



Faculty of Engineering
Alexandria University



AQUAPHOTON ACADEMY

Alexandria
Egypt



ORCA

COMPANY STAFF

“## : Graduation Year

Board

“26 Ibrahim Beshr | | CEO

“26 Ahmed Farahat | | Mechanical CTO

“27 Abdelrahman Okab | | Manipulator Team Lead

“27 Moamen Ahmed | | Sealing Team Lead

“27 Youssef Abobakr | | Frame Team Lead

“27 Omar Fayed | | Electrical CTO

“26 Ibrahim Ismail | | Hardware Team Lead

“26 Mohamed Yousry | | Software Team Lead

“27 Mohamed Khamis | | Firmware Team Lead

Software Team

“27 Ahmed Eslam

“27 Farah Bassiony

“28 Farah El Said

“27 Nour Zeidan

“28 Sara Hany

“27 Soad Emad

“27 Youssef Keshk

“28 Ziad Abouelwafa

Firmware Team

“28 Abdallah Taman

“28 Habiba Shaker

“27 Ibrahim El Shami

“28 Mahmoud El Sayed

“28 Mariam Beshr

“27 Mazen Abobakr

“28 Mohamed Wael

“28 Nour Safeieldine

“26 Omar Hafez

Hardware Team

“27 Ahmed Elgammal

“27 Ahmed Waleed

“26 Amira Mohamed

“26 Ezzeldin Fekry

“27 Karim Heiba

“28 Mohamed Emad

“27 Yasmeen Ashraf

“27 Youssef Alaa

Mechanical Team

“28 Abdelrahman Eid

“28 Abdelrahman Yasser

“28 Karma Negm

“27 Nouran Mahmoud

MENTORS

• Ahmed El Tawil

• Ahmed Sameh

• Hany Hamza

• Ahmed Hindawy

• Ahmed El Sayed

• Ibrahim Shenhapy

• Ahmed Khalaf

• Ahmed Thabet

• Mahmoud Hamada

• Ahmed Rizk

• Amr Al Hagla

• Mahmoud Shenawy

• Ahmed Sakr

• Ayman Adly

• Omar Samy

• Marawan Rabee

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• Mostafa El Assar

• Omar Samy

• Omar Yakout

• Seif Bassiouny

• Yahya Medhat

• Youssef El Rayes

• Ziad Amr

Technical Documentation

ROVS BUILT TO LAST



Abstract

Aquaphoton Academy, shown in Fig. 1, is a student-run company based in Alexandria, Egypt, participating for the 14th time and delivering advanced ROVs and integrated electrical solutions for complex marine challenges. This year, **Orca**, the newly upgraded ROV, is engineered to operate in harsh polar environments, track icebergs, and explore coral habitats, directly addressing the 2026 MATE theme of ocean health, biodiversity, and sustainable energy.



Fig. 1: Aquaphoton Academy's Team Members.

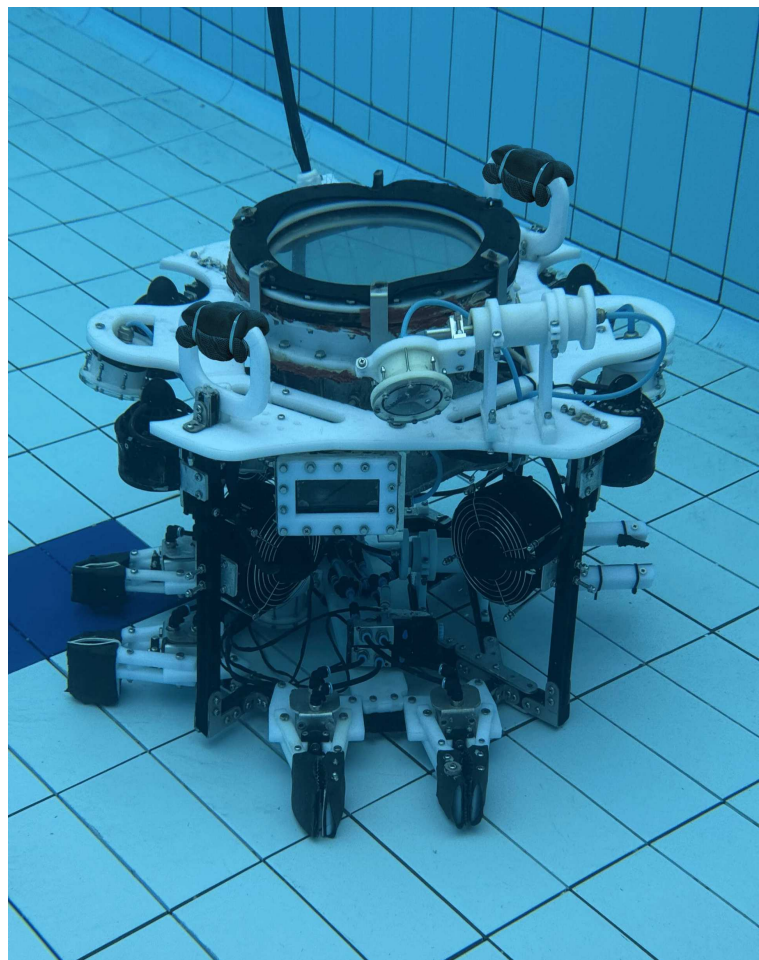


Fig. 2: **Orca**'s Real Life Image.

Orca, shown in Fig. 2, integrates major mechanical and electrical upgrades. Its refined high-density polyethylene (HDPE) frame with a V-slot structure combines the best of the previous two years, improving stability and mission readiness. The canister sealing system was redesigned with a hexagonal enclosure and dual O-ring plug, enabling faster access and reliable watertight integrity. PCBs were upgraded for reliable power and signal distribution, and the control architecture was reorganized to prioritize trajectory generation over low-level hardware control, resulting in smoother navigation through high-velocity currents for (Task 1.3) fly a transect.

Orca's specialized tools directly support real-world marine operations. Its AI-powered OAK-D Lite camera enables coral garden 3D modeling (Task 1.2), simulating underwater conservation methods. Its custom manipulators handle connectors, basket stars, and coral species across multiple tasks, and its DC motor case enables biofouling removal (Task 2.5) and directional camera control. The vertical profiling float contributes to ocean chemistry monitoring aligned with the GO-BGC program (Task 4).

These improvements reflect Aquaphoton's commitment to innovation, sustainability, and building technology that addresses genuine global needs.





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- Our parents and friends for their moral support.



Fig. 3: Supporting Organizations.





1 Design Rationale

1.1 Design Evolution

Aquaphoton's designs have undergone significant development in recent years, and this year's model, **Orca**, shown in Fig. 4, introduces several key advancements over last year's **Octanaut**. Rather than relying entirely on V-slot profiles for the frame structure, an upper HDPE plate was integrated to improve buoyancy and accommodation of various structural fixations.

This year also marks a significant shift in the canister design, improving assembly time and internal accessibility. A hexagonal body structure was adopted to approximate a circular profile while preserving flat mounting surfaces for the glands. This enabled the integration of a circular dual O-ring sealing plug, allowing rapid opening and closure compared to previous designs.

The electrical system was upgraded to enhance overall reliability and operational stability. A custom inertial measurement unit (IMU) was designed, enabling direct system integration and greater flexibility to meet operational requirements. Additionally, a fixation board was carefully designed and implemented to ensure secure mounting of electrical boards while organizing internal components within the canister. This design plays a critical role in maintaining a stable, accessible, and maintainable electrical system.

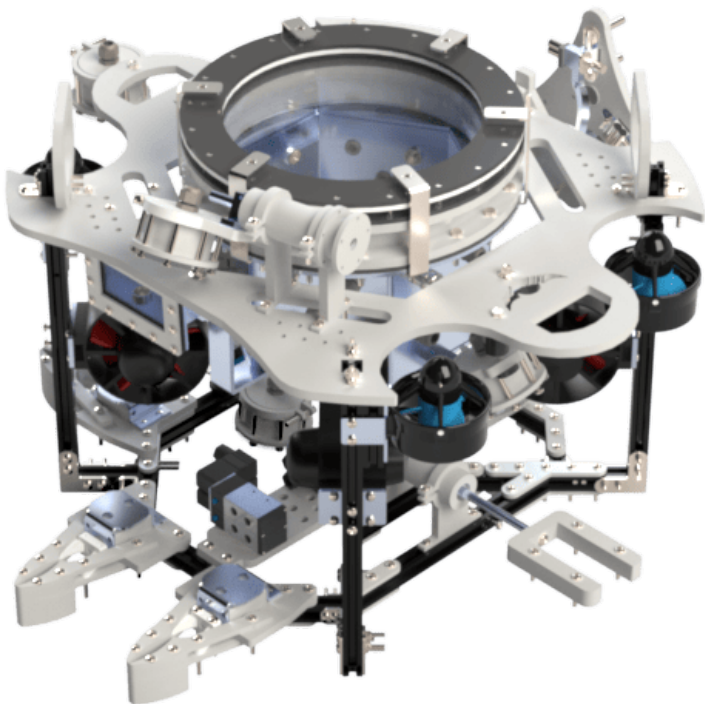


Fig. 4: Rendered Model of **Orca**.

1.2 Innovations

• Canister

Orca's new canister design addresses long-standing accessibility and sealing challenges. Instead of a fully circular enclosure, a hexagonal structure was selected to retain flat mounting faces for cable glands while remaining compatible with a circular sealing approach. This enabled the implementation of a circular plug sealed with dual O-rings, eliminating the need for multiple bolts and significantly reducing assembly time while maintaining reliable watertight sealing.

• Frame

A refined frame architecture combining aluminum V-slot profiles with an HDPE upper plate was introduced to improve structural efficiency and component integration. The V-slot profiles form **Orca**'s structural skeleton, providing rigidity and modularity, while the HDPE plate enables cleaner cable routing, improving system organization, accessibility, and maintainability. It also contributes to overall buoyancy, as shown in Table 3, reducing the need for additional flotation. As a result, this configuration provides a more organized, adaptable, and efficient frame while maintaining the required stability and maneuverability.

• Fixation Board

To ensure secure mounting of the electrical boards and for power distribution purposes, the fixation board, shown in Fig. 5, was designed to provide a rigid structural base for stacking multiple boards, forming a robust, stable system with properly aligned components capable of safely withstanding mechanical vibrations. Power is distributed through wide copper areas that minimize losses and improve heat dissipation. Additionally, the fixation board reduces wiring complexity inside the canister, ensuring compliance with workmanship requirements while achieving higher functionality at a lower cost.

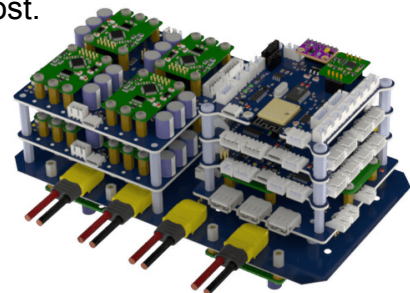


Fig. 5: Rendered System Stack on the Fixation Board.





• Electronic Speed Controller (ESC)

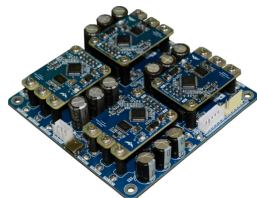
Aquaphoton's hardware subteam designed a custom ESC, shown in Fig. 6a, using an ARM-based controller for enhanced computational performance. The ESC measures voltage, current, temperature, and RPM, and these telemetry data are transmitted to the control board for system monitoring and fault detection.

• ESCs Control Board

The ESCs control board, shown in Fig. 6b, was redesigned to improve system organization and handling. The board manages and monitors up to four ESCs simultaneously. Copper spacers provide both mounting and power transmission, while the communication interfaces, managed by the onboard STM32 microcontroller, enable integration with external control systems, improving functionality and resource efficiency.



