               | Machining Services    |                                            |                                                |                                                                  |                                                          |                       |                              |                                     |       |
|                                                               | 1                     | Purchased                                  | Laser Cutting                                  | Aluminum Sheet and Extruded Links                                | 36                                                       | 452                   | 374.8                        |                                     |       |
|                                                               | 2                     | Purchased                                  | Milling                                        | Acrylic For Mechanisms & Camera Casings                          | 20                                                       | 472                   | 372.8                        |                                     |       |
|                                                               | 3                     | Purchased                                  | Turning                                        | Camera Casings                                                   | 24                                                       | 496                   | 370.4                        |                                     |       |
|                                                               | 4                     | Purchased                                  | Router                                         | HDPE Cutting For Mechanisms                                      | 28                                                       | 524                   | 367.6                        |                                     |       |
|                                                               | 5                     | Purchased                                  | ESCs Board Fabrication                         |                                                                  | 60                                                       | 584                   | 361.6                        |                                     |       |
|                                                               | 6                     | Purchased                                  | Welding                                        | Electrical Enclosure Joining & Frame                             | 26.7                                                     | 610.7                 | 358.3                        |                                     |       |
|                                                               | Pneumatic Components  |                                            |                                                |                                                                  |                                                          |                       |                              |                                     |       |
|                                                               | 1                     | Re-used                                    | Air Compressor                                 | Fluid Power Supply                                               | 125                                                      | 735.7                 | 358.3                        | 857.1                               | 855   |
|                                                               | 2                     | Re-used                                    | Pneumatic Regulators                           |                                                                  | 14.58                                                    | 750.28                | 358.3                        |                                     |       |
|                                                               | 3                     | Purchased                                  | Pneumatic Hoses                                | Fluid transportation Lines (ROV Tether and Internal Connections) | 13.5                                                     | 763.78                | 357.8                        |                                     |       |
|                                                               | 4                     | Purchased                                  | Pneumatic Fittings and Connections             |                                                                  | 12.4                                                     | 776.18                | 356.3                        |                                     |       |
|                                                               | 5                     | Purchased                                  | 5/2 Solenoid Actuated - Pilot Operated DCVs    | Control Actuators' Direction                                     | 30                                                       | 806.18                | 353.4                        |                                     |       |
|                                                               | 6                     | Purchased                                  | Pneumatic Actuators                            | Linear Actuators                                                 | 5                                                        | 811.18                | 352.4                        |                                     |       |
|                                                               | Miscellaneous         |                                            |                                                |                                                                  |                                                          |                       |                              |                                     |       |
|                                                               | 1                     | Purchased                                  | Bearings & Couplers                            |                                                                  | 29                                                       | 840.18                | 349.4                        |                                     |       |
|                                                               | 2                     | Purchased                                  | Fasteners                                      | Bolts, Nuts and Washers for Fixation                             | 65                                                       | 905.18                | 343.4                        |                                     |       |
|                                                               | 3                     | Purchased                                  | T200 Propellers                                | Maintenance For The Re-used Thrusters                            | 30                                                       | 935.18                | 340.4                        |                                     |       |
|                                                               | Sealing Components    |                                            |                                                |                                                                  |                                                          |                       |                              |                                     |       |
| 1                                                             | Purchased             | O-rings                                    | Electrical Enclosure & Camera's Casings        | 15                                                               | 950.18                                                   | 338.4                 |                              |                                     |       |
| 2                                                             | Purchased             | Wire Glands                                | Wires Sealing                                  | 20                                                               | 970.18                                                   | 336.4                 |                              |                                     |       |
| 3                                                             | Purchased             | Teflon                                     | Threads' Sealing                               | 5                                                                | 975.18                                                   | 336.4                 |                              |                                     |       |
| 4                                                             | Purchased             | Mechanical Seals                           | Dynamic Seal For The Motors                    | 1.5                                                              | 976.68                                                   | 336.2                 |                              |                                     |       |
| 5                                                             | Purchased             | Epoxy                                      | Wires Sealing                                  | 20                                                               | 996.68                                                   | 334.2                 |                              |                                     |       |
| General                                                       | Equipment             |                                            |                                                |                                                                  |                                                          |                       |                              |                                     |       |
|                                                               | 1                     | Re-used                                    | Electric Screw Driver                          |                                                                  | 48                                                       | 1044.68               | 334.2                        |                                     |       |
