

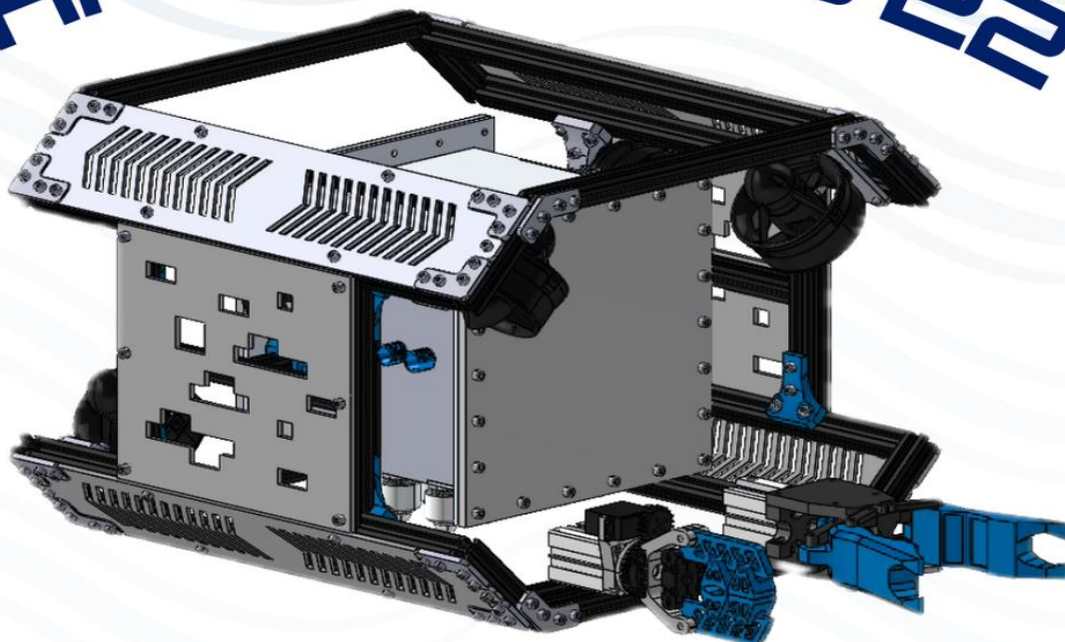


Alexandria, Egypt
Technical Report



2026

FAST TRITON ROVS SHADOW-WING'22



Under the Supervision of
Eng. Muhammad Mongy

27' Mohamed Ehab CEO
27' Aly Abelelah ME Head/ CFO
27' Yahia Mohamed COO
27' Mohamed Osama CTO
28' Youssef Hashem SW Head
27' Youssef Waleed Control Head
27' Saged Khaled Vision Head
27' Adham Waheeb GUI Head
27' Jana Ayman SW
27' Salma Sherif Float Head
30' Ziad Gado SW
28' Hadeer Amer SW
27' Abdelrahman Ahmed SW
27' Kenzy Baher SW

28' Menna Ahmed SW
27' Ahmed Mansour SW
30' Mohamed Sherif SW
27' Gamal Elmarangooz SW
28' Aya Yasser SW
27' Nour Walid SW
28' Marwan Mahmoud SW
26' Marwan Hossam SW
29' Zeina Magdy SW
27' Ziad Magdy EC Head
28' Mariam Mohamed EC / Non Tech.
27' Mohamed Sherif EC
27' Seif Alaa EC
27' Seifeldin Waleed EC

28' Amro Tarek ME / Pilot
28' Aleyeldin Bassam ME
28' Sherif Fahmy ME
29' Farida Gouda ME
28' Bassam Hisham ME
28' Youssef Mohamed ME
28' Abdallah Khaled ME
28' Abdelrahman Salama ME
28' Malak Islam Non Tech.
28' Sama Ahmed Non Tech.
26' Logy Magdy Non Tech.
28' Salma Mohamed Non Tech.



Abstract

Founded in 2024 at the Arab Academy for Science, Technology and Maritime Transport, Team **Triton** is a student-led engineering team participating in the **MATE ROV** Competition. A Photograph of team is shown in *Fig. 1* In its first year of participation, the team achieved **fourth place** in the **Explorer** category, marking a strong foundation for continuous technical growth and **innovation**. Team Triton is committed to bridging the gap between performance and practicality by developing high-quality engineering solutions. This philosophy drives the design and development of **SHADOW-WING'22** as shown in *Fig.2*, the team's **2026 competition ROV**. The system is engineered to meet both industry standards and address **MATE 2026 Competition tasks** while maximizing learning outcomes and technical skill development among team members. **SHADOW-WING'22** features a **fully modular architecture** across mechanical, electrical, and software systems. The mechanical frame is **reconfigurable**, enabling **rapid adaptation** to varying mission requirements. Electrically, the system integrates professionally designed multilayer PCBs with enhanced protection mechanisms to ensure reliability and safety. On the software level, the team developed a fully customized control independent of pre-built platforms, ensuring flexibility, scalability, and future expandability. This abstract provides an overview of the technical innovations, system architecture, and engineering methodologies detailed in the full report.



Figure 1: Team Triton — 41-member student engineering team at AASTMT, Alexandria

Acknowledgments

We would like to thank:

- **AASTMT & Regional Informatics Center** – For granting us access to the university swimming pool, which enabled effective testing and validation of our ROV system. For providing us with a dedicated laboratory environment that supported our design, development, and integration processes.
- **SolidWorks** – For providing us with a student license, allowing us to design, simulate, and optimize our mechanical systems with full professional capabilities.
- **MATE ROV Coordinators** – For their continuous efforts in developing and elevating the competition, and for fostering innovation and technical excellence among participating teams.
- **MATE II** – Empowering future generations to innovate, lead, and succeed
- **Blue-Sub Mechatronics**: For supporting us and accessing us with their components and technical support.



Figure 3: Organizations that provided financial, material, and facility support to our Team Triton



Figure 2: Shadow-Wing'22 — completed 2026 competition ROV

2026



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Project Management

Team Hierarchy and Description

Our team operates under a structured leadership model, with a **CEO**, **COO**, **CTO**, and **CFO**, the organization comprises 41 members and technical leads overseeing key operational areas. The Hierarchy is provided in [Appendix D](#). We are organized into four main sub-teams: Mechanical, Software, Electrical, and Non-Technical. Each sub-team is led by a team leader responsible for task delegation, and progress tracking, while maintaining close coordination with upper management. Our workflow includes weekly stand-up meetings, during which long-term goals are broken down into specific tasks with clear deadlines. Team members are assigned daily responsibilities and report their progress to their respective team leaders, ensuring consistent coordination and efficient execution.

Schedule

Triton divides the season into multiple phases:

Schedule is shown in *Fig.4*

Phase 1: Training and Workshops – Conducting intensive workshops to ensure the team understands ROV concepts, operations, and core engineering principles.

Phase 2: Research and Development (R&D) – Analyzing designs and creating a detailed plan for the Mechanical, Electrical, and Software systems.

Phase 3: Implementation and Testing – Implementing the R&D plans and conducting tests to validate system performance and efficiency.

Phase 4: Vertical Profiling Float Development – Running parallel to later phases, this involves scheduling and implementing the Vertical Profiling Float.

Phase 5: Documentation and Presentation Planning – Preparing accurate and well-structured technical and project-related documents.

Phase 6: Strategy and Tasks Planning with Pilot – This phase is the final water and pilot testing.

Phase 7: Travel Preparations – ROV transport, logistics, and personnel travel document preparation.

Resources Used

We utilized a range of software tools and digital platforms to enhance productivity, streamline project management, and ensure effective collaboration among all sub-teams.

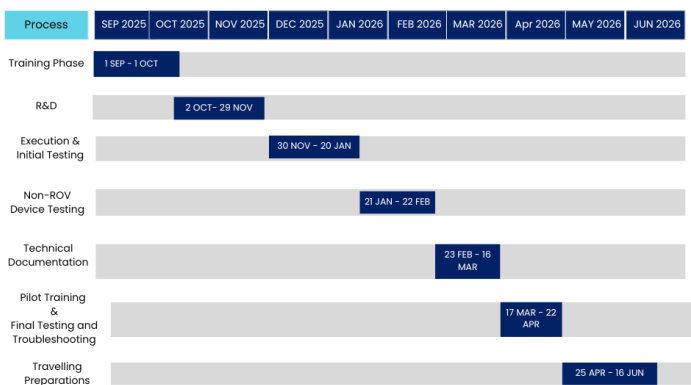
1. **GitHub:** Utilized for version control and collaborative software development, ensuring code reliability, structured updates, and efficient management of our software repositories.
2. **Google Drive:** Served as our central platform for storing and sharing administrative documents, reports, and team resources, enabling easy access and organized file management.
3. **Canva:** Used to design posters, flyers, and promotional materials to support the team's outreach and marketing activities.
4. **Meta Business Suite:** Employed to manage and schedule content across our Facebook and Instagram platforms, helping us maintain a consistent and professional online presence.
5. **EasyEDA:** Used for designing and developing our custom Printed Circuit Boards (PCBs), enabling efficient electronic system integration.
6. **SolidWorks:** Utilized for creating and refining our CAD models, allowing us accurately design, simulate, and optimize the mechanical components of the ROV.

Operational Problem Solving

During Phase 3, several electrical members left the team due to personal circumstances, creating a critical capacity gap. The COO issued an immediate recruitment call, onboarded new members within one week, and the CTO redistributed tasks by priority order. The team recovered full operational capacity within 8 days with no impact on the final deadline.

A second challenge was a lack of cross-team goal alignment, with members working in isolation and causing integration delays. The CEO introduced mandatory weekly stand-up meetings where each sub-team lead reported completed tasks, planned tasks, and current blockers. This created real-time visibility across all sub-teams.

