



SeaFox Inventive's

SEAFOX-IX

TECHNICAL DOCUMENTATION

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SEAFOX INVENTIVE 2026

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I. ABSTRACT

SeaFox Inventive is a student-led underwater robotics company at CETYS Universidad, Mexicali Campus, responsible for the design and development of SeaFox IX, an ROV built for the 2026 MATE ROV Competition. The vehicle was designed with a strong focus on reducing cost, size, weight, and system complexity while improving reliability, maneuverability, and mission performance. One of the

most significant design changes from the previous season was the replacement of the onboard Jetson Nano with a lightweight WT32-ETH01 Ethernet-based embedded architecture. This transition reduced boot time, power consumption, heat generation, and overall system complexity while improving communication reliability and deployment speed. SeaFox IX also integrates custom PCBs, a distributed control architecture, NACA 0015 stabilizing fins, a pitch-enabled gripper system, and modular 3D-printed components to improve underwater stability, manipulation accuracy, manufacturability, and maintenance. Under CEO and CTO leadership, specialized mechanical, electrical, software, and marketing teams collaborated in subsystem design, manufacturing, integration, and testing. Mentor-guided yet student-driven, the company combined multidisciplinary engineering practices with a strong emphasis on safety, cost-effectiveness, and mission-oriented performance to develop a competitive underwater robotic solution.



Fig. 1. SeaFox Inventive company photo.

II. TEAMWORK

A. Company Profile

SeaFox Inventive is a multidisciplinary student-led underwater robotics company from the School of Engineering at CETYS Universidad, Mexicali Campus. The company is organized into executive, research and development, mechanical, electrical, software, and marketing areas, allowing technical work to be divided while maintaining constant collaboration during integration and testing. The CEO coordinated project direction, budgeting, sponsorships, and deadlines, while the CTO supervised subsystem integration and technical decision-making. Department chiefs managed specific responsibilities such as frame manufacturing,

embedded firmware, electrical integration, CAD design, sensor validation, and graphical interface development. Mentors provided technical guidance, but all major design, manufacturing, testing, and documentation decisions remained student-driven. See company organizational chart in Appendix F.

B. Project Management

The 2026 build process followed an iterative plan-define-design-build-test-implement cycle focused on continuous subsystem validation and integration. Early development centered on analyzing the 2026 MATE mission requirements, identifying limitations from the 2025 ROV, and proposing alternative solutions evaluated by cost, manufacturability, reliability, power consumption, available space, and mission performance. Technical decisions were discussed during weekly integration meetings involving mechanical, electrical, and software leads to ensure compatibility between subsystems before fabrication or testing.

ClickUp	Used for task management.
Google Drive	Used for collaborative documentation and file storage.
Facebook Messenger and Zoom	Used for urgent coordination and remote meetings.
Weekly integration meetings	Used to align mechanical-electrical-software dependencies, assign tasks, document issues, and review testing results.
Github	Used for software and firmware version control.

Table 1. Company strategies for project management.

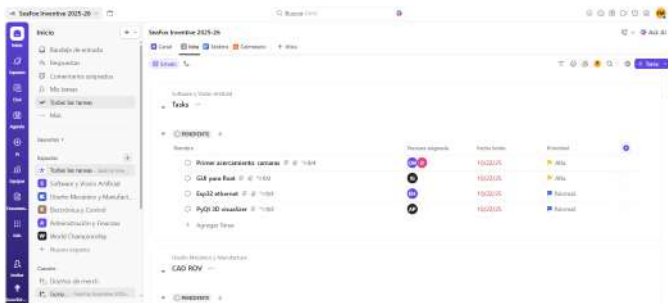


Fig. 2. Examples of tasks within the company's ClickUp.