(a) ESC

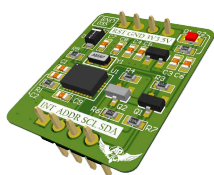


(b) Assembled ESCs Control Board

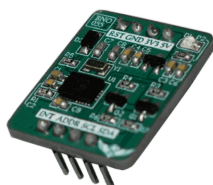
Fig. 6: ESC and ESCs Control Board.

• Custom-designed IMU

A BNO055 IMU, shown in Fig. 7, integrates an accelerometer, gyroscope, and magnetometer. The sensor provides orientation and motion data for **Orca**, which is used to enhance its motion and control system. This improves stability, smooths movement, and reduces response time while maintaining a cost-efficient design.



(a) Render



(b) Real Life

Fig. 7: BNO PCB.

• DC Motor Case

A DC motor case was developed to replace the servo-based camera system, which required frequent opening to replace damaged gears. The sealed housing allows the pilot to safely rotate the main camera and the end effector used in Task 2.5 at various angles.

1.3 Design Process

• Design Brainstorming

During the early design phase, the mechanical subteam analyzed **Octanaut** (last season's ROV) and **Odyssey** (ROV 2023) and identified three candidate frame architectures: full HDPE, full aluminum V-slot, and a hybrid. A full HDPE frame was dismissed early, as replicating **Octanaut's** modularity would require extensive custom machining. A full aluminum frame was rejected due to negative buoyancy, complicating ballasting. The hybrid was therefore selected, with HDPE assigned to buoyancy-sensitive and camera-facing components, and aluminum V-slots assigned to structurally loaded mounts, resolving the minor flexing observed in **Odyssey** under high-thrust maneuvers.

One of **Orca's** most significant design changes was the redevelopment of the canister sealing system. The previous clamp-based enclosure deformed over time and restricted access to internal components. Observing that the team's vertical profiling float had consistently remained leak-free during testing pointed to its O-ring mechanism as the ideal inspiration. With the sealing approach established, attention shifted to canister geometry. An octagonal body was initially considered to approximate a circular profile while preserving flat faces for cable glands, but its narrower faces complicated assembly and maintenance. A hexagonal configuration was therefore adopted, providing wider mounting faces while maintaining compatibility with the circular sealing plug. The final design uses a dual O-ring plug secured by six C-clamps, enabling reliable sealing and rapid access. [1]

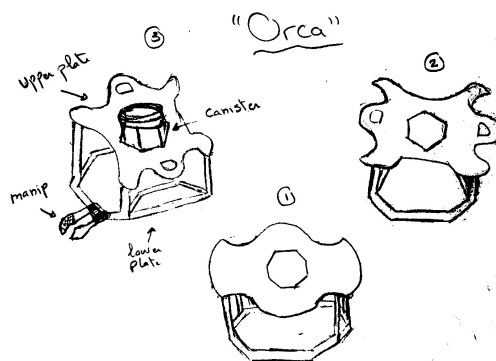


Fig. 8: **Orca's** Design Sketches.



• Preliminary Design

Three-dimensional models of the new frame design were analyzed using precise calculations and stress simulations to ensure structural reliability. These analyses justified the combination of aluminum and HDPE, enhancing overall strength and durability. Additionally, the redesigned camera mounts were implemented to provide a wider field of view, improving visual feedback quality and consistency across diverse underwater conditions.

The electrical system was modularized into independent PCBs to reduce fault propagation and simplify firmware development. Custom ESCs were enhanced with feedback capabilities, and multiple communication protocols were evaluated to identify the optimal solution.

Furthermore, separating the directional control valves (DCVs) control unit from the motor driver unit increased actuator capacity. A fixation board was also designed to ensure secure mounting and efficient power distribution from the tether.

Orca's control system uses a kinematic thrust allocation matrix (TAM) to convert six-degree-of-freedom (6-DOF) pilot commands into optimized thruster outputs. This ensures high maneuverability for complex tasks. This model is integrated with a proportional integral derivative (PID) closed-loop control (depth-hold and yaw-lock) to provide the stability required for station-keeping during the fly a transect mission (Task 1.3).

• Detailed Design

Orca's structural and mechanical components were fully designed using SOLIDWORKS, where flow simulations and stress analysis were conducted to identify structural weaknesses and finalize a manufacturable design, as shown in Fig. 9. A trade-off matrix, shown in Table 1, was used to select the optimal materials based on machinability, gravity, availability, and cost. This evaluation led to a balanced solution combining aluminum and HDPE [2].

The electrical system was developed in parallel; PCBs were designed using Altium Designer, with final layouts exported as Gerber files for manufacturing and a bill of materials (BOM) sent to component suppliers. During this phase, the firmware team tested concepts on development boards before product finalization.

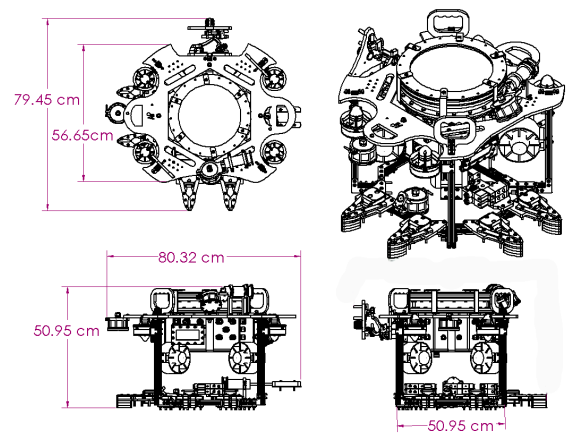


Fig. 9: **Orca's** Drawing and Dimensions in cm.

Table 1: Material Trade off Matrix.

Criteria		Weight						Material Options				
		Frame	Manipulator	Glands	Casings	Camera Fixation	Guides, Screws and Nuts	Score				
								Stainless Steel	Aluminium	HDPE	ABS	Acrylic
1	Cost	0.2	0.2	0.3	0.2	0.1	0.1	6	6	9	4	6
2	Machinability	0.1	0.1	0	0.2	0.3	0	6	9	6	10	1
3	Specific Gravity	0.2	0.3	0.1	0.1	0.1	0.1	2	6	9	10	8
4	Strength	0.2	0.2	0.6	0.1	0.2	0.8	9	8	6	5	4
5	Flexibility	0.3	0.2	0	0.2	0.3	0	5	9	8	5	1
6	Transparency	0	0	0	0.2	0	0	0	0	0	0	10
Total Score Formula		$\sum_{criteria=1}^n (weighting\ of\ component)_{criteria} \times (material\ score)_{criteria}$										
		Frame						5.5	7.6	7.8	6.3	4
		Manipulator						5.2	7.3	7.9	6.8	4.7
		Glands						7.4	7.2	7.2	5.2	5
		Casings						4.5	6.2	6.1	5.3	4.8
		Camera Fixation						5.9	8.2	7.2	6.9	2.8
		Guides, Screws and Nuts						8	7.6	6.6	5.4	4.6

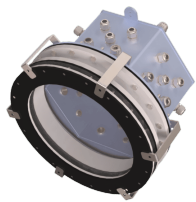
1.4 Manufacturing Process

Manufacturing was performed using computer numerical control (CNC) machines to ensure structural integrity and dimensional accuracy. Aluminum and acrylic sheets were laser-cut, cylindrical parts were produced through turning, the canister's aluminum sheets were bent and welded to achieve a tight seal, and a CNC router was used to cut HDPE plates efficiently and optimize material usage. Hand tools such as drills and angle grinders were used for finishing, hole cutting, and edge smoothing. Components that could not be fabricated from sheet materials were 3D printed from Acrylonitrile Butadiene Styrene (ABS) due to its rigidity and cost-effectiveness. Standard safety precautions, including protective gloves, goggles, and hearing protection, were followed throughout the process [3]. In parallel, the electrical team soldered, tested, and assembled PCBs to detect faults early and simplify debugging.



1.5 Vehicle Core Systems

1.5.1 Mechanical



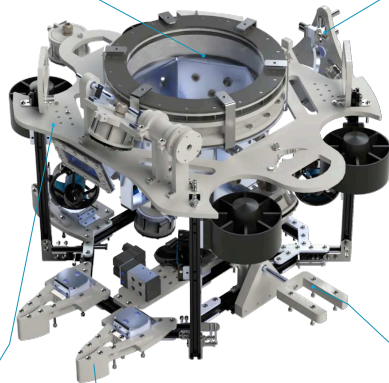
Canister

The canister is designed to protect the electrical system. It features a hexagonal body with six equally spaced flat faces, each measuring 135×150 mm, providing sufficient space to mount the required glands. This geometry supports the adopted sealing technique while improving accessibility. Aluminum was selected for the main body due to its effective heat dissipation, helping to maintain safe operating temperatures for the electronics. For the top cover, acrylic was utilized to allow visual inspection of the internal components.



Tether Strain Relief System

Orca's 26 m tether is encased in an outer sheath for underwater durability. To reduce costs while maintaining reliability, a universal joint mechanism reused from last year is utilized at both ends; this mechanism absorbs tensile loads and sudden forces, preventing damage to the internal power, Ethernet, and pneumatic lines. To ensure neutral buoyancy and reduce drag, the entire bundle is wrapped in rubber sheathing.



Manipulators

The general manipulator is **Orca's** primary handling mechanism, with four manipulators installed to perform multiple tasks, including handling basket stars (Task 1.1), connectors (Task 3.2), and PVC pipes of various diameters. Each manipulator has two HDPE end effectors mounted on a horizontal 32×25 mm compact, double-acting pneumatic piston that delivers a maximum force of 217 N. The end effectors feature a closing range from 1 to 8 cm, providing secure grasping and sufficient clamping force for underwater operations.



Frame

Orca's frame is primarily constructed from 6061 aluminum alloy due to its high strength-to-weight ratio, ductility, and corrosion resistance. An upper HDPE plate helps achieve near-neutral buoyancy. The structure combines aluminum and stainless steel components to utilize the mechanical advantages of each material [4].



DC Motor

The DC motor enclosure is made of HDPE, sealed with a flange and two radial O-rings. The shaft is sealed with an oil seal, ensuring reliable torque transmission while maintaining impermeable integrity. The motor is secured within the enclosure using a 3D-printed mount, and a bearing dampens vibration for stable operation.

• Frame's Mechanical Design

The frame consists of an upper plate and lower plate connected by four vertical 20×20 mm aluminum V-slot profiles, providing flexible mounting points for cameras, thrusters, and manipulators. The V-slot profiles are oriented at 45° to support the thruster configuration.

The upper HDPE plate, shown in Fig. 10, includes openings for cable routing and reduced hydrodynamic drag, and it houses the main camera and a tether strain-relief mechanism. It also supports four vertically mounted Blue Robotics T200 thrusters, the canister holder, and two integrated HDPE handles for safe handling.

The lower plate features an octagonal V-slot structure supporting four HDPE manipulators. An additional HDPE plate is used to mount the DCVs, improving accessibility and cable management.



Fig. 10: **Orca's** Upper Plate Stress Analysis.



• Propulsion

Orca's propulsion system features eight thrusters for full 6-DOF control: four horizontal APISQUEEN U92 and four vertical Blue Robotics T200 thrusters.

The U92 thrusters, shown in Fig. 11a, are mounted on vertical V-slots at 45° in an X-configuration, providing 46.09 N forward and 32.373 N backward thrust per thruster. According to (1), this yields a total thrust of 110.963 N per DOF, improving surge and sway performance while contributing to yaw control.

$$F_{\text{net}} = 2 \times \cos(45^\circ) \times (F_{\text{forward}} + F_{\text{backward}}) \quad (1)$$

The T200 thrusters are installed on the upper plate for heave control and roll/pitch stabilization, with a maximum thrust of 36.4 N each and a total of 145.6 N. This configuration enables full 6-DOF motion, as shown in Fig. 11b, ensuring stable and efficient underwater operation [5].