Figure 4: Seven-phase project timeline spanning September 2025 to June 2026





Design Rationale

Design Concept and Planning

In the 2026 season, our team decided to develop a completely new ROV from the ground up rather than iterating on our previous vehicle. This decision was made to provide our new members with the opportunity to gain experience in designing and building an ROV from scratch, allowing them to fully understand the engineering process involved. To arrive at these design decisions, the team conducted structured brainstorming sessions during the R&D phase (October–November 2025). Each sub-team independently generated at least three design alternatives per major system component. Alternatives were evaluated using weighted decision matrices with criteria of cost, manufacturability, mission performance, and timeline feasibility. The highest-scoring option was adopted. Our new vehicle, Shadow-Wing'22, was designed to address several limitations encountered with our 2025 ROV, Deadpool. During the 2025 season, we identified multiple design challenges that affected operational efficiency. The limited vertical space within the frame made integration of mission-specific payloads difficult, restricting the system to a single gripper and two cameras, increasing pilot workload. The electrical architecture relied on direct cable connections rather than dedicated PCBs, resulting in signal noise, unstable connections, and increased system complexity. Additionally, the software system was largely dependent on pre-built solutions, limiting our ability to optimize it for our specific needs. For the 2026 season, our team aimed to address all of these challenges through a comprehensive redesign. Dimensions, weight, and cost are shown in Fig. 5

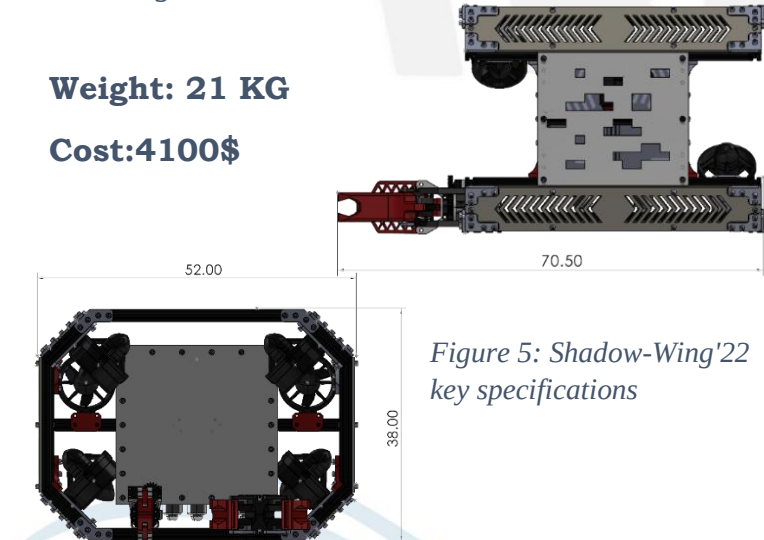


Figure 5: Shadow-Wing'22 key specifications

System Approach

We began with the mechanical design of our ROV, focusing on increasing the **vertical space** within the frame. This allowed us to accommodate multiple payloads, cameras, and grippers while maintaining flexibility for future expansions as shown in Table 1. Our goal was also to create a modular frame that supports different motor configurations, enabling easy adjustments depending on mission requirements. After finalizing the frame concept, we shifted our focus to the design of the electronic enclosures. We carefully considered the appropriate sizes and dimensions to ensure efficient component placement, minimize cable clutter, and simplify troubleshooting. To further improve organization and reliability, we decided to integrate custom PCBs. Comparison is shown in Table 2.

Aspect	Vertical Alignment
Space	Uses vertical space efficiently without enlarging the frame footprint
Payload Integration	Enables organized placement of cameras, grippers, and sensors in layers
Mobility	Keep the ROV compact.

Table 1: Vertical Alignment Pros

Aspect	PCBs	Cables
Reliability	More reliable connections	Higher chance of loose connections
Troubleshooting	Easier to Troubleshoot	Harder to trace
Cost vs Effort	Higher initial design and manufacturing cost	Lower cost but higher effort

Table 2: PCBs VS Cables



Vehicle System

Mechanical System

Material Selection

Selecting the right material for our ROV frame was critical to ensuring durability, performance, and lightweight construction. After evaluating multiple options, we chose **2020 Aluminum Extrusion** over alternatives like Titanium and Steel due to its optimal balance of strength, weight, and cost effectiveness. Aluminum offers excellent corrosion resistance due to its natural oxide layer, making it well-suited for underwater environments. It is also lighter than Steel, enhancing the ROV's maneuverability and speed. These advantages make 2020 Aluminum Extrusion the ideal material for our ROV frame, ensuring efficiency, and performance in challenging underwater conditions. Additionally, our enclosure material is Aluminum. Aluminum's high thermal conductivity allows efficient heat dissipation from internal components, preventing overheating and ensuring stable operation. Its ease of fabrication makes it simple to machine, customize, and repair, reducing production time and costs.

Brainstorming

Criteria	Box Frame	H-Frame	Vertical Stack
Space & Payload Integration	2/5	3/5	5/5
Modularity	2/5	3/5	5/5
Accessibility	3/5	4/5	5/5

Table 3: Frame Shape Brainstorming

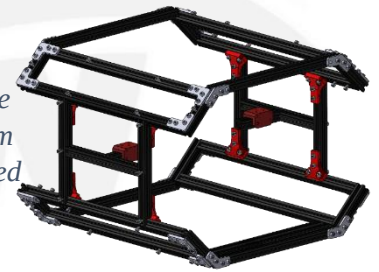
Aspect	Aluminum Extrusion 2020	3D Printing (PLA/PET G/ABS)	Carbon Fiber
Strength	High	Moderate	Very High
Cost	Moderate	Low	High
Manufacturability	Easy	Very Easy	Difficult

Table 4: Aluminum vs 3D printing vs Carbon Fiber

Frame

The ROV frame as shown in *Fig. 6* features a modular design for high-precision payload integration and rapid mission reconfiguration. Constructed primarily from 2020 aluminum extrusions, the frame utilizes a standardized V-slot fastening system that eliminates the need for permanent manufacturing processes such as welding or drilling. This approach significantly reduced structural risk during assembly and allows for infinite mounting points of sub-systems along the 2020 aluminum extrusion. In alignment with the competition's focus on environmental sustainability, the team successfully allocated from existing inventory excess aluminum stock from last year's storage, optimizing resource efficiency without compromising structural integrity. To ensure precision where manual cutting tolerances varied, the team engineered custom 3D-printed brackets to secure critical frame joints. These application-specific parts are complemented by 5 mm aluminum brackets laser-cut from sheet stock which provide the high-torque mounting points required for the thrusters. This hybrid assembly of standardized extrusions and custom-engineered brackets results in a rigid, lightweight skeleton capable of supporting diverse mission tools at multiple mounting locations.

Figure 6: Assembled ROV frame constructed from 2020 aluminum extrusions with custom 3D-printed brackets





Propulsion

Building upon our vision, which aims to combine functionality with engineering prowess, we decided to implement a new thruster configuration for this year's competition. We were inspired by Qysea's ROV series, whose thruster configuration influenced our approach. This enabled us to optimize our propulsion performance and achieve a great power-consumption-to-maneuverability ratio. Nonetheless, there is a small key difference between Qysea's ROV and ours. While their vehicle typically arranges their configuration across 2 planes, **ShadowWing-22 adopts a 3-plane configuration**. This design choice was made deliberately to create additional space within the frame, allowing greater flexibility for integrating extra payloads. ShadowWing-22 is powered by 6 [6] T200-thrusters arranged to provide 6 degrees of freedom as shown Table.6, which is a huge improvement from last year's 5 degrees. Unlike conventional designs, which supports four degrees of freedom (4-DOF), enabling surge, sway, heave, and yaw motion across all primary axes. ShadowWing-22's new configuration allows for the addition of pitch maneuvering. Such a new addition greatly assists our pilot in completing complex tasks in a timely manner. While the system allows for an 8-thruster-configuration, we deliberately limited it to **6 thrusters** only to reduce power-consumption without sacrificing performance. Particular attention was given to the design behind the shrouds. After a thorough review of the available scientific research in the field of hydrodynamics, we explored several geometries for the pattern of the shrouds to protect the thrusters while optimizing fluid flow and maintaining maximum efficiency output from the thruster. Trade-offs are shown in Table 4.



Point of Comparison	Value	Notes
Unit cost	\$270	Original unit price (reference value).
Performance	3.71 kg.f (@ 12 V)	Thrust Value
Power Consumption	17 A (@ 12 V) —205W	Throttle Value

Table 5: T200 Thruster Characteristics

Buoyancy

To ensure our ROV performs predictably underwater, we applied Archimedes' Principle to calculate the buoyant force. This calculation allows us to determine the exact amount of ballast or flotation needed to achieve a neutrally buoyant state we have used swimming noodles and swimming boards to adjust our buoyancy. The buoyant force acting on the ROV is calculated using:

$$F_b = \rho g V \quad (1)$$

Where:

- F_b = Buoyant force (N)
- ρ = Density of water (1000 kg/m³ for water)
- g = Gravitational acceleration (9.81 m/s²)
- V = Volume of displaced water (m³)

For neutral buoyancy, the buoyant force must equal the weight of the ROV:

$$W = mg \quad (2)$$

Where:

- m = Mass of ROV (21 kg)
- g = Gravitational acceleration (9.81 m/s²)

Substituting the ROV mass:

$$W = 21 \times 9.81 = 206.01 \text{ N} \quad (3)$$

Thus:

$$F_b = W = 206.01 \text{ N} \quad (4)$$

The ROV floats, meaning that:

$$F_{ROV} > F_b \quad (5)$$

$$F_{ROV} > 206.01 \text{ N} \quad (6)$$

Parameter	6 Thrusters	8 Thrusters
Degrees of Freedom	6-DOF	6-DOF
Max Power Consumption	205W*6=1230W	205W*8=1640W
Current Draw @ 48V	~25.6A	~34.2A
Frame Space Required	Moderate	High
Cost	\$270 *6 = \$1620	\$270 *8 = \$2160
Weight Added	6*427g = 2562g	8*427g = 3416g
Selected	✓	✗

Table 6: 6 Thrusters vs 8 Thrusters
Trade-off Analysis



Enclosure

Following our vision for innovation, we have decided to use a similar but improved manufacturing process for our enclosure as shown in *Fig. 7*. This year's enclosure is made out of six aluminum plates, which are designed to connect to each other to minimize any shifting when bolting the plates together. Such a manufacturing process has achieved a high level of precision, with minimal deviation between the CAD model and the actual enclosure. The enclosure measure 23 cm in length, 26.4 cm in width, and 25.8 cm in height. Our spacious and versatile faceless enclosure has also allowed us to create a custom mount and cover for the OAK-D-S2 camera inside as shown in *Fig. 8*. To have a clear view inside the ROV, we are using two acrylic sheets on each side to spot any issues with the internal systems. To ensure the sealing of our enclosure, we have installed a rubber gasket between the acrylic and the outer aluminum plate, secured with 22 M5 bolts on each side. We have also added two large HDPE washers one behind the aluminum plate and one in front of the acrylic to prevent the acrylic from cracking under the pressure of the bolts. Additionally, we have decided to add **23 Blue Robotics penetrators**. This allows us to use four penetrators on each side of the ROV for our T-200 thrusters and pneumatic grippers, and **provides 15 additional penetrators** for our tether connection and manipulators. We have also added a customized rack system for the three PCBs to debug any electrical issues should they arise.