Individual members were assigned specific responsibilities beyond departmental roles, including

CAD design, custom PCB development, firmware programming, tether management, graphical interface integration, manufacturing, and subsystem testing. Technical decisions were made collaboratively during weekly integration meetings, where subsystem leads evaluated solutions based on reliability, cost, manufacturability, power consumption, and mission performance. ClickUp and weekly meetings helped resolve real integration problems by improving coordination between departments. For example, during assembly, interference between internal electronics placement and cable routing created accessibility and integration issues inside the enclosure. The problem was assigned to both the mechanical and electrical teams through ClickUp task tracking, leading to a redesign of the internal layout and custom PCB mounting system that reduced cable clutter, improved accessibility, and simplified maintenance and troubleshooting.

C. Operational Strategy & Resources

To meet mission requirements and maintain cost-effectiveness, SeaFox Invenio developed strategies for efficient resource use and streamlined operations, as seen in Table 2.

Procurement and Budgeting	Handled by the CEO, using cost estimates based on previous seasons and adjusted for inflation and sponsorship inputs.
Tool and Material Selection	Done collaboratively, ensuring alignment between availability, budget, and functional requirements.
Quality Assurance processes	Includes continuous peer-review of mechanical assemblies, electrical safety validation, and simulation-based software testing.
Safety Protocols	Standardized across all departments, and all work sessions require compliance with PPE and risk mitigation checklists.

Table 2. Company strategies for efficient resource use.

D. Build Schedule

See build schedule in Appendix E.

Build schedule phases

Recruit ment & Training	• Class visits • First meeting and role assignments • Safety training
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	• Software, mechanical and electrical training
Design & Planning	• Competition Manual Requirements Review • Design ideas brainstorming • Electronic arrangement brainstorming • Software architecture planning • Adjustments based on cost, weight, size and feasibility
Manufacturing	• Frame cutting and assembly • Custom mount fabrication • Electronics enclosure preparation • Thruster and component installation • Waterproofing and fit verification • Buoyancy and ballast adjustments
Integration	• Mechanical assembly • Electrical Integration • Sync controls with hardware, camera and interface test • Initial pool tests
Final Testing	• Full mission tasks simulations • Fine-tuning and improvements
Documentation	• Documentation preparation

Table 3. Build schedule phases description.

III. DESIGN RATIONALE

A. Vehicle Overview

We designed our vehicle with a deliberate focus on optimization across cost, size, and weight to improve performance during the 2026 MATE mission tasks. In terms of cost, the team significantly reduced system expenses by redesigning the control architecture, eliminating the onboard computer used in previous seasons and replacing it with a lightweight Ethernet-based system that maintained full operational capability while improving reliability and deployment speed during time-limited missions. Regarding size, the vehicle geometry was carefully redesigned to achieve a more hydrodynamic profile suited for the flume tank and transect task, improving maneuverability, station-keeping performance, and precise alignment during coral inspection, manipulation, and observation missions. Weight reduction was also a major structural priority, as minimizing excess mass improved buoyancy control, passive stability, and handling during delicate tasks such as coral collection, sensor installation, and maintaining position in current conditions. Together, these trade-offs reflect SeaFox Inventive's iterative engineering approach, where lessons learned from

previous competition seasons directly guided mission-oriented improvements in operational efficiency, reliability, and underwater performance, consistent with established practices in the design of unmanned underwater vehicles for scientific and robotics applications [1].



Fig. 3. SeaFox IX.

B. Innovations and design changes

Innovation	Description	Benefits
Gripper	Mission-adaptable gripper/claw geometry with a pitch degree of freedom for tool alignment.	Increases versatility during missions by allowing precise tool positioning, reducing the need for multiple end-effectors and improving object manipulation success rate.
Custom mounts	Custom 3D-printed mounts, thruster guards, camera brackets, and assembly fixtures to reduce cost and improve manufacturability.	Lowers manufacturing costs, enables rapid iteration and replacement, and ensures component fitment tailored to the vehicle's specific geometry.
Control Architecture	Shift from an onboard Jetson Nano computing architecture to a lower-power WT32-ETH01 embedded Ethernet architecture.	Significantly reduces system cost, power consumption, and overall vehicle weight while simplifying the control pipeline and improving reliability in competition conditions.