|                                                               | 2                     | Purchased                                  | Crimp Pliers, Crimpers                         | Small-Job Fabrication                                            | 30                                                       | 1074.68               | 331.2                        |                                     |       |
|                                                               | 3                     | Re-used                                    | Wire Cutters/Strippers                         |                                                                  | 12                                                       | 1086.68               | 331.2                        |                                     |       |
|                                                               | 4                     | Re-Used                                    | Drill, Grinder, Tree Drill and Snappers        |                                                                  | 290                                                      | 1376.68               | 331.2                        |                                     |       |
|                                                               | PCB Fabrication       |                                            |                                                |                                                                  |                                                          |                       |                              |                                     |       |
|                                                               | 1                     | Purchased                                  | Etching Solution Acid                          |                                                                  | 2                                                        | 137.68                | 331.0                        | 72.5                                | 80    |
|                                                               | 2                     | Purchased                                  | Soldering Paste Flux                           |                                                                  | 2                                                        | 138.08                | 330.8                        |                                     |       |
|                                                               | 3                     | Purchased                                  | Fiber glass PCB Boards                         |                                                                  | 20                                                       | 140.08                | 328.8                        |                                     |       |
|                                                               | 4                     | Re-Used                                    | Hot Gun                                        |                                                                  | 5                                                        | 140.58                | 328.8                        |                                     |       |
|                                                               | 5                     | Re-Used                                    | Digital Soldering Iron                         | Tools                                                            | 16                                                       | 142.18                | 328.8                        |                                     |       |
|                                                               | 6                     | Re-Used                                    | Desoldering Pump 366-D                         |                                                                  | 2                                                        | 142.38                | 328.8                        |                                     |       |
|                                                               | 7                     | Purchased                                  | Tin Lead Soldering wire                        |                                                                  | 10                                                       | 143.38                | 327.8                        |                                     |       |
|                                                               | Prototyping           |                                            |                                                |                                                                  |                                                          |                       |                              |                                     |       |
| 1                                                             | Purchased             | Aluminum Extrusion Welding                 | Strength Testing                               | 5                                                                | 143.88                                                   | 327.3                 |                              |                                     |       |
| 2                                                             | Purchased             | Wood For Prototypes (Example: Testing Rig) | Aluminum Machining Process (Optimum Selection) | 3.5                                                              | 144.218                                                  | 327.0                 |                              |                                     |       |
| Electrical Components                                         | Vision System         |                                            |                                                |                                                                  |                                                          |                       |                              |                                     |       |
|                                                               | 1                     | Re-used                                    | 1x Stereo OAK-D W Camera                       |                                                                  | 449                                                      | 1891.18               | 327.0                        |                                     |       |
|                                                               | 2                     | Re-Used                                    | 5x Digital Mono Camera                         |                                                                  | 178.6                                                    | 2069.78               | 327.0                        |                                     |       |
|                                                               | 3                     | Purchased                                  | 3x Digital Mono Camera                         |                                                                  | 58                                                       | 2127.78               | 321.2                        |                                     |       |
|                                                               | Sensors               |                                            |                                                |                                                                  |                                                          |                       |                              |                                     |       |
|                                                               | 1                     | Purchased                                  | Gas Pressure Sensor                            | For ROV Motion Feedback                                          | 1.5                                                      | 2129.28               | 321.0                        | 204                                 | 233   |
|                                                               | 2                     | Re-Used                                    | IMU Sensor                                     |                                                                  | 15.6                                                     | 2144.88               | 321.0                        |                                     |       |
|                                                               | Electrical Components |                                            |                                                |                                                                  |                                                          |                       |                              |                                     |       |
|                                                               | 1                     | Re-Used                                    | DC-DC Converter (48V to 12V)                   | For Voltage Step-down                                            | 140                                                      | 2284.88               | 321.0                        |                                     |       |
|                                                               | 2                     | Re-used                                    | DC-DC Converter (48V to 5V)                    |                                                                  | 9.5                                                      | 2294.38               | 321.0                        |                                     |       |
|                                                               | 3                     | Purchased                                  | 30m 10M CAT6 6c Ethernet Cable                 | For ROV Tether                                                   | 15                                                       | 2309.38               | 319.9                        |                                     |       |