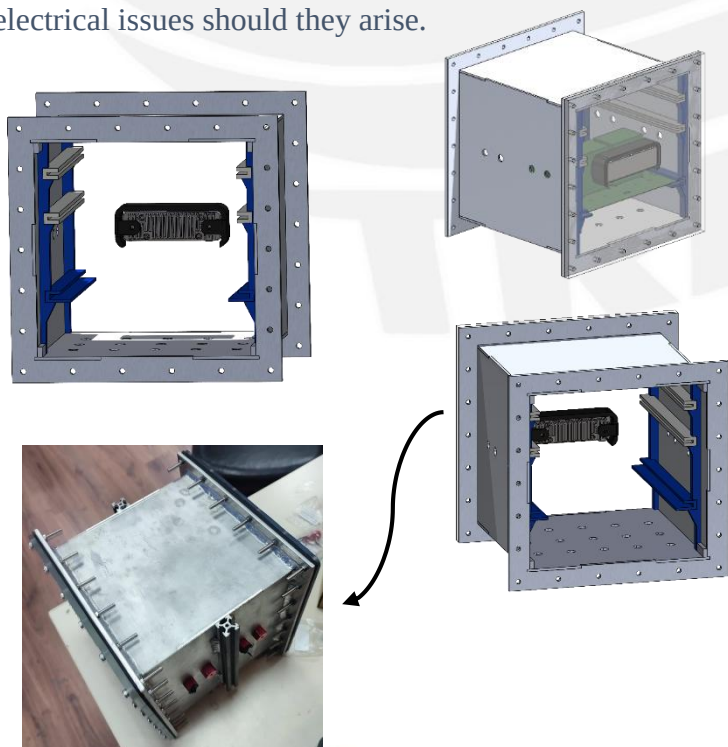


Figure 7: Aluminum enclosure — exploded and assembled views

CFD

Computational Fluid Dynamics (CFD) simulations were conducted during the design process to evaluate flow characteristics, detect pressure points, and calculate drag and lift forces. These simulations allowed the team to analyze water flow behavior around critical components such as the frame and thruster shrouds, helping identify potential sources of drag and flow disturbance. The analyses were performed using [1] SolidWorks Flow Simulation and ANSYS, enabling the team to test different design configurations and refine the geometry accordingly. [3] CFD results showed the drag and lift forces to be **0.6289 kg.force** and **0.0133 kg.force**, respectively as shown in *Fig.8*, supposing the ROV was moving at a constant 0.3 m/s velocity as shown in *Fig. 9*.

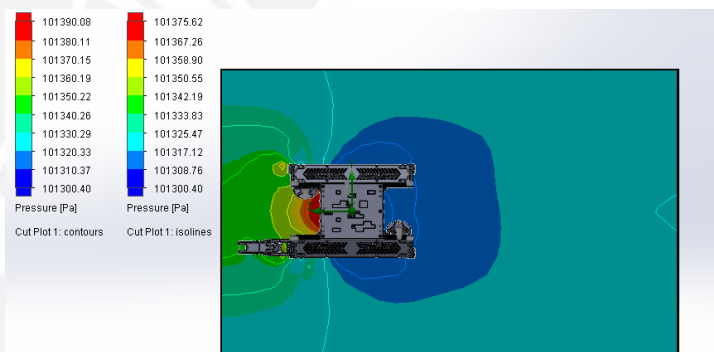


Figure 8: CFD pressure contour plot at 0.3 m/s forward velocity — drag force 0.6289 kgf

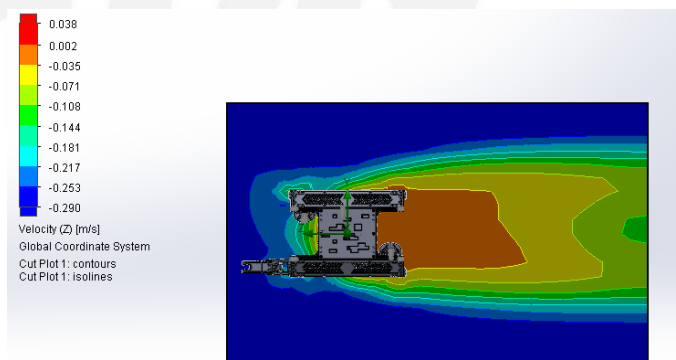


Figure 9: CFD velocity distribution showing flow behavior around the frame and thruster shrouds at 0.3 m/s



Payloads

Lighting System

The lighting system provides high-output illumination while utilizing a specialized housing designed to prevent LED overheating. The light is mounted on a rear aluminum base plate as shown in *Fig.10*, which acts as a heat sink by dissipating thermal energy directly into the water. The front is sealed with a clear acrylic cap, providing a pressure-resistant window for maximum light transmission.

Rope Winder

Designed for Recovering the Buoy Anchor, which requires deploying a measured length of rope underwater to mark a transect line, the retractable rope winder ensures controlled and efficient rope deployment synchronized with ROV movement, preventing slack accumulation and tangling that would invalidate the task. Integrated into a modular fixation system, it can be rapidly attached, removed, or repositioned across multiple frame locations, allowing the pilot to optimize rope exit angle relative to deployment direction. The retractable mechanism also enables clean retrieval post-deployment without deck crew intervention, as shown in *Fig. 11*.

Pneumatic Hooking Mechanism

The Pneumatic Hooking Mechanism as shown in *Fig.12* is powered by a pneumatic cylinder specifically engineered to meet the objectives of Tasks Testing **Whale Safe Fishing Gear**, **Service the Holyrood Subsea Observatory**, and **Powering an Oil Platform From a Wind Farm**. It utilizes a 50mm stroke to extend the hook, allowing it to efficiently capture and secure underwater objects. Centrally mounted on the ROV to ensure a balanced positioning, the mechanism features a sliding guide through its support to provide maximum stability during tasks. Once objects are hooked, an integrated fixed support acts as a rigid boundary, trapping the object against the hook's frame to prevent any shifting or falling.

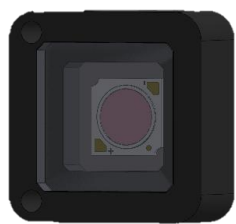


Figure 10:
Underwater lighting
system CAD

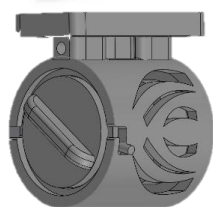


Figure 11: Retractable
rope winder CAD
designed for Task 2
rope deployment

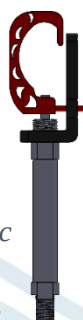


Figure 12: Pneumatic
hooking mechanism
tailored for task 2.3,
2.5, and 3.2

Camera Enclosure

The camera enclosure features a compact, pressure resistant cylindrical design that ensures optical clarity and easy assembly. Its stepped internal arrangement provides precise alignment, minimizes vibration, and maintains camera stability. The housing has an overall length of approximately **45.5 mm** and includes **stepped internal sections (12 mm, 15 mm, and 22 mm)** to properly accommodate the camera module and maintain alignment. **The front cover features stepped diameters (40 mm, 32.5 mm, and 30.5 mm)** as shown in *Fig.13* that allow secure seating of the acrylic window. Waterproofing is achieved using **PU 50 sealant**, creating a strong, flexible, and permanent seal. The enclosure is made from **HDPE** for strength and moisture resistance, while an acrylic window ensures high transparency. It is manufactured using lathe turning operations, including external turning and internal boring, followed by deburring and edge finishing according to technical drawing specifications. Overall, the design offers uniform stress distribution, reduced stress concentration, clear vision, reliable waterproofing, ease of manufacturing, low cost, lightweight structure, durability underwater, and minimal maintenance.

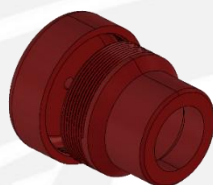


Figure 13: Custom
HDPE camera
enclosure

Grippers

To efficiently perform mission tasks requiring manipulation of objects with varying geometries — cylindrical samples, irregular polyps, and hook-and-pull operations — the team developed three complementary pneumatic grippers, each uniquely designed for a specific use case and evaluated through a weighted decision matrix as shown in *Table.7*

The **first** of the three designs is a rotating gripper that has two points of contact that rotates by utilizing gears and a servo motor, the gripper as shown in *Fig. 14*.



The **second** design is a four-jaw pneumatic gripper that excels in holding irregular shaped objects that a normal two jaw gripper can't hold on to without difficulty due to it having more point of contact as shown in *Fig. 15*.

Our **third** design, while it may seem obsolete when compared to the other two grippers, is a two-jaw gripper that has a wider range of motion compared to its counterparts. We are also currently working on a two-jaw multi-use gripper that can not only hold cylindrical objects, but also carry out the standard applications of a normal two-jaw gripper as shown in *Fig.16* .

The designs we have made aren't a one size that fits all situations, but each has a distinct difference in how each one is used and the purpose behind their creation. The grippers were made with the tasks in mind while being constrained to real-world applications.

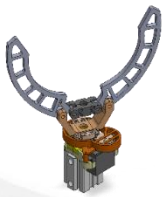


Figure 14: Gear-driven rotating gripper with two contact points and servo actuation

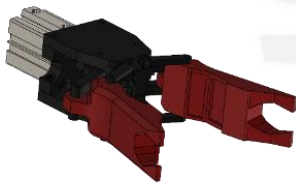


Figure 16: Two-jaw pneumatic gripper with extended range of motion



Figure 15: Four-jaw pneumatic gripper

Tether

Our tether incorporates 2 AWG-8 DC power cable along with CAT6 Ethernet cable, all encapsulated within a flexible meshed shield, also we have 2 hoses connected to our compressor and grippers to supply air as shown in *Fig.17* We selected the AWG-8 power cable for its high conductivity and low voltage drop, ensuring it meets the power requirements of our buck converters. To ensure safe and reliable ROV operation, our team follows a structured tether handling procedure:

Pre-Mission: The tether is inspected for damage, securely connected, and laid out to avoid tangling.