The U92 was favored over the T200 due to its higher overall score in cost, efficiency, and propeller strength, while the T200 was selected for vertical placement because of its compact size. The U92's higher thrust was also a key advantage for the fly a transect mission, where a stable position is required to be maintained against waves for 30 seconds in the flume tank.

Table 2: Thruster's Trade-off matrix

		Weight	T200	U92
1	Cost	0.2	5	9
2	Weight	0.1	8	4
3	Volume	0.1	7	5
4	Efficiency	0.3	4	7
5	Sustainability	0.1	3	8
6	Propeller Strength	0.2	4	8
	Total Score	1	31	41

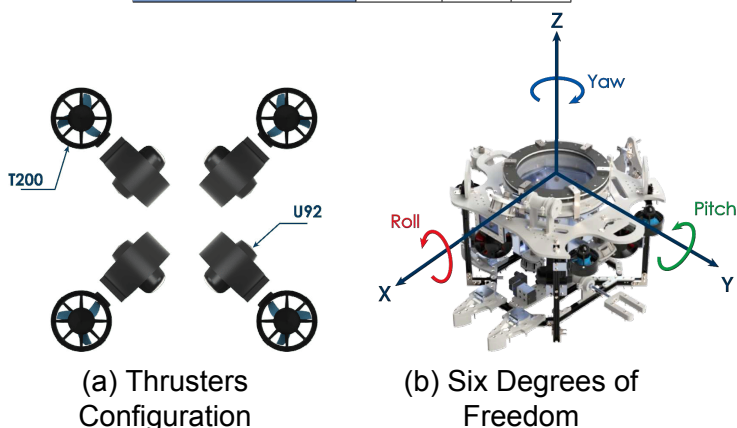


Fig. 11: **Orca's** Propulsion.

Flow simulations validated **Orca's** ability to withstand drag forces and estimate maximum

operational speed. As shown in Fig. 12, a drag force of 48 N was calculated at 1 m/s over a projected area of 0.0465 m² according to (2).

$$F_D = C_D * A * \rho * V^2 / 2 \quad (2)$$

where F_D : drag force, C_D : coefficient of drag, A : projected area, ρ : density of the fluid, and V : flow velocity relative to the object.

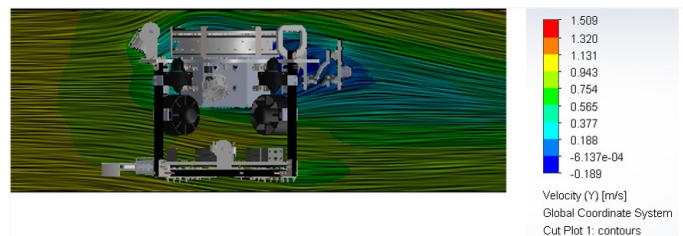


Fig. 12: Flow Simulation in SOLIDWORKS.

• Buoyancy and Stability

During design, simulations determined the shift of the center of buoyancy (C_b) relative to the center of gravity (C_g). It was concluded to be 1.88 mm to the left of **Orca**, 9.16 mm to the back, and 56.17 upwards.

To ensure efficient underwater operation, **Orca** must achieve neutral or slightly positive buoyancy in order to remain stable without requiring excessive thrust from the propulsion system. The external buoyancy foam compensated for the shift [6].

Taking the left rear edge of the upper plate as a reference, **Orca's** C_g coordinates are (294.14, -279.3, -113.18) mm, and its C_b is located at (284.98, -281.18, -57.01) mm. **Orca's** total weight is 309.015 N, and its displacement volume is 0.0256 m³.

The buoyant force acting on **Orca** was calculated according to Archimedes' principle, which states that the buoyant force acting on a submerged body is equal to the weight of the fluid displaced by that body. This relationship is expressed in (3).

$$F_b = \rho * V * g \quad (3)$$

where: ρ : fluid density, V : displaced volume, g : acceleration due to gravity, and F_b : buoyancy force. F_b equals 251 N.

To evaluate the vehicle's buoyancy characteristics, a detailed breakdown of each component's mass, volume, and resulting buoyant force was conducted. Table 3 summarizes the buoyancy contribution of all major components. A volume of approximately 0.0059 m³ of foam is required to achieve neutral buoyancy.



Table 3: **Orca's** Buoyancy Table.

ITEM	QTY	Mass (Kg)	Weight (N) ($M \cdot g$)	Volume (cm ³)	Buoyant Force (N) ($\rho \cdot g \cdot V$)	Net Buoyant Force (N) ($F_b - W$)
Upper Plate	1	1.4	13.734	1458	14.303	0.56898
Lower Plate	1	2.5	24.525	1514.57	14.85793	-9.66707
Canister	1	9	88.29	15135	148.4744	60.1844
Canister Housing	1	0.65	6.3765	205.42	2.01517	-4.36133
C Clamps	6	0.38	3.7278	38	0.37278	-3.35502
Glands	37	0.98	9.6138	189.92	1.86312	-7.75068
T200 Thrusters	4	1.32	12.9492	780	7.6518	-5.2974
U92 Thrusters	4	4	39.24	1950	19.1295	-20.1105
Vertical V-slots	4	0.768	7.53408	232.916	2.28491	-5.24917
Strain Relief	1	0.742	7.27902	473	4.64013	-2.63889
Handles	2	0.14	1.3734	144.846	1.42094	0.04754
Fittings	28	0.34	3.3354	73	0.71613	-2.61927
Connectors	35	0.28	2.7468	8.75	0.08584	-2.66096
Motor Cases	2	0.61	5.9841	32.044	3.14352	-2.84058
Camera Cases	4	0.41	4.0221	779.76	7.64945	3.627346
OAK-D Case	1	0.42	4.1202	200	1.962	-2.1582
DCVs	5	1	9.81	500	4.905	-4.905
Manipulators	4	2.8	27.468	1100	10.791	-16.677
Bolts	360	2.75	26.9775	424.08	4.16022	-22.8173
Nuts	360	0.52	5.1012	63	0.61803	-4.48317
Washers	150	0.15	1.4715	9.3	0.09123	-1.38027
L Brackets	22	0.34	3.3354	90	0.34335	-3.24711
Total	1033	31.5	309.015	25609.002	251.224	-57.7907

Sealing

Canister Sealing

The canister cover sealing system consists of two main parts: a circular aluminum flange welded to the body, with an HDPE seat and gasket permanently bolted during manufacturing, and a circular plug fitted into the seat and sealed with two O-rings [7]. Since machining an integrated O-ring groove directly into the aluminum body was not practical, an intermediate HDPE seat was introduced to simplify manufacturing and improve accessibility. Both parts are held together with six aluminum C-clamps to maintain watertight integrity under high pressure, and thirty AGRO glands seal the electrical wires passing through the canister. This enclosure enables rapid removal while maintaining reliable sealing.

DC Motor Case Sealing

The DC motor enclosure is made of HDPE, sealed with a flange and two radial O-rings. The shaft is sealed with an oil seal, as shown in Fig. 13, ensuring reliable torque transmission along with a tight seal. The motor is secured within the enclosure using a custom 3D-printed internal mount, allowing the same enclosure design to accommodate different components, and a bearing dampens vibration for stable operation.



(a) Assembled View

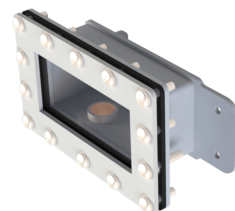


(b) Exploded View

Fig. 13: Rendered DC Motor Case.

OAK-D Camera Case Sealing

The camera enclosure, shown in Fig. 14, is an aluminum container (110 × 50 × 32 mm) with a welded flange (76 × 84 mm) sealed using a custom gasket and bolts. Moreover, the camera case features a sealed cable with an AGRO gland and an acrylic lens, which provides clear underwater vision.



(a) Assembled View



(b) Exploded View

Fig. 14: Rendered OAK-D Camera Case.

Manipulator Camera Case

Fig. 15 shows the camera case positioned to capture the manipulators. Retaining last year's design leverages its proven reliability to maintain system effectiveness in the current model. The case is a hollow cylindrical HDPE container with a cross-sectional area of 56 mm² and a height of 40 mm. A 5 mm thick acrylic lens is sealed by an O-ring with a 62 mm diameter and a 2 mm thickness, then secured with bolts. The camera case is mounted via threaded inserts on the HDPE extension, and its cables are sealed with an AGRO gland at the base.



(a) Assembled View



(b) Exploded View

Fig. 15: Rendered Manipulator Camera Case.





1.5.2 Electrical

Orca's electrical system integrates power distribution, control, and communication to ensure reliable vehicle operation. It consists of four PCBs: a Control Unit, a DCVs Control Unit, a Motor Driver Unit, and a Power Unit. All boards use surface mount device (SMD) technology to reduce size and cost. Compared to last season, the Signal Distribution Unit was divided into two boards: the Motor Driver Unit and the DCVs Control Unit, allowing the integration of additional motor drivers for both DC and stepper motors. [8]

• Control Unit

The Control Unit plays a crucial role in managing **Orca's** motion and processing feedback from various sensors, including the IMU and pressure sensor. The board communicates with ESCs control boards through serial peripheral interface (SPI) protocol.

• Power Unit

The Power Unit is responsible for supplying power to **Orca's** control stack. It consists of three buck converters that step down an input voltage of up to 48 V to 12 V, 6 V, and 5 V for system distribution. The unit was redesigned with removable buck modules to simplify debugging and maintenance, and includes sensors to monitor the voltage and current of each converter, improving efficiency and reliability.

• Motor Driver Unit

The Motor Driver Unit includes a dedicated STM32 microcontroller to handle communication with the DCV unit via SPI. It controls and manages the signals for two servo motors, four stepper motors, and four DC motors.

• DCVs Control Unit

The DCVs Control Unit operates the solenoids of the directional control valves and several auxiliary actuators in **Orca**, powered by an STM32 microcontroller. It can control up to fourteen DCVs and features DC and stepper motor drivers. The board also provides power channels for two high-intensity flashlights, includes analog-to-digital converters (ADCs) for sensor feedback, and supports interfacing with a leakage sensor.

Fig. 16: Full System Overview.

• System Integration

As shown in Fig. 16, the four PCBs are interconnected to form **Orca's** complete electrical stack. Power is distributed through four spacers, which are insulated with heat-shrink to ensure safe operation.

• USB Hub

Last year, a custom USB 3.0 hub, shown in Fig. 17, was designed to provide stable high-speed data transmission. It supports data rates of up to 5 Gb/s, ten times faster than USB 2.0, while maintaining backward compatibility. Improved power management prevents voltage fluctuations that could affect camera performance, enabling low-latency video streaming.

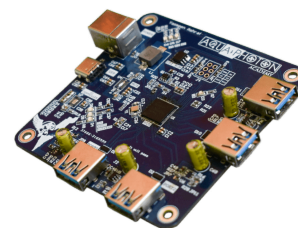


Fig. 17: USB Hub 3.0.





• Power Calculations

To ensure electrical protection and safety, the fuse size was determined based on the full load amperage (FLA) measured during full submersion, with full forward and full downward thrust applied to all motors, using the control box's multimeter. Hence, the selected fuse size is the next available standard value, as shown in Table 4.

Table 4: Selected Fuse Size According to MATE Specifications.

Measured FLA at 48 V	48 V FLA Competition Specifications	Fuse Ampere Size	JCASE Color
22 A	20.6 A to 26.3 A	25 A	White

The power consumed was calculated using the operating voltage and the maximum current that can be drawn for all components of the electrical system, based on the datasheet specifications or practical experiments, as shown in Table 5.