Custom PCB integration	Custom integration for PWM, IMU, pressure/depth sensing, leak detection, and logic-level distribution.	PCB for IMU, pressure/depth sensing, leak detection, and logic-level distribution.	Consolidates multiple electronic functions into a single board, reducing wiring complexity, minimizing failure points, and improving overall system compactness and maintainability.
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Table 4. Innovation and design changes table.

C. Mechanical Systems

1) Frame and Structural Design

The frame of SeaFox IX is built from 20 mm square anodized aluminum extrusion. This material was selected because it provides a practical balance between rigidity, corrosion resistance, low weight, cost, and modularity.[4] The extrusion profile allows mechanical subsystems to be mounted directly with standard fasteners, making it easier to adjust or replace components during testing. Several frame materials were considered, including steel, aluminum, and polycarbonate. Steel offered high strength but added unnecessary weight and corrosion concerns. Polycarbonate was useful for protective or transparent parts, but it was not convenient as the main modular structure. Anodized aluminum extrusion was selected because it provided the best balance for a competition ROV. The final frame size was chosen to provide enough mounting area for thrusters, cameras, the electronics capsule, gripper, ballast, and mission tools while keeping the ROV manageable for deployment and underwater navigation. The frame also leaves clearance around the thrusters to improve water flow and reduce flow obstruction during operation.

Frame material trade analysis

Material	Advantages	Limitations	Decision
Steel	High strength	Heavy, corrosion concerns	Rejected for main frame
Polycarbonate	Useful for covers and transparent parts	Less convenient for modular frame	Rejected for main frame
Anodized aluminum extrusion	Rigid, modular, corrosion-resistant, serviceable	Higher cost than PVC	Selected

Table 5. Frame material trade analysis.

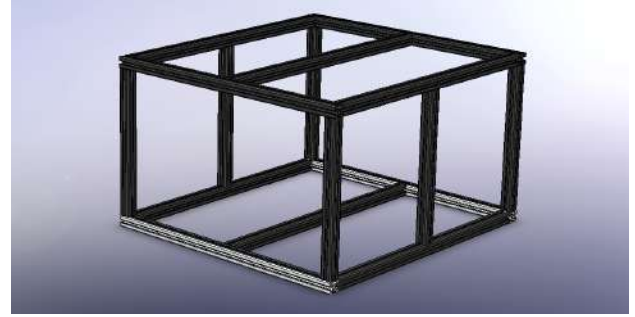


Fig. 4. Frame.

2) Electronics Enclosure.

SeaFox IX reuses the Blue Robotics 6-inch Watertight Enclosure from the previous season. This decision reduced cost and avoided unnecessary redesign of the frame and internal mounting layout. The enclosure already met the team's size, sealing, and integration requirements, making it suitable for the updated electrical architecture. The enclosure is positioned near the upper-central region of the frame. This placement protects the electronics while also contributing to the vehicle's buoyancy and balance. Since the capsule contains air volume, its position helps keep the center of buoyancy above the center of gravity.



Fig. 5. Original electronics enclosure.

3) Custom Mounts and Mechanical Interfaces

Most custom mounts and mechanical interfaces were designed and manufactured in-house using 3D printing. PETG was used for many printed parts because it offers good mechanical performance, water resistance, and printability.[5] Metallic parts were reserved for high-load areas, especially gripper

shafts, where plastic would not provide enough strength or wear resistance.

Method	Advantages	Limitations
3D printing	Low cost, fast iteration, useful for custom geometries, easy replacement.	Not ideal for high-load or high-wear parts.
Machining	Stronger and more precise parts.	Higher cost, slower manufacturing, less accessible.
Commercial parts	Reliable, tested, and often waterproof-rated.	Higher cost and less customization.

Table 6. Manufacturing Method Analysis.

a) Electronics Enclosure Mount

The electronics enclosure mount secures the Blue Robotics 6-inch enclosure to the aluminum extrusion frame. Its function is to keep the enclosure fixed during movement, deployment, and recovery while still allowing removal for inspection and maintenance. Since the enclosure was reused and modified this season, the mount also helps reduce stress on the enclosure body and maintain a stable interface with the frame.