|                                                               | 4                     | Re-used                                    | 30m Power Cable 10AWG                          |                                                                  | 150                                                      | 2459.38               | 319.9                        |                                     |       |
|                                                               | 5                     | Purchased                                  | Connectors, Data Headers and Cables            | PCB Power and Communication                                      | 13                                                       | 247.238               | 318.2                        |                                     |       |
|                                                               | 6                     | Re-used                                    | 8x Blue Robotics T200 Thrusters                | 8x For ROV Movement                                              | 180.0                                                    | 427.238               | 318.2                        |                                     |       |
|                                                               | 7                     | Re-Used                                    | 8x Blue Robotics ESCs                          | For thrusters' control                                           | 224                                                      | 449.638               | 318.2                        |                                     |       |
|                                                               | 8                     | Re-used                                    | 3x USB Hub                                     |                                                                  | 10.2                                                     | 459.638               | 318.2                        |                                     |       |
|                                                               | 9                     | Purchased                                  | DC Motors                                      |                                                                  | 5                                                        | 451.138               | 317.9                        |                                     |       |
|                                                               | 10                    | Purchased                                  | Water Pump                                     |                                                                  | 4.5                                                      | 451.608               | 317.3                        |                                     |       |
| 11                                                            | Purchased             | Pressure Sensor                            |                                                | 15                                                               | 453.108                                                  | 315.8                 |                              |                                     |       |
| 12                                                            | Purchased             | Servo Motors                               |                                                | 80                                                               | 461.108                                                  | 307.8                 |                              |                                     |       |
| Operation                                                     | Microprocessors       |                                            |                                                |                                                                  |                                                          |                       |                              |                                     |       |
|                                                               | 1                     | Re-Used                                    | Jetson Nano                                    | Main Computer of the ROV                                         | 291                                                      | 490.208               | 307.8                        |                                     |       |
|                                                               | 2                     | Purchased                                  | 4x STM32F4xxx, 2x ESP32S                       | Microcontroller                                                  | 12                                                       | 491.408               | 306.6                        |                                     |       |
|                                                               | Top Side Control Unit |                                            |                                                |                                                                  |                                                          |                       |                              |                                     |       |
|                                                               | 1                     | Re-Used                                    | Station Box                                    |                                                                  | 59                                                       | 497.308               | 306.6                        |                                     |       |
|                                                               | 2                     | Re-Used                                    | 2K Screen Monitor                              |                                                                  | 60                                                       | 503.308               | 306.6                        |                                     |       |
|                                                               | 3                     | Re-Used                                    | PS5 Controller                                 | Station Components                                               | 95                                                       | 512.808               | 306.6                        |                                     |       |
|                                                               | 4                     | Re-Used                                    | Power supply                                   |                                                                  | 485                                                      | 561.308               | 306.6                        |                                     |       |
|                                                               | 5                     | Re-Used                                    | Switch Connector                               |                                                                  | 13                                                       | 562.808               | 306.6                        |                                     |       |
|                                                               | 6                     | Re-Used                                    | Fuse Holder                                    |                                                                  | 11.91                                                    | 563.799               | 306.4                        |                                     |       |
|                                                               | 7                     | Re-Used                                    | 30A- Fuses                                     | For Safety                                                       | 11                                                       | 564.899               | 306.4                        |                                     |       |
|                                                               | 8                     | Re-Used                                    | Anderson Connector                             |                                                                  | 11.3                                                     | 566.029               | 306.4                        |                                     |       |
|                                                               | Propbuilding          |                                            |                                                |                                                                  |                                                          |                       |                              |                                     |       |
|                                                               | 1                     | Purchased                                  | PVC                                            | For building the underwater playground to test the ROV missions  | 20                                                       | 568.029               | 304.6                        | 48                                  | 48    |
|                                                               | 2                     | Re-Used                                    | PVC                                            |                                                                  | 40                                                       | 572.029               | 304.6                        |                                     |       |
|                                                               | 3                     | Purchased                                  | O-balls and Carbiners                          |                                                                  | 15                                                       | 573.529               | 303.1                        |                                     |       |
|                                                               | Safety                |                                            |                                                |                                                                  |                                                          |                       |                              |                                     |       |