Table 5: Power Calculations for **Orca's** Electrical Components.

Component	Operating Voltage (V)	Max. Current (A)	Quantity	Consumed Power (W)
Thruster (U92)	12	15	4	720
Thruster (T200)	12	9	4	432
USB Camera	5	0.5	4	10
OAK-D Camera	5	1	1	5
DCV	12	0.33	4	15.84
Raspberry Pi	5	2	1	10
DC Motor	12	1	2	24
ESP32	3.3	0.26	1	0.858
STM32	3.3	0.15	4	1.98
USB Hub	5	0.4	1	2
BNO055	3.3	0.1	1	0.33
Pressure Sensor	3.3	0.1	1	0.33
Total				1222.34

• Tether Management Protocol

To ensure operational safety and maintain the integrity of the communication link, Aquaphoton adheres to a strict tether management protocol during all phases of deployment.

► Pre-Deployment & Connection

The Tether Manager begins with a visual inspection of the cable for abrasions or kinks. The tether is first secured via mechanical strain relief at the surface station before the signal, power, and pneumatic lines are connected to the pilot's station, as shown in Fig. 18. This prevents accidental tension from damaging the connectors or internal conductors.

► Active Operation

During the mission, the Tether Manager handles the line in synchronization with **Orca's** movements. The goal is to give the ROV sufficient slack for maneuverability while preventing the tether from becoming entangled in the thrusters or pool debris.

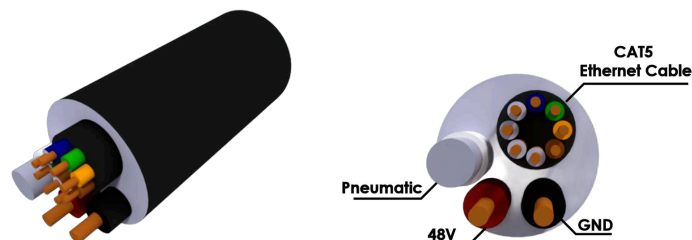


Fig. 18: Tether System Overview.

► Recovery & Storage

When the mission is over, the tether is disconnected from the surface station. To prevent twisting and damage to the tether, the underhand-overhand coiling technique is utilized. This ensures the tether deploys smoothly and remains flat during future operations. Once coiled, the tether is secured around **Orca's** round canister for safe transport and compact storage.

• Vision System

The vision system was significantly improved this year with the addition of an OAK-D Lite camera for accurate underwater distance measurement using disparity mapping. Four USB cameras, valued for their compact size and image quality, were retained, including a wide-angle camera repurposed for side-view situational awareness. A more detailed illustration of **Orca's** vision system is shown in Figs. 19 and 20.

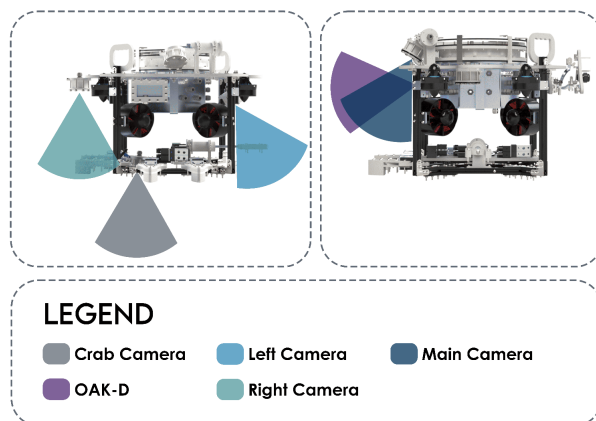


Fig. 19: **Orca's** Field of View.



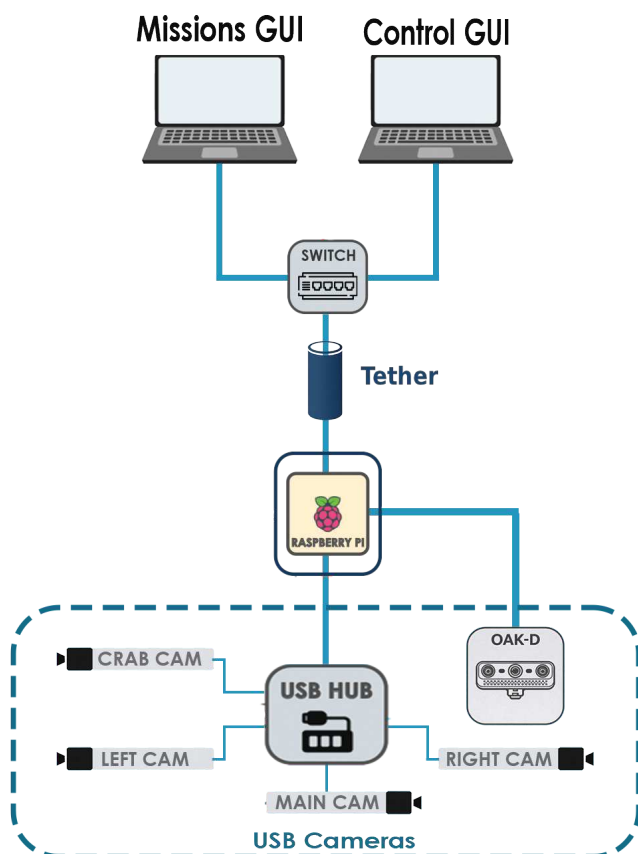


Fig. 20: Cameras System Diagram.

• Topside Control Station

Orca's control station, shown in Fig. 21, consists of two laptops: one that runs the Control graphical user interface (GUI) and the other runs the Missions GUI. The control station setup also contains an Xbox controller and a portable control box for power distribution, AC and DC. Furthermore, the input DC voltage and drawn current are measured using a digital multimeter for power monitoring. A 5 VDC source was provided to power the Ethernet switch responsible for communication, and a kill switch was installed to disconnect the power delivered to **Orca** immediately in case of emergency.



Fig. 21: **Orca's** Control Station.

• Control System

Orca's control system was engineered to address the 2026 competition's environmental challenges, particularly high-velocity currents in the Flume Tank (Task 1.3). To ensure station-keeping stability, the architecture transitioned from fixed motor ratios to a kinematic Thruster Allocation Matrix ($\mathbf{K}^\dagger$), which calculates the force required from each of the eight thrusters (T_{1-8}) for desired 6-DOF movement (4). Resultant values are processed through a lookup table for precise force-to-RPM conversion. High-level tasks such as PID calculations and signal generation were migrated from the topside laptop to the onboard Raspberry Pi, dedicating the pilot's station to 6-DOF trajectory generation while the onboard system handles low-level hardware timing.

$$\begin{bmatrix} T_1 \\ T_2 \\ T_3 \\ \vdots \\ T_8 \end{bmatrix} = \mathbf{K}^\dagger \begin{bmatrix} \text{Surge} \\ \text{Sway} \\ \text{Heave} \\ \text{Roll} \\ \text{Pitch} \\ \text{Yaw} \end{bmatrix} \quad (4)$$

► Development and Software Tools

Robot Operating System 2 (ROS 2) was employed for modular node integration, enabling the TAM, mapping, and PID modules to operate as independent yet interconnected units. PlotJuggler, as shown in Fig. 22, was used during tuning to visualize real-time response curves and determine optimal K_p , K_i , and K_d parameters for counteracting water currents. Git with a strict branch-per-feature workflow maintained code integrity throughout development.

► Verification and Safety

System stability was validated through three testing phases: dry testing to confirm TAM logic [9] and safety mechanisms, pool trials to refine Depth-hold and Yaw-lock PID controllers, and controlled failure scenarios to verify watchdog timer effectiveness during communication loss. This process ensures **Orca's** stability against sudden currents while protecting competition venue infrastructure.

► System Comparison

After months of testing and evaluation, the TAM system demonstrated several advantages over the previous approach, while also highlighting certain limitations. A comparative analysis was conducted





to assess the performance and trade-offs between the RPM / Fixed Ratios and TAM control systems shown in Table 6.

Table 6: Comparison Between RPM-Based and TAM Control Approaches.

Aspect	RPM / Fixed Ratios system	TAM system
Control Approach	Hardcoded thruster ratios	Model-based force & moment allocation
Motion Capability	Limited to predefined directions	Full 6-DOF combined motion
Tuning	Simple manual ratios tuning	Requires systematic tuning
Scalability	Poor (requires full re-tuning)	Adaptable
Motion Fidelity	High accuracy (limited to defined motions & speeds)	Moderate accuracy across all motions & speeds
Robustness	Limited (tuned scenarios)	Robust (wide operating range)
Autonomous Integration	Difficult with hardcoded functions	Easy with high-level commands
Modularity	Limited	High modularity
Axis Decoupling	Limited	Structured (force/moment-based control)
Configurability	Easily adaptable to different ROVs	Complex (Requires a dedicated kinematic model)
Setup Effort	Low	Higher (model derivation & thrusters calibration required)

1.5.3 Software

• Communication System

Orca's communication system can be divided into three main layers: communication between the station laptop and the Raspberry Pi, communication between the Raspberry Pi and the onboard microcontrollers, and inter-microcontroller communication within the underwater system.

The Raspberry Pi serves as the main communication hub between the topside station and **Orca's** underwater system, as shown in Fig. 23. The underwater control system is primarily based on the Raspberry Pi and five microcontrollers: one ESP32 and four STM32. The

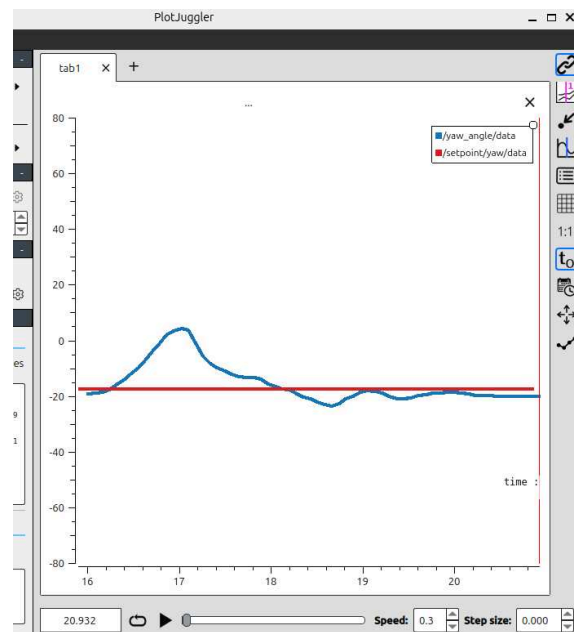


Fig. 22: Yaw PID Controller Tracking Performance.

ESP32 is responsible for motion processing, as well as acquiring feedback from the BNO055 IMU sensor for heading estimation and the MS5540C pressure sensor for depth measurement. It interfaces with the ESC control board through two STM32 microcontrollers for horizontal and vertical thruster control. In addition, two STM32 boards are used for auxiliary functions such as controlling the grippers and DC motors.

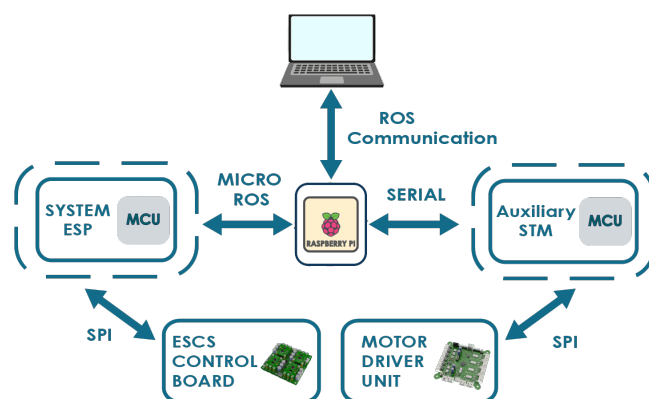


Fig. 23: Communication System Diagram.