Deployment: Released in sync with ROV movement to prevent slack buildup and maintain communication.

Monitoring: A dedicated member oversees tether slack and position throughout the mission.

Adjustment: Length and tension are actively managed based on vehicle movement and environmental conditions

Post-Mission: The tether is retrieved carefully to prevent twisting and is inspected for wear or damage before storage

Length: 28m

Neutral Buoyant

Connected to our ROV and Control Station with a Strain Relief

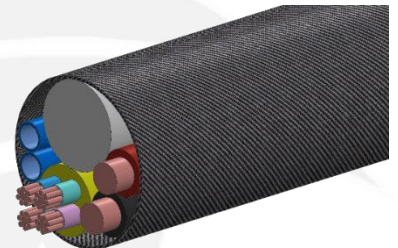


Figure 17: 28 m neutrally buoyant tether cross-section

	Servo	DC	Stepper	Pneumatic	Blue Robotics
Cost (5)	5	5	4	4	1
Torque (5)	4	4	2	5	5
Simplicity in use (5)	3	2	3	4	5
Stability (5)	5	4	3	5	5
Range of motion (5)	5	2.5	2.5	4	2
Score (25)	22	17.5	12.5	22	18

Table 7: Decision matrix for grippers



Electrical System System Overview

The system is divided into 3 subsystems (Power Board, ESC Board, Control Board), these 3 subsystems are 3 PCBs that are connected via cables and supported on a rack. The system starts when the tether is hooked to the Power Board, the power board then supplies other boards via onboard cabling after making the necessary conversions to the topside supply's 48V. The ESC Board is the navigator board (the heavy duty board) that is responsible for controlling the T200 thrusters via PWM generated by the Arduino GIGA in the Control Board. Finally, the Control Board is responsible for dealing with low-level processing of sensors and PWM generation via Arduino GIGA and handling cameras/imu and other complex processing via raspberry pi 4. Power Calculation is shown in [Appendix C](#).

Power Board

The power board as shown in *Fig.18* is supplied input of 48V & 30 AMPs via tether, then the input is stepped down via [8] **2 ADQ800s** to exactly 11.8V & up to 60 AMPs. These industrial buck convertors were specifically picked for their high efficiency that is 96%, their superior overvoltage/undervoltage/overcurrent/undercurrent protection, and their handling of high ampacity that allows the 2 combined to supply up to 120 AMPs. Then the output of ADQs is split into 2 parts, 11.8V that is then stepped down via a **DC-DC step down buck convertor to 5V** and 11.8V. This power board is the main distribution system for the entire electrical system as it supplies ESC board with 11.8V and up to 100 AMPs, 11.8V & 5V for the control board, 5V via USB cable to raspberry pi, and 11.8V for cooling fans mounted on each ADQ.

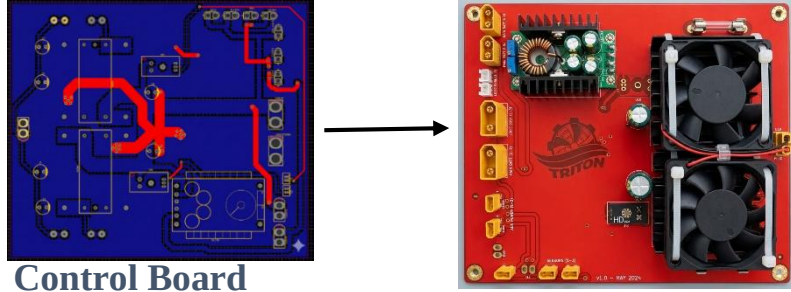
NOTE:

Some Capacitors were added before and after each ADQ for filtering noise that has resulted from ripple current generated from the ADQ800 itself. (The specific circuitry/capacitor ratings used were recommended by the datasheet of the ADQ)

Values used:

- 100nF/100V capacitor
- 220μF/100V electrolytic capacitor
- 330μF/50V capacitor

Figure 18:
Power PCB



Control Board

The Control Board PCB as shown in *Fig.19* serves as the primary intelligence and sensor fusion hub for the ROV's three-layer architecture. Centered around an **Arduino Giga R1** and a **Raspberry Pi** unit, the board manages high-level mission logic alongside real-time hardware control. To ensure mission-critical reliability, the design integrates redundant telemetry through dual IMUs and pressure sensors, while high-current power is routed via **XT60** connectors to supply independent 12V and 5V rails. Actuation is handled by a **Cytron 10MDA** motor driver and a backup use of MOSFET-switched solenoid path that switches using the Arduino, which is reinforced with flyback diodes to protect the logic circuitry from inductive voltage spikes.

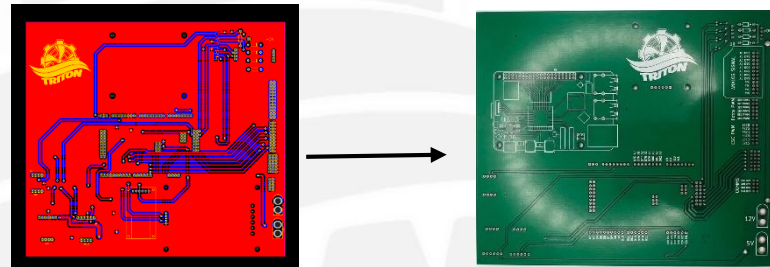


Figure 19: Control PCB

ESC Board

The ESC Power Distribution PCB as shown in *Fig.20* is a high-capacity power plane engineered to support up to six Blue Robotics ESCs with a total system throughput of approximately 100A. This board functions as a sophisticated Power Distribution Board (PDB), featuring individual current sensors in series with each ESC for power monitoring and fault detection across the thruster array. To maintain signal integrity and protect against the high-frequency noise of brushless motor switching, the PCB employs a distributed capacitance strategy, utilizing 220uF/50V Low ESR capacitors at each ESC terminal as well as a Schottky diode. This configuration effectively suppresses back-EMF spikes and voltage ripples, ensuring.

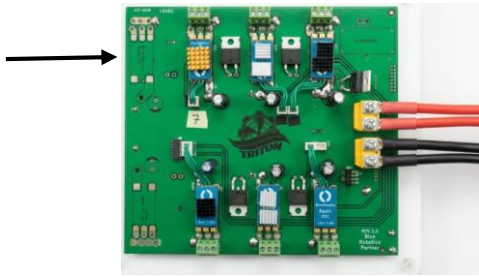


Figure 20:
ESCs PCB

Station

The control station as shown in Fig.21 prioritizes practicality, safety, and ease of operation. Housed in a compact "grab-and-go" box, it features a main power switch and voltmeter for immediate power control and voltage monitoring. A **7mm acrylic sheet** divides the station into two sections: the upper operational interface, accessible to both pilot and co-pilot, and the lower section for wiring and supporting electronics. This separation reduces cable clutter and minimizes accidental disconnections. Dedicated connector holders (Anderson, Ethernet, and XT60) are angled at **45 degrees** for easier access, alongside a side power plug. The pilot's main display is protected by a custom engraved screen protector, while a mini touchscreen provides environmental feedback to the co-pilot. A 3D-printed **95-degree custom hinge** improves the station's opening angle, and a spool system as shown in Fig. 22 enables neat tether storage and deployment, protecting the tether from damage and easing the tether-man's workflow. Such a spool mechanism not only facilitates the tether-man's work, but also prevents the tether itself from any potential damage.

Figure 21: Topside
control station

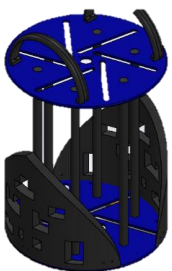
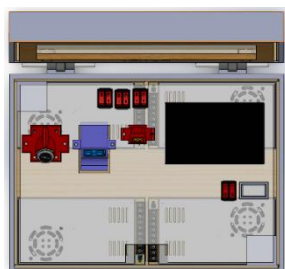


Figure 22:
Integrated tether
spool system



Software System Vision System System Overview

The ROV vision system provides real-time visual feedback for piloting while enabling computer vision capabilities required for mission tasks. Due to challenges in underwater environments such as reduced visibility and light attenuation, multiple cameras were integrated to ensure adequate visual coverage and task-specific functionality. The system consists of five cameras with different roles. Two USB cameras are used for navigation and manipulation assistance. A Raspberry Pi Camera Module provides a wide field of view for the gripper workspace. Additionally, the OAK-D S2 is used for both high resolution piloting through its RGB sensor and for stereo depth perception required for computer vision tasks. All camera streams are transmitted to the control station using the Transmission Control Protocol, ensuring reliable delivery of video frames between the ROV and the surface station.

Camera Configuration

Front Navigation Camera:

A **USB camera** as shown in Fig.23 mounted at the front of the ROV provides the primary view for navigation and obstacle detection. Manipulator Camera: A **second USB camera** is positioned near the manipulators to monitor the workspace of the two grippers and assist the pilot during manipulation tasks. Wide Field-of-View Camera: A **Raspberry Pi Camera Module** as shown in Fig.24 provides a wider view of the gripper workspace, reducing blind spots and improving operational awareness. High-Resolution RGB Camera: The RGB sensor of the [5] **OAK-D S2** as shown in Fig.25 provides a clear high-resolution video stream that improves visual clarity during piloting while the stereo sensors enable depth-based analysis.



Figure 23: USB camera used for
front navigation



Figure 24: Raspberry Pi
camera module providing
wide field-of-view



Figure 25: OAK-D S2 stereo
depth camera



Vision Tasks

1. Coral Garden 3D Modeling and Measurement

The 3D coral garden model was generated using a photogrammetry and Neural Radiance Field (NeRF) pipeline as shown in *Fig.26*. First, underwater video footage of the coral garden prop was captured from multiple viewing angles. The extracted frames were processed using the COLMAP structure-from-motion framework to estimate camera poses and reconstruct the scene geometry. The resulting dataset was then trained using Instant-NGP, which applies NeRF-based rendering to create a detailed and realistic 3D representation of the underwater environment

2. Underwater Distance Measurement

To ensure accurate distance measurements across all underwater tasks, the stereo camera system was calibrated at a known operating depth to account for the optical properties of the aquatic medium. The calibration process involved measuring multiple known reference lengths underwater, with the resulting values averaged to derive a unified scale factor. This scale factor was applied universally to all stereo-derived distance measurements throughout the competition, including coral garden length assessment and keel depth determination, correcting for systematic error and ensuring dimensional accuracy across all reported measurements.