|                                                               | 1                     | Re-Used                                    | 2x Life Jackets                                |                                                                  | 13                                                       | 574.829               | 303.1                        |                                     |       |
| 2                                                             | Re-Used               | Water Resisting Shoes                      | Tethermen's Safety                             | 12.5                                                             | 576.079                                                  | 303.1                 |                              |                                     |       |
| 3                                                             | Re-Used               | 2x Safety Goggles                          |                                                | 6.5                                                              | 576.729                                                  | 303.1                 |                              |                                     |       |
| 4                                                             | Re-Used               | Non-slip Gloves                            |                                                | 5                                                                | 577.229                                                  | 303.1                 |                              |                                     |       |
| 5                                                             | Re-Used               | 4x Ear plugs                               |                                                | 1                                                                | 577.329                                                  | 303.1                 |                              |                                     |       |
| 6                                                             | Purchased             | 3x first aid kit                           | For Workshop                                   | 13                                                               | 578.629                                                  | 301.8                 |                              |                                     |       |
| Administration                                                | MATE ROV Competition  |                                            |                                                |                                                                  |                                                          |                       |                              |                                     |       |
|                                                               | 1                     | Purchased                                  | MATE ROV Registration Fees                     | International Competition                                        | 390                                                      | 617.629               | 262.8                        |                                     |       |
|                                                               | 2                     | Purchased                                  | MATE ROV Registration Fees                     | Regional Competition                                             | 280                                                      | 645.629               | 234.8                        |                                     |       |
|                                                               | 3                     | Purchased                                  | Fluid Power Quiz Fees                          |                                                                  | 35                                                       | 649.129               | 231.3                        |                                     |       |
|                                                               | Marketing Purposes    |                                            |                                                |                                                                  |                                                          |                       |                              |                                     |       |
|                                                               | 1                     | Purchased                                  | Poster                                         |                                                                  | 11                                                       | 650.229               | 230.2                        | 189.0                               | 188.5 |
|                                                               | 2                     | Purchased                                  | Flyers & Stickers                              |                                                                  | 25                                                       | 652.729               | 227.7                        |                                     |       |
|                                                               | 3                     | Re-Used                                    | Banners                                        |                                                                  | 27                                                       | 655.429               | 227.7                        |                                     |       |
|                                                               | 4                     | Purchased                                  | T-Shirts                                       |                                                                  | 200                                                      | 675.429               | 207.7                        |                                     |       |
|                                                               | 5                     | Re-Used                                    | 2x Flag                                        |                                                                  | 25                                                       | 677.929               | 207.7                        |                                     |       |
|                                                               | ROV Testing Logistics |                                            |                                                |                                                                  |                                                          |                       |                              |                                     |       |
|                                                               | 1                     | Purchased                                  | Villa Rent                                     | With a swimming pool to test the ROV                             | 930                                                      | 770.929               | 1147.4                       |                                     |       |
|                                                               | 2                     | Purchased                                  | Transportation                                 | Fuel, Tolls & material transportation                            | 19                                                       | 772.829               | 1128.4                       |                                     |       |
|                                                               | Total                 |                                            |                                                | 772.829                                                          |                                                          |                       | Description                  |                                     |       |
| Project Cost (USD)                                            |                       |                                            |                                                | 772.829                                                          | Total costs of the project including the re-used items   |                       |                              |                                     |       |
| Re-Used and Donations (USD)                                   |                       |                                            |                                                | 465.669                                                          | Donations and re-used items from the last years' project |                       |                              |                                     |       |
| Project Cost without Re-Used                                  |                       |                                            |                                                | 307.16                                                           | Paid project cost                                        |                       |                              |                                     |       |
| Total Income (USD)                                            |                       |                                            |                                                | 420.0                                                            | Funds raised from the employees, prizes, and donations   |                       |                              |                                     |       |
| Total Balance (USD)                                           |                       |                                            |                                                | 1128.4                                                           | Incomes - Expenses                                       |                       |                              |                                     |       |