Joystick 6-DOF motion commands and auxiliary control signals for the grippers and DC motors are processed, mapped and published into multiple ROS 2 topics from the station to the underwater system, while sensor data is published from the control unit back to the station. Thereafter, PID controllers are applied to correct errors in the 6-DOF desired forces. In the final stage, corrected outputs pass through the TAM to determine each thruster's required force contribution. These forces are converted to RPM values and sent to the actuation system.





● Graphical User Interface

Orca's GUI provides the pilot with real-time ROV state through camera feeds, sensor data, and status monitors, prioritizing simplicity for effective mission operation. This year, the Control and Missions interfaces were unified into a single React application, as shown in Fig. 24, allowing the co-pilot to access the Missions GUI directly from the main interface via a navigation button.

► Control GUI

Built on React for its performance, stability, and remote access capabilities, the Control GUI retains a timer, speed indicator, Raspberry Pi temperature monitor, multi-camera video feeds with screenshot and recording support, and icons for motion direction, Pi connectivity, and ESP32

ROS 2 node status. A Configurations window supports thruster testing and camera settings. New additions this year include TCP and camera connectivity indicators, an IMU-driven compass for situational awareness, and PID performance graphs for monitoring control behavior.

► Missions GUI

The Missions GUI was rebuilt in React, replacing last year's PyQt6 implementation, and integrated within the same application as the Control GUI for consistency and simplified interaction. It allows the co-pilot to switch between missions while displaying relevant camera feeds, mission data, and float sensor readings, enabling quick access to mission-specific tools and improving operational efficiency.

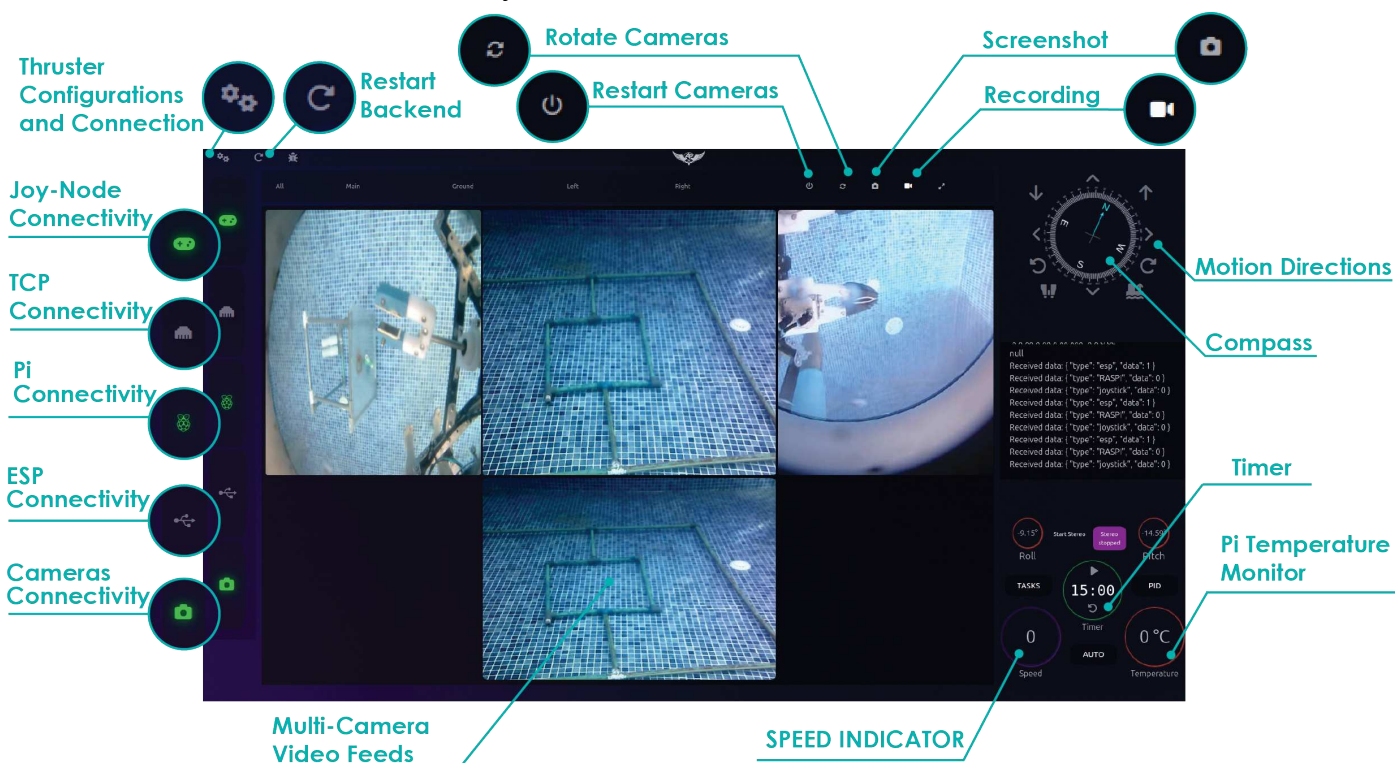


Fig. 24: **Orca's** GUI.

● Gazebo Simulation

To enhance reliability and reduce development risks, **Orca** is validated in both simulated and real-world environments. Simulation enables rapid testing and iteration before real-world deployment.

This year, Aquaphoton added a simulated testing feature using Gazebo on ROS 2, as shown in Fig. 25, allowing new control strategies and ROV movements to be tested virtually before physical trials. This enables early detection of errors, faster debugging, and easier adjustments to thruster configurations, motor positions, and overall design before assembly. [10]

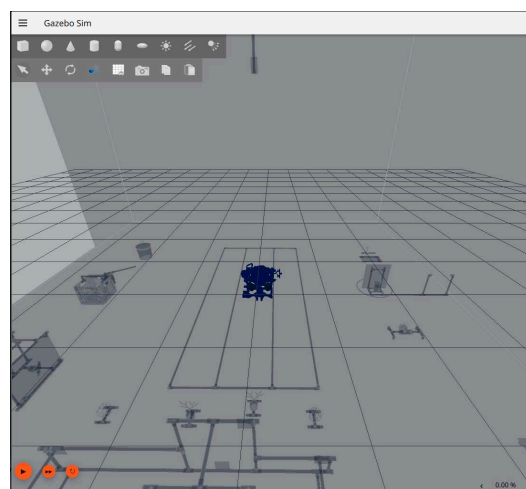


Fig. 25: Gazebo Underwater Simulation.





1.6 Auxiliary Mission Tools

1.6.1 Vertical Profiling Float

The vertical profiling float, shown in Fig. 26, was developed in contribution to the NSF-funded GO-BGC project, which aims to expand global ocean observation. This year's float performs two precise vertical profiling tasks for ocean health data collection.

The float integrates mechanical, hardware, and software components for controlled vertical movement. A PID-controlled buoyancy engine adjusts syringe position via a motor to regulate depth. To close the control loop, a magnetic encoder tracks screw rotation and a depth sensor provides real-time depth measurements, both feeding back continuously to the PID controller to correct positional errors and maintain accurate vertical motion across both profiles.

An ESP32 microcontroller connects the float to the task station via a WebSocket server, enabling profile data transmission to the Missions GUI upon mission completion. The GUI displays depth-over-time graphs, as shown in Fig. 27, providing a clear visual representation of the float's adherence to specified depth and duration constraints.

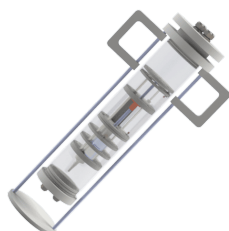


Fig. 26: Vertical Profiling Float.

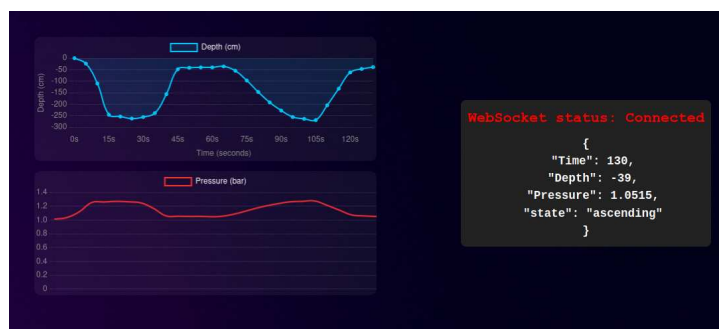


Fig. 27: Depth-over-time graph showing the Vertical Profiling Float's performance.

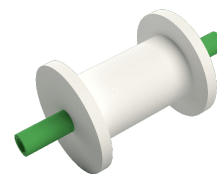
1.6.2 Payloads

• Locking Mechanism

For the buoy anchor (Task 2.4), a spring-loaded locking mechanism, as shown in Fig. 28, was developed to securely attach to the buoy anchor's U-bolt. Functioning like a spring clip, it clamps onto the U-bolt, establishing a 360° grip and preventing detachment during recovery. A PVC pulley integrated into the ROV guides the rope and maintains tension once the mechanism is engaged. After attachment, **Orca** reverses, allowing the rope to roll through the pulley and be pulled toward the poolside under constant tension.



(a) Buoy Anchor Side



(b) ROV Side

Fig. 28: Locking Mechanism.

• Holyrood Camera Cleaning

A U-shaped end effector, fabricated from HDPE, is coupled to a motor that drives its rotation for the observatory camera (Task 2.5). The end effector features two teeth that secure the PVC pipe between them, enabling the motor to rotate the inner plastic sheeting, as shown in Fig. 29.



Fig. 29: Holyrood Camera Cleaning Mechanism.

1.6.3 Software Algorithms

• Coral Garden Ridge Modelling

ROVs are used for autonomously navigating challenging environments to monitor coral reef health and restoration efforts.

Orca rotates 360 degrees around the coral garden (Task 1.2) to capture multi-view images. Neural Radiance Fields (NeRF) was selected for reconstruction because it represents the environment as a continuous 5D function (x, y, z, θ, ϕ) rather than a sparse point cloud. The algorithm operates by casting camera rays through the scene; for each sampled point along a ray, a multilayer perceptron (MLP) predicts the





volume density and view-dependent RGB color. By minimizing the difference between the rendered views and the original 2D images, the network converges on a highly detailed 3D geometry that effectively captures complex light scattering. While the OAK-D Lite camera provides depth data specifically for real-world scaling and length measurements, the 3D geometry is extracted from the neural density field and converted into a textured mesh, as illustrated in Fig. 30.



Fig. 30: 3D Model Output Example.

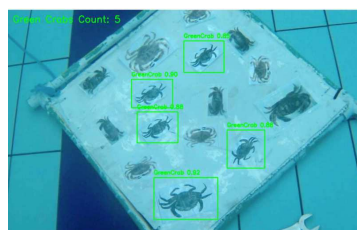
• Mitigate Invasive Species

Detection and counting of the European green crab (Task 2.1) is crucial to mitigate the threat posed to native creatures.

Machine learning algorithms are commonly used for these types of problems. Specifically, the you only look once (YOLO) framework was employed to accurately detect the European green crab population. A YOLOv11n model was trained on 160 images collected and manually annotated for this purpose. Annotations were achieved by drawing bounding boxes around European green crabs, native Jonah crabs, and native Rock crabs, with labels distinguishing the invasive species from the native ones as shown in Fig. 31b. This approach achieved 96% test accuracy for the green crab class and was designed to provide real-time counts and visual bounding boxes while specifically ignoring native rock and Jonah crabs to ensure the accuracy of the mitigation effort, as shown in Fig. 31a [11].