3. European Green Crab Detection

The vision system also detects and counts European Green Crab individuals as shown in *Fig.28*. A fine-tuned YOLOv8 model trained on a custom dataset (1024 images) captured from a USB camera to identify and count the crabs within the scene using 50 epochs with patience 50.

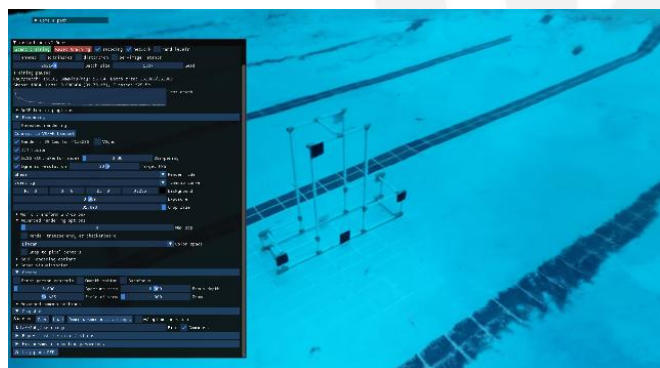


Figure 26: 3D Modeling of coral garden

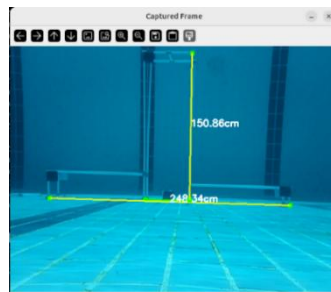


Figure 27: Measuring Length of Coral Garden using the scale factor



Figure 28: European Green Crab Detection

Control System

Shadow Wing's control system spans a custom flight controller firmware (Equinox) to a browser-accessible pilot interface, unified under [2] ROS 2 Jazzy middleware.

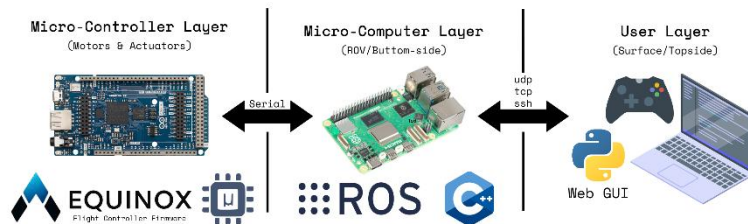


Figure 29: System Architecture

Flight Controller — Equinox

Requirements were derived from mission task analysis and benchmarked against ArduSub, establishing a functional baseline for flight modes, attitude control, and safety behaviour. Where mission requirements exceeded ArduSub's feature set or demanded tighter ROS 2 integration, **Equinox** was designed to surpass it.

Equinox runs on an [4] Arduino Giga (STM32H7, 480 MHz, 1 MB RAM) — selected because [11] micro-ROS supports only a limited hardware subset. It operates as a monolithic micro-ROS node with internally modular, stateless code, eliminating cross-module side effects. A known limitation of this architecture is that the monolithic boundary increases firmware image size and complicates incremental OTA updates.

Firmware is developed on GitHub via a branch-per-module workflow. Stateless module design means a module passing isolated testing is validated for deployment — a property confirmed in practice when the power monitoring module failed isolated testing due to incorrect sensor readings, was diagnosed, and resolved before integration. Modules are bench-tested with hardware, then pool-validated end-to-end. Firmware updates are deployed over a dedicated webserver on the ROV, and startup is fully automated via systemd services – minimising pre-dive setup time.



The Movement system as shown in *Fig.31*, supports four flight modes:

- **Manual** - unassisted.
- **Stabilisation** - level attitude.
- **Depth Hold** - fixed depth.
- **Position Hold** - fixed depth + level attitude.

The latter two are critical for coral garden transects and iceberg perimeter surveys. A cascade PID controller fuses dual-redundant [10] BNO055 IMUs via health-weighted NLERP quaternion blending, with a six-DoF prioritised mixer guaranteeing attitude correction before translational demand as shown in *Fig.30*. All system parameters are runtime-tuneable with [13] Ziegler-Nichols relay PID autotune available on attitude axes. Voltage and current are continuously monitored, where a critical anomaly triggers automatic remote power cutoff. **Equinox** also drives all payloads, including grippers, with pre-dive motor testing available to test all actuators and motors.

Topside GUI

The GUI as shown in *Fig.32* runs as a ROS 2 node serving a Flask/Socket.IO web interface accessible from any networked device. Video is isolated to a dedicated WebSocket channel to prevent congestion from degrading command responsiveness. Flask and Socket.IO were chosen for development speed; a limitation is that they do not provide hard real-time guarantees — these are enforced at the firmware layer instead. The pilot interface consolidates depth, attitude, safety state, and motor gain into a unified status bar with a drag-and-drop multi-camera grid, heartbeat monitoring, camera reconnection logic, and live ROS log telemetry.

Pass 1 — Attitude (rx, ry, rz)

$$T_i^{\text{att}} = w_{rx}M_{i,rx} + w_{ry}M_{i,ry} + w_{rz}M_{i,rz}$$

$$P_{\text{att}} = \max_i |T_i^{\text{att}}|$$

Figure 30:
Mixer
Equations

$$s_{\text{att}} = \begin{cases} \frac{1}{P_{\text{att}}} & P_{\text{att}} > 1 \\ 1 & \text{otherwise} \end{cases}$$

$$H = 1 - P_{\text{att}} \cdot s_{\text{att}} \quad (\text{remaining headroom})$$

Pass 2 — Linear (x, y, z)

$$T_i^{\text{lin}} = w_xM_{i,x} + w_yM_{i,y} + w_zM_{i,z}$$

$$P_{\text{lin}} = \max_i |T_i^{\text{lin}}|$$

$$s_{\text{lin}} = \begin{cases} \frac{H}{P_{\text{lin}}} & P_{\text{lin}} > H \\ 1 & \text{otherwise} \end{cases}$$

Combine & Clamp

$$T_i = \text{clamp}(T_i^{\text{att}} \cdot s_{\text{att}} + T_i^{\text{lin}} \cdot s_{\text{lin}}, -1, +1)$$

$$i = 1 \dots 6, \quad T_i \in [-1, 1]$$

If $P_{\text{att}} > 1$ then $H = 0$ and translation is fully suppressed.

where

w_j	normalised pilot command per DOF, $j \in \{x, y, z, rx, ry, rz\}$, w
$M_{i,j}$	mixer table entry: contribution of DOF j to motor i , entries $\in$
$T_i^{\text{att}}, T_i^{\text{lin}}$	per-motor attitude and linear thrust
$P_{\text{att}}, P_{\text{lin}}$	peak thrust magnitude across all motors
$s_{\text{att}}, s_{\text{lin}}$	scale factors (≤ 1)
H	thrust headroom remaining after attitude allocation

Figure 31:
Movement
System
Flowchart

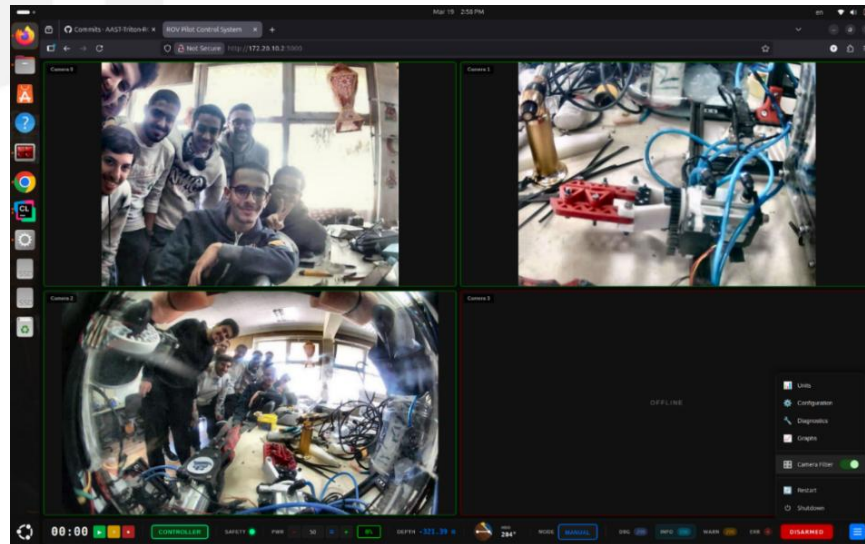
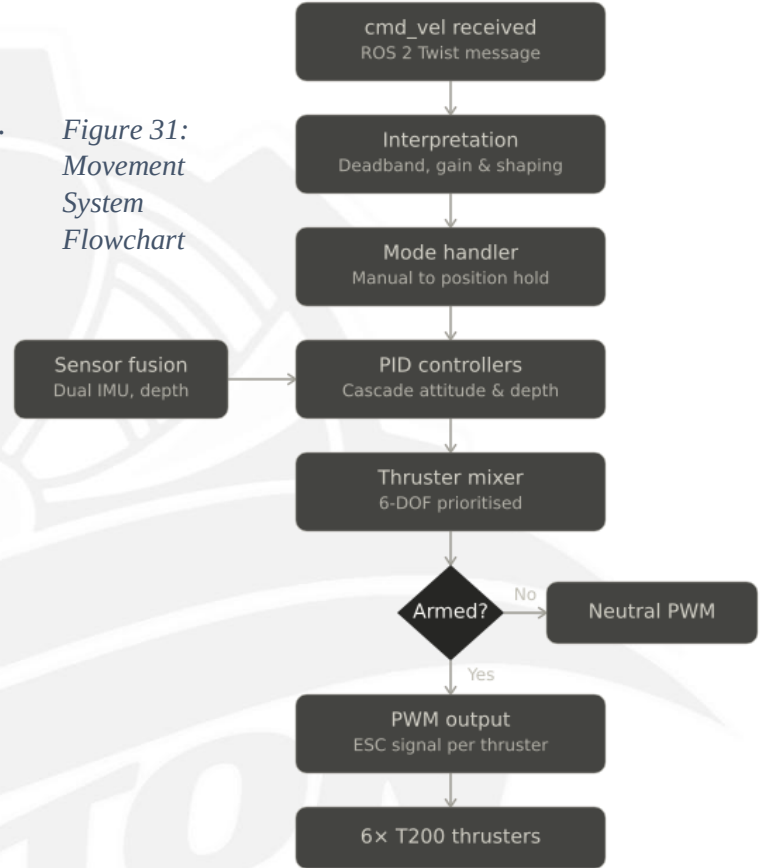