2 Safety

Since its founding, Aquaphoton has prioritized safety across all operations, maintaining protocols that protect team members, **Orca's** integrity, and the marine environment. Protocols are continuously updated to address new equipment and challenges, with experienced mentors



(a) Green Crab Detection



(b) Annotation Process

Fig. 31: Green Crab Detection and Annotation.

supervising training to ensure proper equipment use, as shown in Fig. 32.



Fig. 32: Safety Practices in Action.

2.1 Workshop Safety

The workshop is divided into electrical and mechanical zones, each equipped with appropriate safety gear including face shields, gloves, and welding filters. A Safety Director oversees all fabrication activities, enforcing protocols listed in Appendix B. Jobsite safety and environment analysis (JSEA) is conducted before high-risk machinery use, and personal protective equipment (PPE) such as safety glasses and antistatic wrist straps is strictly enforced in each zone.

2.2 Safety Training

Safety is the foundation of every Aquaphoton Academy training session and a key criterion in mentor selection. New members receive instruction on safety regulations followed by supervised hands-on experience, as summarized in Table 7.





Table 7: Safety Training Matrix.

Training Topic	All Members	Elec.	Mech.
Safety Regulations	✓		
PPE Usage	✓		
Emergency Procedures	✓		
Fume Extraction	✓		
Tool Handling	✓		
Soldering Safety		✓	
Antistatic Wrist Strap		✓	
PCB Inspection		✓	
Precision Drilling			✓
Material Procedures			✓
CNC & Laser Cutting			✓
Sharp Tool Handling			✓

2.3 ROV Safety Features

Orca incorporates multiple safety features this year: the frame was sanded to remove sharp edges, screws were secured against vibration, and thruster propellers were shrouded for operator safety. A master Emergency Stop button on the topside control box enables immediate tether power cut-off. Following Smart Atlantic Alliance guidelines, external cables are grouped and anchored to create a snag-free profile, reducing entanglement risk with mission props. Lift handles were relocated to a dedicated safety zone, isolated from front manipulators for safe deployment, and manipulator-padded grips prevent damage to surrounding equipment. A firmware watchdog timer cuts thruster signals after 500 ms of lost communication, preventing runaway scenarios.

2.4 Safety Checklist

All team members adhere to strict safety regulations throughout every stage of **Orca**'s deployment. Routine inspections verify compliance, with a comprehensive checklist provided in Appendix C. A dedicated Safety Director oversees the process and ensures strict adherence at every step.

3 Testing and Troubleshooting

3.1 Mechanical Testing

Testing validates **Orca**'s safety and performance before final assembly, ensuring system efficiency, reducing assembly errors, and shortening assembly time. The frame underwent stress analysis, confirming its ability to withstand

heavy loads and harsh conditions. A scaled canister prototype (Fig. 33) was fabricated and pressure-tested, confirming leak-free operation under required conditions [3]. A wooden gripper prototype enabled rapid, cost-effective evaluation across objects of various shapes and sizes, validating the mechanism's functionality. The pneumatic tools, DCVs, and sealing port were also tested, confirming correct control system response and leak-free performance under high water pressure, as shown in Fig. 34.



Fig. 33: Canister's Prototype.

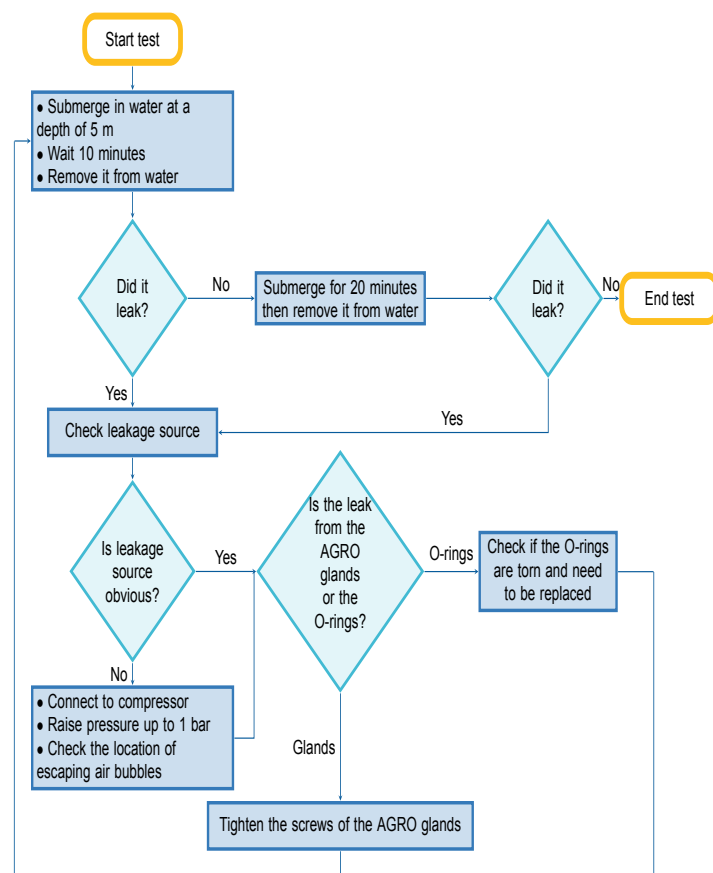


Fig. 34: Sealing Test Flowchart.

3.2 Electrical Testing

All components, including PCBs, thrusters, and wiring, were tested for faults prior to system assembly. PCB assembly was performed in two phases: first, the power section was soldered





to verify proper power delivery; then, the control and signal sections, including the microcontrollers, were soldered. After soldering, the microcontrollers were validated using test scripts. The testing procedures are shown in Fig. 35.

When **Orca** is powered on, the ESCs emit a tone confirming proper power and signal connectivity. A switch connects the station to the Raspberry Pi via Ethernet. Additionally, each thruster is configured individually.

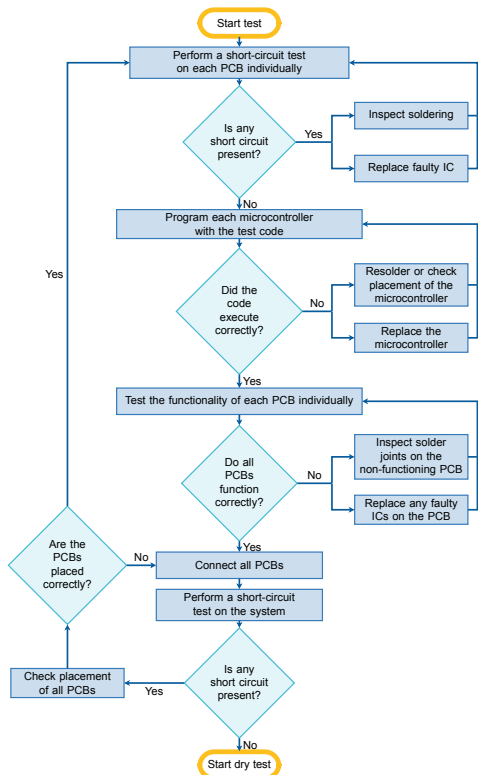


Fig. 35: Electrical System Testing Flowchart.

3.3 Full System Testing

Full-system testing procedures, shown in Fig. 36, are carried out on **Orca** before any operations.

4 Logistics

4.1 Company History

Aquaphoton Academy, founded in 2012, has participated in the MATE ROV Competition since 2014, as shown in Fig. 37, achieving significant milestones. Company accomplishments include:

1. In 2026, achieved 1st place in the Regional MATE ROV Competition.
2. In 2025, achieved 3rd place in the Regional MATE ROV Competition.
3. In 2024, achieved 2nd place in the Regional MATE ROV Competition and 6th place in the International MATE ROV Competition in

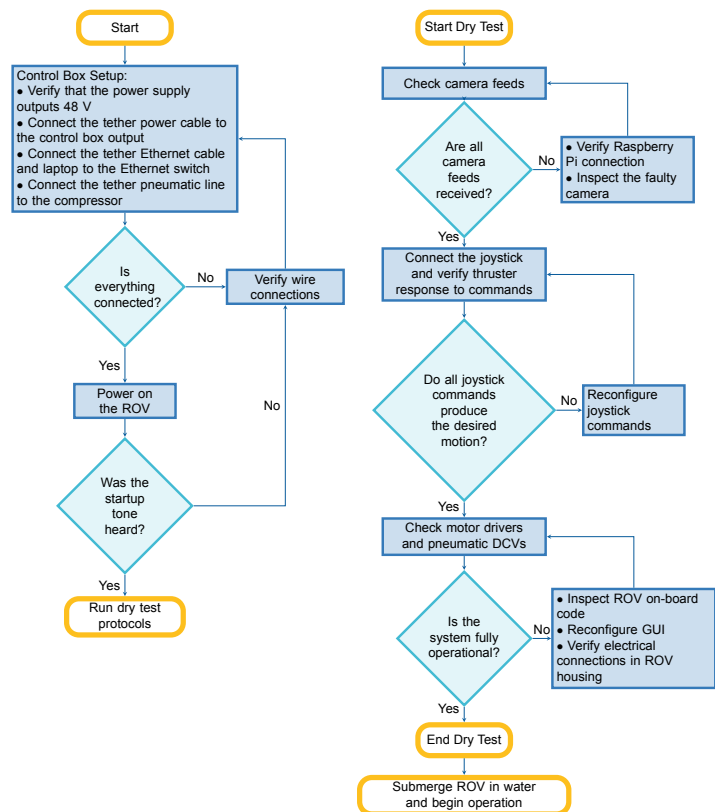


Fig. 36: Full System Test Flowchart. Tennessee, USA.

4. In 2023, achieved 1st place in the Regional MATE ROV Competition and 5th place in the International MATE ROV Competition in Colorado, USA.
5. In 2021, achieved 2nd place in the Regional MATE ROV Competition and 5th place in the International MATE ROV Telepresence category.

4.2 Company Structure

Aquaphoton Academy comprises 38 members organized into two technical teams, mechanical and electrical, and three non-technical teams: documentation, media and social media, and public relations (PR), with non-technical responsibilities carried out by the same members involved in technical work. Each team is divided into smaller project groups, with each group responsible for a specific part of the ROV. The organization is led by a CEO and two CTOs overseeing the technical teams. This structure ensures efficient collaboration, clear communication, and effective task distribution. For details regarding the company structure chart and job descriptions, see Appendix D.





Fig. 37: Aquaphoton Academy's ROVs over the Years.

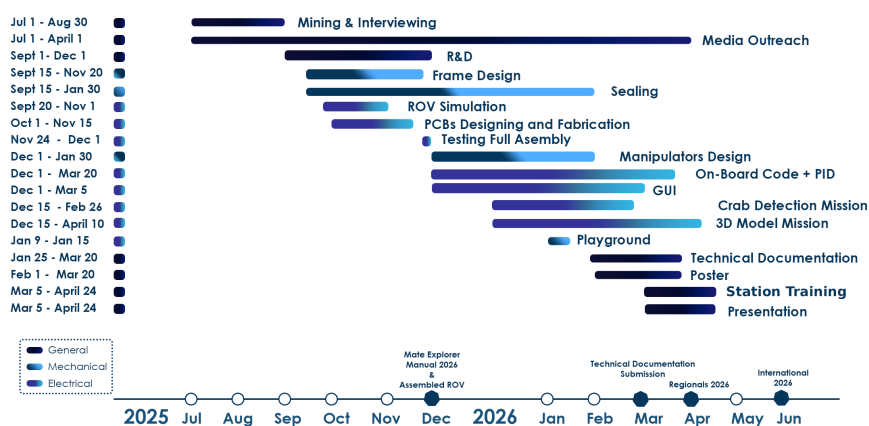


Fig. 38: Project Gantt Chart.

4.3 Project Management

4.3.1 Project Scheduling

An accurate project timeline, illustrated in Fig. 38, is essential for success. Aquaphoton uses a Trello board to track progress across all project groups, shown in Fig. 39. The CEO and CTOs define phase durations and coordinate with non-technical heads to ensure the schedule stays on track. Subteams hold weekly meetings to assign tasks and assess progress, while company-wide meetings provide updates, announce events, and facilitate decision-making. Periodic board meetings monitor schedule adherence, budgets, and resource needs, with the participation of the CEO and senior executives.



Fig. 39: Aquaphoton Academy's Trello Board.

4.3.2 Workspace Management

Aquaphoton Academy's workshop includes a PCB soldering station, a pressurized water testing area, a machining area, and a storage room. Efficient workspace management is maintained by preparing tools and cleaning the area before tasks. A workshop director oversees organization and performs repairs or improvements as needed.

4.3.3 Shared Files and Libraries

Aquaphoton Academy leverages cloud storage to enhance collaboration. Design files can be shared, tasks submitted, and corporate knowledge accessed remotely. Overleaf streamlines documentation, allowing members to view and comment in real time. GitHub supports parallel code development, keeping everyone updated on the latest version and edit history. In addition, a shared Altium workspace ensures PCB designs are accessible to all team members.

4.4 Build vs. Buy

For **Orca**, instead of purchasing components, Aquaphoton Academy designed and manufactured custom ESCs, a hexagonal canister, a new frame, and custom manipulators. This approach





enabled better system integration and performance improvements, resulting in a more compact design. The enhanced ESC ensures reliable power management under demanding conditions. The hexagonal canister simplifies wiring for electrical and pneumatic systems, while the custom frame and manipulators are tailored to **Orca**'s operational needs. Commercial alternatives exist but are typically more expensive and less flexible than custom-built solutions.

4.5 Budget and Accounting

All of Aquaphoton Academy's self-funded budget is constrained and must be used carefully to avoid unnecessary expenses. Therefore, the CFO manages all of Aquaphoton's finances, including setting budgets and ensuring that the company's financial resources are utilized efficiently. A more detailed analysis of the budget can be found in Appendix E and Appendix F.

5 Future Improvements

As illustrated in Fig. 40, a custom adjustable buck converter is being developed to replace heavier and more costly off-the-shelf modules. This ongoing R&D focuses on compact and configurable designs that maximize internal canister space and support wider voltage ranges. The open architecture additionally improves debugging and maintenance. The project will continue next season to finalize testing, reliability, enclosure design, and system integration.

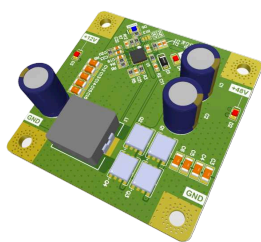


Fig. 40: Rendered Buck Converter.

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7 Appendices

A SIDs

• Electrical SID

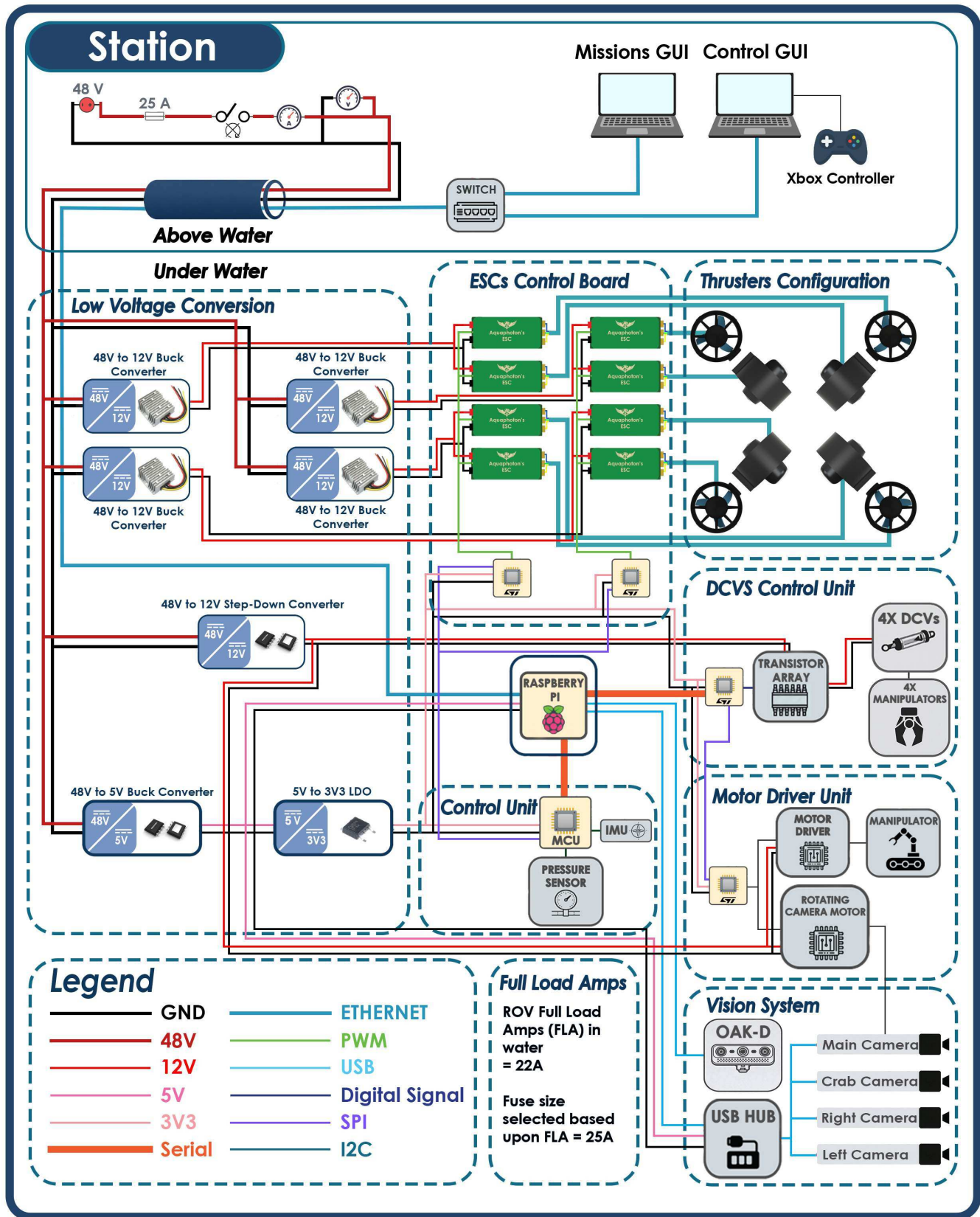


Fig. 41: Electrical SID.





• Pneumatic SID

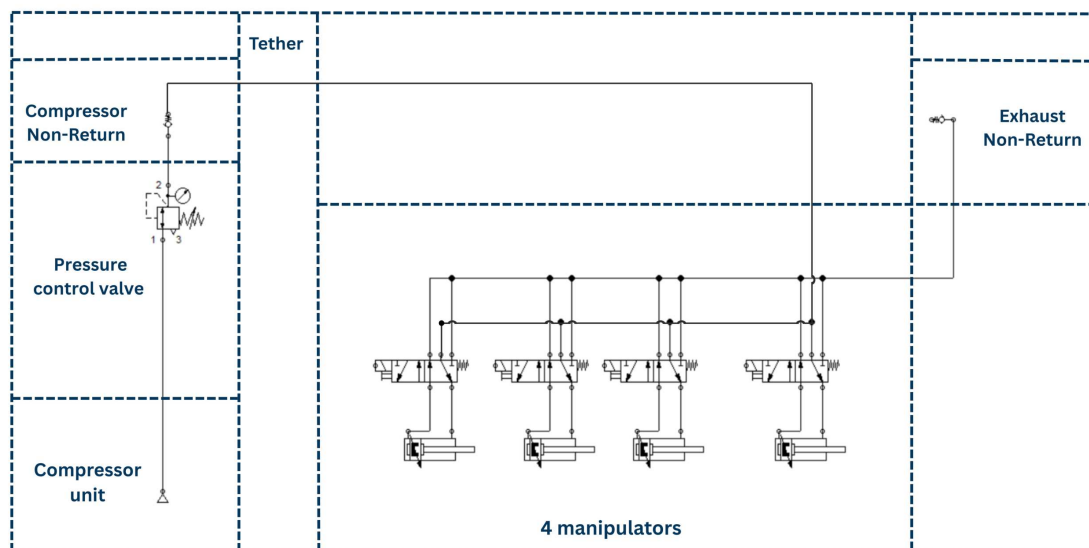


Fig. 42: Pneumatic SID.

B Construction Checklist

- ☐ Sanitized proper personal protective equipment (PPE) (e.g. gloves) is worn when performing tasks.
- ☐ Maintenance and repairs are performed proactively.
- ☐ Emergency kits, including fire extinguishers and first-aid kits, are checked regularly to make sure they are stocked and functional.
- ☐ Hazardous materials are clearly marked and stored separately to ensure they are handled carefully.
- ☐ Sharp tools are handled carefully, when not in use, they are stored in racks and boxes, and their sharp edges are covered with a cap if available.
- ☐ Any in-water tests are performed far away from the Electrical Team's work area.
- ☐ The work area is well-ventilated, and additional fume extractors are used to prevent the inhalation of harmful fumes when soldering or working with epoxy, glass fiber, etc...

C Operational Safety Checklist

► Before Deployment

- ☐ Only designated crew members on deck.
- ☐ On-deck crew wearing proper safety attire.
- ☐ Power is OFF.
- ☐ Poolside is clear of obstructions.
- ☐ Tether is untangled and connected to the ROV through the strain relief.
- ☐ Tether is connected to the topside control station.
- ☐ No exposed wires or loose connections.
- ☐ Electronics housing is sealed.
- ☐ Control computer is running.

► Powering Up

- ☐ Control box's multimeter is reading 48 V.
- ☐ Dry test of thrusters, manipulators, and payloads.
- ☐ Check all camera feeds.

► Launching and In Water

- ☐ Two members are handling the ROV.
- ☐ Tether-man has hold of the tether.
- ☐ Visually inspect for leakage and check for air bubbles.
- ☐ Test thrusters, manipulators, and payloads.

► Loss of communication

- ☐ Resend test package.
- If no communication:
- ☐ Press the kill switch to power down the ROV.
- ☐ Retrieve the ROV via tether.
- ☐ Check that the ROV is free from damage or leakage.

► Retrieval

- ☐ Pilot surfaces the ROV and then turns off the thrusters and PID controller.
- ☐ Designated on-deck crew members grab hold of the ROV by its handles.
- ☐ ROV is secured on deck.
- ☐ ROV and the control box are powered down.