Figure 32: Web-based pilot GUI showing four-camera grid, depth and attitude status bar, arming controls, and real-time telemetry



Float

The float system was redesigned to improve precision by optimizing both its structure and buoyancy mechanism. The acrylic enclosure tube length was reduced from 500 mm to 260 mm to create a more compact and efficient design. In addition, an external piston-based buoyancy engine was developed, where the piston extends outward to increase the float's volume or retracts inward to decrease it, allowing accurate density control and precise vertical profiling. Internally, all electronic components are compactly integrated into a dedicated control section containing custom-made PCBs and power management units. Below this section, a battery pack and a 40 kgf/cm geared DC motor connected to a lead screw convert rotary motion into linear piston movement. The buoyancy section includes a sealed piston chamber manufactured together with the bottom flange, while the in-house silicone rubber piston incorporates built-in O-rings to prevent water leakage during operation. The float body length reaches 347.29 mm excluding the buoyancy engine, and a surrounding handle is included for easier handling. Electrically, the system is powered by a 12V battery pack that drives the motor driver, while buck converters regulate the voltage to 5V for the Arduino Nano, encoder, and TOF sensor, and to 3.3V for the ESP32 and pressure sensor. The ESP32 acts as the primary controller, processing pressure and TOF sensor readings and communicating with the Arduino Nano, which controls motor actuation using encoder feedback for precise piston displacement. A PID controller regulates piston movement to maintain target depth, while collected mission data is transmitted via Wi-Fi to a Python program for depth-versus-time visualization.

Safety

Safety Rationale

Safety Philosophy

Safety is a fundamental priority for Triton and is integrated into every stage of the design, construction, and operation of our ROV, Shadow-wing'22. The team adopts a proactive safety approach that focuses on identifying potential

hazards early and implementing preventive measures to reduce risk. Our safety framework addresses personnel safety, equipment protection, and operational safety throughout the entire development process. From the initial design phase to fabrication, testing, and deployment, all activities are conducted in accordance with the safety guidelines established by the MATE ROV Competition. Regular risk assessments, safety briefings, and continuous process improvements help ensure that all team members remain aware of potential hazards. By embedding safety considerations into both the vehicle design and operational procedures, Triton protects team members, preserves equipment integrity, and minimizes environmental impact during mission operations. Safety Checklist is shown in [Safety Checklist](#).

Personnel

All team members involved in the construction and operation of Shadow-wing'22 are required to follow established safety protocols to maintain a safe working environment as shown in *Fig. 33*.

Personal Protective Equipment (PPE):

Appropriate PPE is mandatory during fabrication and testing activities. Team members utilize safety glasses, protective gloves, masks when necessary, and hearing protection when operating power tools or other loud equipment. These precautions reduce the risk of injury during mechanical and electrical work.



Figure 33: Team member wearing mandatory PPE



Equipment Safety

Triton enforces strict equipment handling procedures to ensure the safe use and maintenance of all tools and systems used during the development of **Shadow-wing'22**.

Inspection and Maintenance:

All tools and equipment are routinely inspected to identify signs of wear, damage, or malfunction that could create safety hazards. Any equipment found to be defective is immediately removed from service until it can be repaired or replaced.

Proper Storage and Return:

To maintain an organized and safe workspace, all tools and equipment must be returned to their designated place.

Section	Tool	Place
Mechanical	Drill Bits	Mechanical Storage
Electrical	Wagos, XTs connectors	Electrical Storage
Software	Arduinos	Software Storage

Table 8: Storage table

Task-Specific Safety Precautions

Mission Task Safety Precautions For Task 2 (rope deployment and hooking), the pneumatic system is pressurized to a maximum of 2 bar; the compressor is shut off and lines are depressurized before any above-water handling of the gripper payloads. For Task 3 (polyp capture), the pneumatic hooking mechanism is only activated via the GUI. All manipulator operations are preceded by a "Payload Armed" call-out in the Call and Response protocol

Safety Features

The ROV system integrates several electrical and mechanical safety features to ensure reliable and safe operation. Electrically, the power system uses two high-efficiency **ADQ800 buck converters** as shown in *Fig. 34* with built-in protections against overvoltage, undervoltage, overcurrent, and undercurrent conditions. Filtering capacitors are installed before and after the converters to reduce ripple and electrical noise, while cooling fans prevent overheating during high-current operation. The control board improves reliability through **redundant sensors** (dual IMUs and pressure sensors), and **flyback diodes** protect the circuitry from inductive voltage spikes. Additionally, the ESC distribution board includes individual current sensors for each ESC and uses low-ESR capacitors and Schottky diodes to suppress voltage spikes and maintain power stability. Mechanically, all thrusters are shrouded as shown in *Fig. 35* to prevent accidental contact and protect the propellers from debris, a strain relief as shown in *Fig.36* is installed at the tether connection to reduce stress on the cable and connectors, and corner guards as shown in *Fig.37* are added to the frame to eliminate sharp edges and improve handling safety. Also our gripper which utilize gears has been shrouded to IP-20 standards as shown in *Fig.38*.

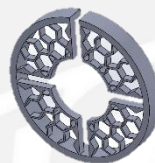


Figure 35: 3D-printed thruster shrouds



Figure 34: Artesyn ADQ800 industrial buck converters



Figure 36: Tether strain relief fitting at ROV entry point

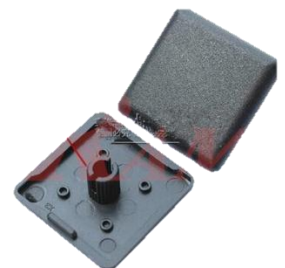


Figure 37: Aluminum frame corner guards

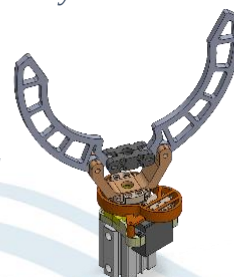


Figure 38: Gripper gears shrouded to IP-20 standards



Operational Safety

Our operational safety is maintained through a structured four-phase workflow: **Pre-Power, Power-Up, Retrieval, and Emergency Response**. Before applying power, the deck crew performs a physical integrity check, inspecting the tether for wear, verifying the electronics housing seal, and ensuring thrusters are clear of debris. Once energized at 48V, the team follows a "Call and Response" protocol, alerting all members before powering the Thruster Control Unit (TCU) and performing directional tests to verify joystick mapping and sensor feedback. During retrieval, the Pilot and Co-Pilot coordinate to disable all thrusters before the ROV is manually recovered to the deck. In the event of a Loss of Communication, the team is trained to cycle station power immediately; if the system remains unresponsive, a manual tether recovery is initiated followed by a full teardown inspection to identify the point of failure.

Lab Safety Policy

- No member is allowed in the lab unless one of the following is present: **CEO, CTO, COO** or a sub team head.
- Every component or tool used must be returned to its designated place.
- If you finish a task, the workspace must be cleared and the items stored in a safe, known location.
- Submit a hazard report to the Safety Officer immediately upon any encountered hazard.
- Eating and drinking is prohibited inside the lab.
- Store all lubricants, and adhesives in labeled containers and use them only in well-ventilated areas
- Ensure clear communication between all team members before activating any electrical or motion-controlled systems.

Testing and Troubleshooting

Vehicle Testing

Our vehicle testing protocol follows a validation cycle to ensure mission readiness. Before final enclosure assembly, we conduct a systematic compliance check observing PWM communication, gripper actuation, and camera feeds. During early pool testing, the Raspberry Pi lost power intermittently, causing complete control system failure. This was resolved by replacing the two-stage

48V→12V→5V conversion with a direct 48V→5V buck converter, eliminating accumulated voltage drop. We also discovered slow water ingress at one penetrator during the initial 5-meter depth test; the gasket was reseated, and a foam test confirmed full watertight integrity before re-deployment. Upon retrieval, the enclosure is visually inspected for moisture.

Troubleshooting Strategy

A systematic troubleshooting strategy is implemented to ensure quick fault detection and system reliability. The process begins with mechanical checks, where penetrators, gaskets, enclosure sealing, and external wiring are inspected to prevent any leakage. A foam test is also conducted to confirm watertight integrity.

Next, electrical diagnostics are performed, especially in cases of communication loss between the ROV and the station. This includes verifying power indicators on the Raspberry Pi and Arduino GIGA, checking cabling and signal integrity, inspecting ESCs, and ensuring cables are free from damage or interference such as back EMF.

Finally, software troubleshooting is divided into control and vision subsystems. For control, Ethernet connectivity, ROS communication, onboard services, and system status are verified, followed by a reboot if needed. For vision, camera connections, calibration, and software setup are checked, while measurement accuracy is improved through proper positioning and frame averaging. This structured approach enables efficient fault isolation and rapid system recovery. Troubleshooting checklist is shown in [Troubleshooting Checklist](#).

Prototyping

Before committing to professional manufacturing, the team prototyped each board in-house PCB using traditional printing and etching techniques, verifying trace routing, component placement, and connectivity early to avoid costly revision cycles. We prototyped the thruster shroud; the initial design lacked sufficient propeller clearance, causing interference. A revised design increased shroud thickness and spacing.



Built vs Buy, New vs Used Mechanical

Component	State	Justification
Frame	Built, New	Modular, light weight
Enclosure	Built, New	More space, great heat dissipation.
Pneumatic Grippers	Built, New	Faster, No Electrical Issues

Table 9: Mechanical

Electrical & Software

Component	State	Justification
Raspberry pi	Buy, Used	Re-used from 2025; benchmarked at 95% CPU headroom during peak load — no upgrade needed
48V-12V ADQs Converter	Buy, New	Higher Amperage, More Safety
Arduino GIGA	Buy, New	Building our own flight controller
OAK-D S2 Camera	Buy, Used	Stereo depth and RGB capabilities fully meet 2026 vision task requirements
USB Camera	Buy, Used	30fps/1080p over USB 3.0 sufficient for pilot navigation

Table 10: Electrical & Software

References

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- [12] Cytron Technologies. "10A DC Motor Driver (MDD10A) User Manual." <https://docs.cytron.io/cy-sm-mdd10a>
- [13] Ziegler, J. G. and Nichols, N. B. "Optimum Settings for Automatic Controllers." Transactions of the ASME, vol. 64, pp. 759–768, 1942.



Safety & Operation Checklist

→ Pre-Power Procedure (Pilots & Deck Crew)

- ☐ Uncoil tether and inspect for cuts, twists, or wear.
- ☐ Secure tether to Control Station and confirm proper strain relief.
- ☐ Connect and secure tether to ROV.
- ☐ Check electronics housing is sealed and secure.
- ☐ Inspect electronics for visible damage or loose connectors.
- ☐ Ensure all fasteners on electronics housing are tightened.
- ☐ Confirm thrusters are free of any debris.
- ☐ Connect power to the Control Station.

→ Power-Up Procedure (Pilots & Deck Crew)

- ☐ Confirm power supply output is 48V.
- ☐ Boot control systems and video feed.
- ☐ Alert all deck members before powering on.
- ☐ Call out “Thrusters Test”.
- ☐ Test each thruster directionally (forward/back).
- ☐ Switch between all video feeds and confirm proper display.

→ ROV Retrieval (Pilots & Deck Crew)

- ☐ Co-Pilot disables thrusters and calls out “Thrusters Disabled”
- ☐ Deck crew removes ROV from the water.
- ☐ Once on deck, confirm thrusters are disabled and enclosure is intact.
- ☐ Co-Pilot powers off Control Station if demobilizing.

→ Loss of Communication (Pilots & Deck Crew)

- ☐ Cycle power on Control Station to attempt reconnection.
- ☐ If still offline, recover ROV manually via tether.

→ Manufacturing of ROV

- ☐ Break down all tasks into documented, step-by-step procedures before execution
- ☐ Execute all manufacturing processes, like drilling and soldering, at their designated stations in lab
- ☐ Ensure all wires and electrical connections are insulated to avoid accidental contact or short circuits
- ☐ Wear suitable personal protective equipment, including safety glasses and gloves, during drilling, cutting, or similar processes
- ☐ Inspect all power tool cords for damage before each use; do not use tools with frayed or damaged cables
- ☐ Work in a ventilated area or under a fume extractor when soldering or, adhesives, or flux.
- ☐ Verify correct polarity on all XT60 and Anderson connectors before first power-up
- ☐ Confirm all ESC signal wires are secured away from power cables to prevent back-EMF interference
- ☐ Perform continuity test on all PCB rails before connecting to the 48V supply
- ☐ Never test the system at full 48V without first verifying continuity and short-circuit
- ☐ Clamp all work pieces securely before drilling or cutting; never hold material by hand during power tool operation.



Troubleshooting Checklist

→ Mechanical:

- ☐ Check penetrators if there are any gaps
- ☐ Check gasket if it is tightly pressed
- ☐ Check enclosure if there is any leakage
- ☐ Check outer wiring if there is a gap or any leakage
- ☐ Foam test on penetrators with assistance of vacuum

→ Electrical:

- In case of disconnected communication between ROV & station

- ☐ Check lights of Raspberry pi and Arduino GIGA
- ☐ Check on-board caballing connections
- ☐ Check signals
- ☐ Check ESCs
- ☐ Check for back EMF
- ☐ Check for cables' conditions

→ Software:

● Control:

In case of ROV disconnection

- ☐ Check Ethernet
- ☐ Check Raspberry pi
- ☐ Check μ ROS agent
- ☐ Check ROS system on Raspberry pi
- ☐ Check EQUINOX companion service
- ☐ Check ROS system on station
- ☐ Reboot

- In case of gripper not moving

- ☐ Check logs
- ☐ Check payload topic
- ☐ Check motor drivers' LED indicators
- ☐ Check pneumatic connections

● Vision

- ☐ In case of devices incompatibility
- ☐ Check camera indices
- ☐ Check cables connections
- ☐ Check installation of required packages and files
- ☐ Verify calibration of OAK-D S2
- ☐ Ensure the 45 cm reference object (if used) is visible in the frame
- ☐ Move the ROV closer or further if depth is unstable
- ☐ Average measurements across multiple frames
- ☐ Apply basic image enhancement if visibility is low

Appendix A

Presented here is our ROV Electrical SID providing a comprehensive overview of the complete electrical architecture — spanning from the Topside Control Station all the way down to the ROV itself. It also includes engineering calculations that justify the fuse ratings selected throughout the system. Finally, a color-coded wiring diagram offers a visually intuitive representation of all ROV interconnections.

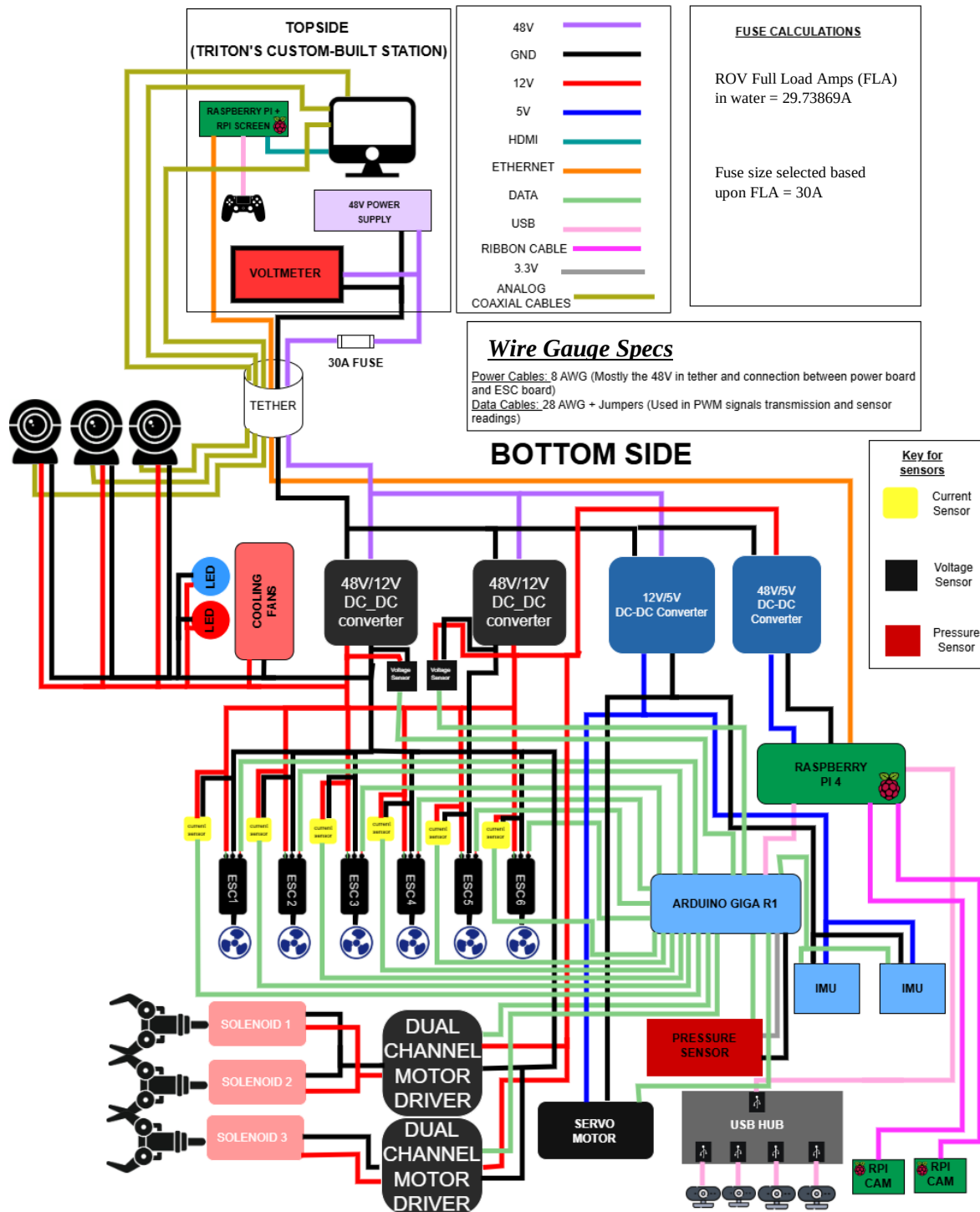


Figure 39:
Electrical
SID



Appendix B

Presented here is our ROV Pneumatic SID providing a comprehensive overview of the complete grippers and pneumatic systems used.

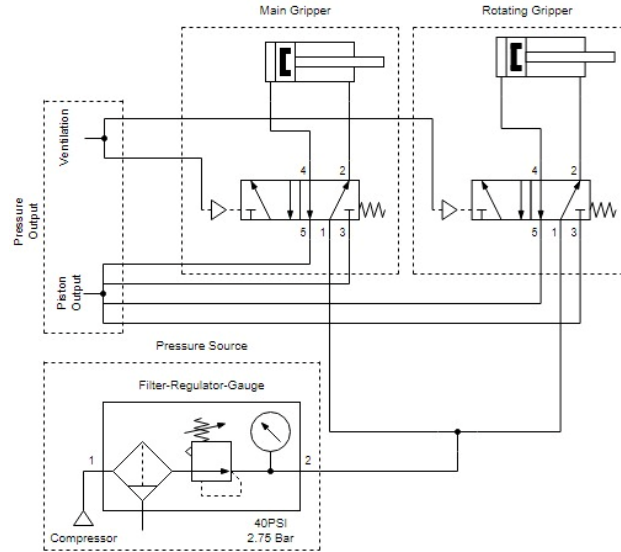


Figure 40: Pneumatic SID

Appendix C

Power calculation table for our ROV components.