D Company Structure and Job Description

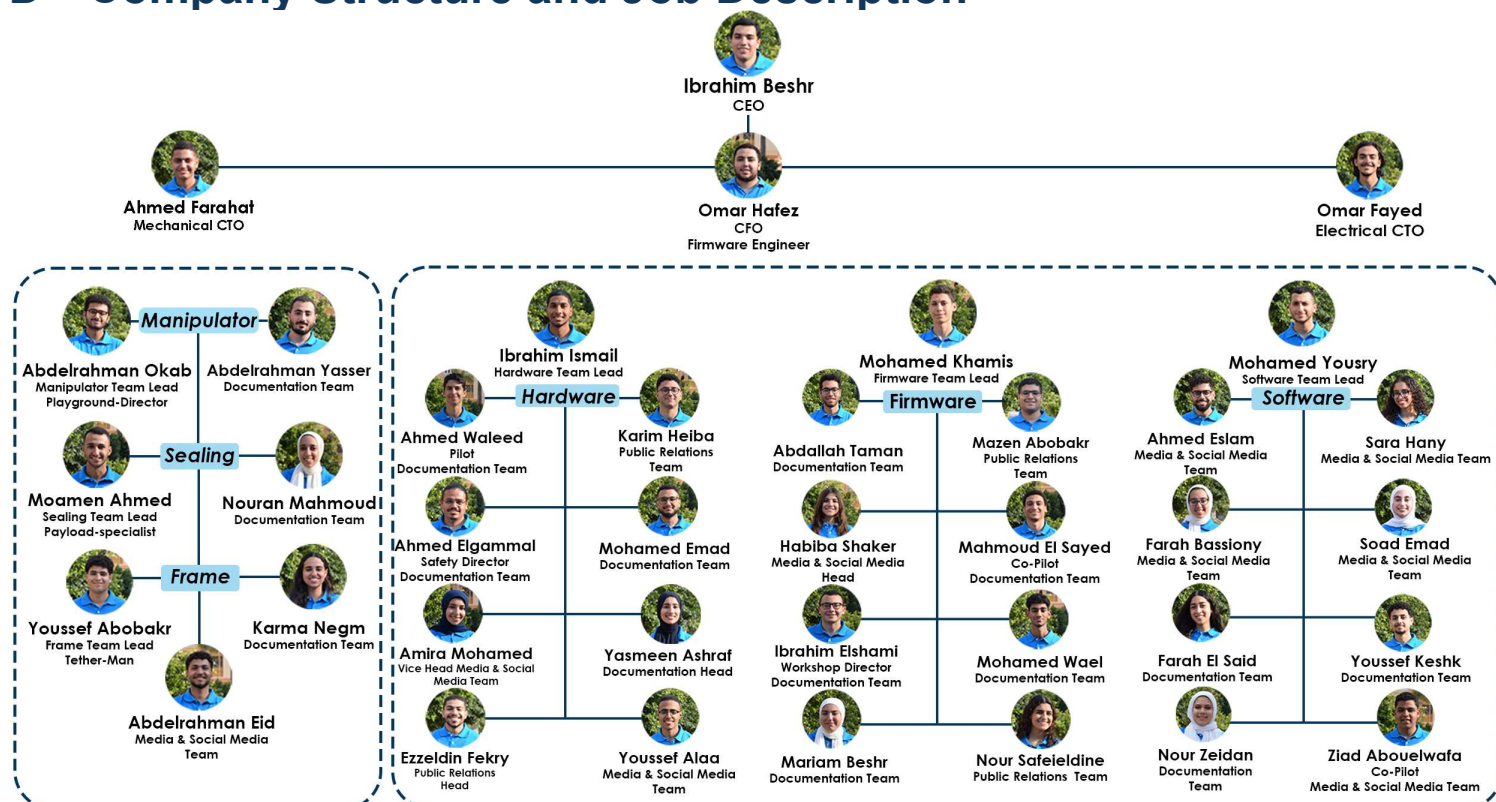


Fig. 43: Company Structure.

CEO The official representative of the company, interdepartmental coordinator.

CTO Manages project groups and day-to-day operations.

Team Lead Guides the sub-team members and monitors the progress of assigned tasks.

CFO Bookkeeper, handles the company finances and sets the budget.

Documentation Team Led by a head, responsible for documents submission.

Media & Social Media Team Led by a head, responsible for all graphic designs and media displays. Also, they manage all the social media accounts by creating a seasonal plan.

PR Team Led by a head, and is responsible for all the public relations affairs.

Workshop Director Maintains working order of the workspace, and performs routine maintenance.

Playground Director Simulates the ROV's operating conditions, and coordinates the in-water testing.

Safety Director Ensures all safety protocols and procedures are followed.

Pilot Controls the movement of the vehicle from a cabin or other indoor location on the surface.

Co-Pilot Assists the pilot during mission tasks.

Tether-Man Responsible for handling the tether while the ROV is underwater.

Payload Specialist Handles all payloads, unloading samples, and plastic debris gathered by the ROV.

E Project Budget

Table 8: Income Sources.

	Source	Budget (USD)
Income	Employees Dues	3934.7
	Alexandria University Fund	636.2
	Youth Welfare	473
	Arab Contractors	412.5
	NextPCB	272.9
	Hardware Bootcamp	71
	Fund From Last Year	1,324.5
Total (USD)		7,124.9



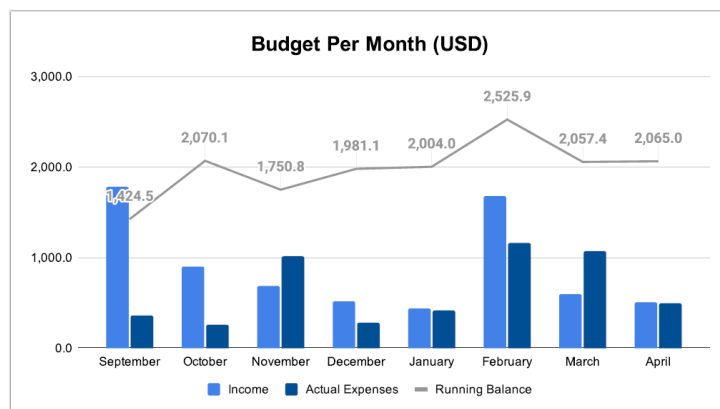


Table 9: Product/Operations.

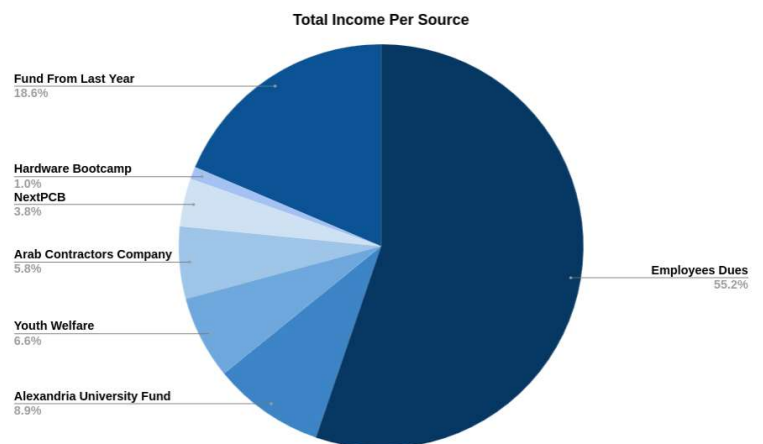
	Component	Estimated Budget (USD)	Project Cost (USD)	Difference (USD)
Production	Production Cost	2,636.6	2,372.3	264.3
	R&D Costs	189.2	158.3	30.9
	Running Costs	2,243.9	2,282.0	-38.1
	Equipment	247.3	247.3	0.0
Total (USD)		5,317.0	5,059.9	257.1
Income (USD)			7,124.9	
Fund for next season (USD)			2,065.0	
Category		Project Cost (USD)		
Travelling Expenses	Team Transportation in St. John's		1,750	
	ROV Shipping		3,000	
	Residency in St. John's Per Member For 15 Days		300	
	Ticket Expenses Per Member		1,150	
	Visa Fees Per Member		135	
	Travelling Expenses Per Member * X		1,585 * X	

Table 10: Monthly Income.

Budget per Month						
Month	Income (USD)			Accumulative Income	Expenses (USD)	Differences (USD)
	Source	Amount	Income		Actual Expenses	Running Balance
September	Employee Dues	459.8	1,784.3	1,784.3	359.8	1,424.5
	Fund from last year	1,324.5				
October	Employee Dues	489.1	901.6	2,685.9	256.0	2,070.1
	Arab Contractors	412.5				
November	Employee Dues	516.6	690.6	3,376.5	1,009.9	1,750.8
	NextPCB	174.1				
December	Employee Dues	516.6	516.6	3,893.1	286.3	1,981.1
January	Employee Dues	442.8	442.8	4,335.9	419.9	2,004.0
February	Employee Dues	503.3	1,683.5	6,019.4	1,161.6	2,525.9
	Alexandria University Fund	636.2				
	Youth Welfare	473.0				
	Hardware Bootcamp	71.0				
March	Employee Dues	503.3	602.2	6,621.6	1,070.7	2,057.4
	NextPCB	98.9				
April	Employee Dues	503.3	503.3	7,124.9	495.7	2,065.0
	-	-				
Total (USD)		-	7,124.9	7,124.9	5,059.9	2,065.0



(a) Monthly Cash Flow



(b) Total Income

Fig. 44: Project Budget Charts.





F Cost Breakdown

Table 11: Detailed Project Expenses.

Aquaphoton Academy				From: 9/1/2025			
School Name: Alexandria University				To: 5/18/2026			
The Exchange Rate between USD and EGP is 52.85 EGP / Dollar on Monday 5/18/2026							
DETAILED PROJECT EXPENSES							
Category	Component	Description	Status	Estimated Cost (USD	Project Cost (USD	Difference (USD)	
Product Cost	Thrusters T200	4*T200, 4*Our ESCs	Re-used	-	-	-	
	Thrusters U92	4*U92, 4*Our ESCs	Re-used	-	-	-	
	Material Fabrication	V-Slots, HDPE, Aluminum, Acrylic	New	473.0	377.5	95.6	
		CNC, Laser, Milling, 3D Printing	New	378.4	398.9	-20.4	
	Pneumatics	Pistons, Valves, Fittings, Tubes	New	62.2	62.2	0.0	
	Fasteners	Screws, L-Fixations, Caps	New	94.6	81.5	13.2	
	Sealing	O-Rings, Glands, Marine Epoxy	New	129.8	129.8	0.0	
	Electrical	Pi 4, Buck Converters, PCBs	Upgraded	1135.3	977.6	157.7	
	Vision	OAK-D Lite, 4* USB Cameras	Upgraded	268.7	268.7	0.0	
	Tether	Sheath, Power, Ethernet Cable	Re-used	-	-	-	
	Control Unit	Box, Buttons, Switch, Joystick	Re-used	-	-	-	
	Miscellaneous	Weights, Foam, 2*DC Motors	Upgraded	56.8	61.0	-4.3	
	Safety Eq.	Shrouds, Caps, Stickers, Fuses	Upgraded	37.8	15.2	22.6	
	Total				2636.6	2372.3	264.3
	R&D costs	Mechanical	Hexagonal Canister, Manipulators, Camera Fixations	New	189.2	158.3	30.9
Electrical		Test Boards PCBs	Donated	0.00	0.00	0.00	
Total				189.2	158.3	30.9	
Running costs	Playground	PVC Pipes, PVC Connectors, Corrugated Sheets, Spray Colors, Ropes, O-balls, Crab Print & Lamination, Bucket	New	96.7	96.7	0.0	
	Workshop	Workshop Fees	New	189.2	227.3	-38.1	
	Competition Registration	Mate, Mate Egypt, Fluid Power Quiz	Sponsored	636.2	636.2	0.0	
	Printables	Poster, Banners, Documentation Reports, Flyers, Brochures, Business Cards	New	215.4	215.4	0.0	
	T-shirts	Company Staff T-Shirts	New	310.9	310.9	0.0	
	Training & Testing	Pool Transportation	New	756.9	756.9	0.0	
	Travel Expenses	Transportation, ROV Shipping (Regional)	New	38.6	38.6	0.0	
	Total				2243.9	2282.0	-38.1
Equipment costs	Compressor	25 Litre Compressor Unit + FLR unit	Re-used	-	-	-	
	Power Supply	4 * 12V-30A	Re-used	-	-	-	
	Mechanical Tools	Driller, Screw Drivers, Sand Paper, Piller, Silicon, Tools Maintenance	Upgraded	121.7	121.7	0.0	
	Electrical Tools	Soldering Iron Station, Flux, Solder, Avo Meter, Tools Maintenance	Upgraded	125.6	125.6	0.0	
	Total				247.3	247.3	0.0
Total Cost				5317.0	5059.9	257.1	