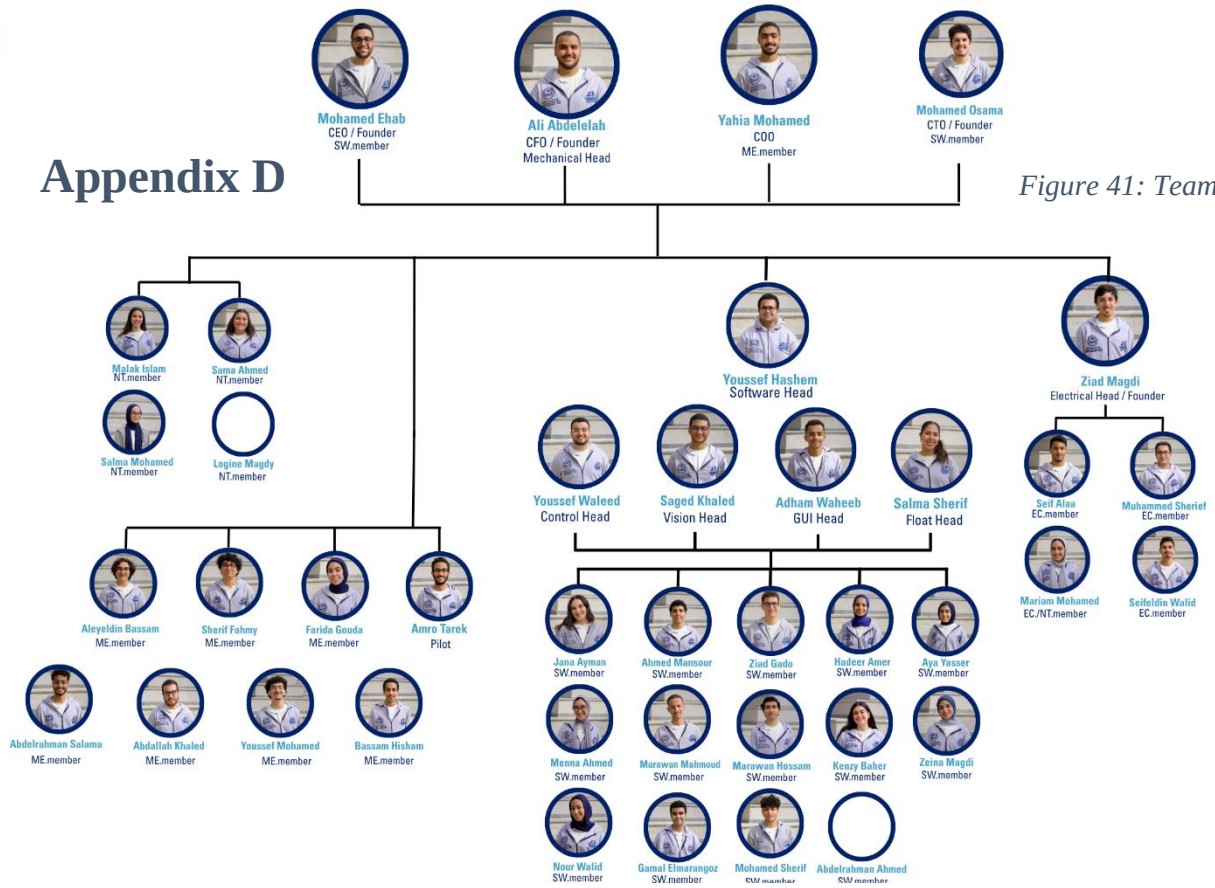
Power Calculation Table									
Component	Model	Qty	Voltage (V)	Max Current (A)	Config Current (A)	Max Power per Unit (W)	Config Power per Unit (W)	Total Max Power (W)	Total Config Power (W)
Motors	Blue Robotics T200 Thrusters	6	11.8	17	17	200	200	1200	1200
Buck conv. 48V→12V	ARTESYN ADQ800-48S12B	2	-	-	-	25	25	50	50
Buck conv. 48V→5V	LM2596HVS	2	-	-	-	4	4	8	8
Buck conv. 12V→5V	XL4016 DC-DC Buck converter	1	-	-	-	6	6	6	6
Cooling Fans	SUPERRED CHD6012ES-A	2	11.8	0.3	0.3	3.6	3.6	7.2	7.2
Underwater LEDs	Blue Robotics Subsea LED Indicator	2	11.8	0.05	0.05	0.59	0.59	1.18	1.18
Pressure Sensor	Blue Robotics Bar Depth/Pressure Sensor	1	3.3	0.00125	0.00125	0.004125	0.004125	0.004125	0.004125
Stereo Camera	OAK-D S2	1	5	1	1	5	5	5	5
Controller	Arduino GIGA R1 WIFI	1	5	0.9	0.5	4.5	2.5	4.5	2.5
IMU	ADAFRUIT BNO055	2	5	0.0123	0.0123	0.0615	0.0615	0.123	0.123
Processing Unit	Raspberry Pi 4 8GB	1	5	5	5	25	25	25	25
Camera	Raspberry Pi Camera	2	3.3	0.25	0.25	0.825	0.825	1.65	1.65
USB Hub	USB HUB 3.0	1	5	0.9	0.9	4.5	4.5	4.5	4.5
USB Camera	AUKEY PC-W3 Webcam FHD1080p	4	5	0.9	0.9	4.5	4.5	18	18
Motor Driver	Cytron MDD3A Dual Channel DC Driver	2	11.8	3	3	35.4	35.4	70.8	70.8
Servo Motor	MG996R Tower Pro	1	5	2.5	0.7	12.5	3.5	12.5	3.5
Gripper	YONGYI PNEUMATIC PUMP	3	11.8	0.25	0.25	3	3	9	9
Analog Cameras	CCTV Analog Cameras	3	11.8	0.42	0.42	5	5	15	15
TOTAL								1438.457 W	1427.457 W

Total Max Power Consumption: 1438.457125 W
 Total Config Power Consumption: 1427.457125 W
 Current Drawn (Max): 1438.457125 / 48 = 29.968 A
 Current Drawn (Config): 1427.457125 / 48 = 29.738 A
 Fuse Used: 30 A

Table 11: Power Calculation Table



Appendix D



Appendix E

Our Initial Budget sheet created pre-season to estimate nearly total budget needed.

Team Name: AAST Triton ROVs

ROV Budget Sheet

Team Name: AAST Triton ROVs		From: 1/9/2025			
CFO: Aly Abdelalah					
Income					
Source			USD Exchange Rate	Amount EGP	Amount USD
			52.339634		
AASTMT				£10,000.00	\$191.06
Expenses					
Category	Type	Description		Amount EGP	Amount USD
Mechanical	Purchased	Frame, Enclosure, Grippers, Sealing Materials, Spare parts for System		£40,000.00	\$764.24
Electrical	Purchased	PCBs Manufacturing, Microcontrollers, Microprocessors, Electrical wires, Connectors		£60,000.00	\$1,146.36
	Donation (AAST)	Thrusters		£138,000.00	\$2,636.63
Software	Purchased	USB hubs, Streaming Cameras, Float Components		£30,000.00	\$573.18
	Re-used	Stereo Camera		£15,000.00	\$286.59
Non-Tech	Purchased	Marketing Materials, Competition Docs, Marketing Display Props, Uniform		£50,000.00	\$955.30
Total Income:				£10,000.00	\$191.06
Total Expenses:				£333,000.00	\$6,362.29
Total Expenses Re-use/Donations:				£153,000.00	\$2,923.21
Total Fundraising Needed:				£170,000.00	\$3,248.02

Table 12: Budget Sheet



Appendix F

Our ROV total cost.

Team Name: AAST Triton ROVs

ROV Cost

Category	Type	Item	Count	Exch. Rate	Value EGP	Value USD
Mechanical	Purchased & Manufactured	ROV Frame	-	\$52.34	£6,000.00	\$114.63
Mechanical	Purchased & Manufactured	Enclosure, Penetrators, Acrylic Sheet	-	—	£4,000.00	\$76.42
Electrical	Donated (AAST)	T200 Thrusters	6	—	£150,000.00	\$2,865.79
Mechanical	Purchased, Manufactured, Assembled	Grippers	2	—	£3,000.00	\$57.32
Software, Mechanical	Camera & Enclosure	USB Camera	2	—	£1,600.00	\$30.57
Software	Camera	Stereo Camera	1	—	£15,735.00	\$300.62
Electrical	Purchased & Manufactured	Control PCB with Arduino GIGA, Raspberry Pi 5 8GB, 2 IMU Adafruit	-	—	£17,862.60	\$341.27
Electrical	Purchased & Manufactured	Power PCB with 2 ADQs Converters, 2 fans, 12-5 Buck Converter	-	—	£12,292.00	\$234.84
Electrical	Purchased & Manufactured	ESCs PCB Manufacturing, ESCs included in Thrusters price	-	—	£1,600.00	\$30.57
Software	Purchased	Raspberry Pi cameras	2	—	£1,720.00	\$32.86
				Total Cost	£213,809.60	\$4,084.90

Table 13: ROV Cost

Appendix G

The table above presents a comparison between the initial pre-season budget and the actual project expenditure

Team Name: AAST Triton ROVs Budget vs. Actual Comparison							
CFO: Aly Abdelelah		From: 1/9/2025					
Category	Type	Description	Budgeted (EGP)	Budgeted (USD)	Actual (EGP)	Actual (USD)	Variance
EXPENSES							
Mechanical	Purchased	Frame, Enclosure, Grippers, Sealing Materials	£40,000	\$764	£27,469	\$526	Under ✓
Electrical	Purchased	PCBs, Microcontrollers, Electrical wires	£60,000	\$1,146	£77,862	\$1,490	Over ✗
	Donation (AAST)	Thrusters	£138,000	\$2,637	£150,000	\$2,869	~On track
Software	Purchased	USB hubs, Cameras, Float Components	£30,000	\$573	£32,580	\$623	~On track
	Re-used	Stereo Camera	£15,000	\$287	£15,000	\$287	On track ✓
Non-Tech	Purchased	Marketing, Competition Docs, Uniform	£50,000	\$956	£50,900	\$974	On track ✓
TOTALS							
Total Expenses			£333,000	\$6,362	£333,811	\$6,389	~On Budget

Table 14: Comparisons Initial Budget vs Project Cost

Our overall project cost.

Project Costing

	Total spent		125,000.00	\$2,072.15
	Total spent		25,000.00	404.43