Fig. 6. Electronics enclosure mount.

b) Thruster Mounts

Custom thruster mounts attach the six propulsion thrusters to the frame in their required positions and orientations. These mounts keep the thrusters aligned while leaving enough clearance for water flow around the propellers and through the open frame. Their modular design also allows the team to adjust, remove, or replace thrusters during testing and

troubleshooting without modifying the main structure. To support this design decision, the PETG bracket was evaluated through FEA using the expected thruster load and operating pressure at 3 m depth. The analysis showed a maximum Von Mises stress of 46.12 MPa near the mounting holes, with a maximum displacement of 0.113 mm. These results indicate that the mounts provide adequate stiffness to maintain thruster alignment, while the calculated safety factor of 1.04 shows that the design is functional but should be locally reinforced in future iterations to increase reliability [20], [21].

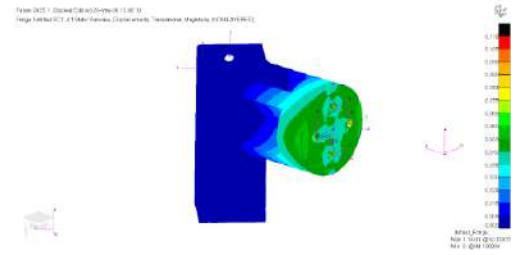


Fig. 7. Thruster mounts.

c) Thruster Guards

The thruster guards were redesigned after testing showed that strings or loose materials could enter the propeller area. The updated guards reduce the opening size around the thrusters to better protect both the inlet and outlet areas. This improves safety during handling and reduces the risk of entanglement with tether elements, strings, or mission props.

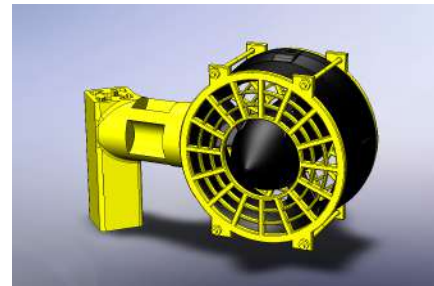


Fig. 8. Thruster with mount and guards.

d) Electronics Carrier Plate

The electronics carrier plate follows the same design used in the previous season, based on the Blue Robotics Watertight Enclosure RAILS system. Although the design was kept, the part was reprinted

for this year's vehicle to ensure a cleaner assembly and reliable support inside the reused enclosure. The carrier plate was printed in Fiberon PETG-ESD filament, which provides strength, dimensional stability, and electrostatic-dissipative properties to help protect the electronics from static discharge.



Fig. 9. Electronics carrier plate.

e) Camera mounts and housing

Camera mounts were designed to provide visibility for navigation, tool operation, and mission-specific tasks. Their positions were adjusted during testing to improve the pilot's view of the gripper and surrounding environment. The mounts are modular so the camera angles can be modified if testing shows blind spots or poor visibility. Because waterproof cameras were considered too expensive, the team designed custom underwater housings for standard cameras. The camera housing uses a two-piece rear cover to allow the camera cable to exit the enclosure. Marine-grade epoxy adhesive and two-component epoxy resin were applied around the acrylic window, rear covers, and cable exit.

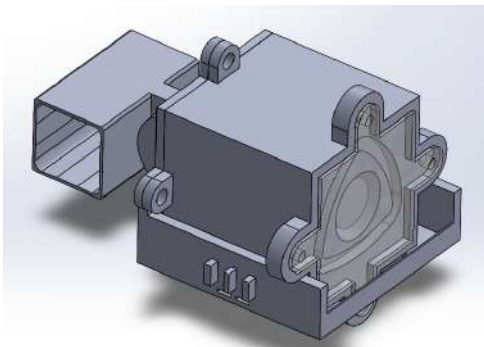


Fig. 10. Custom camera bracket.

f) Gripper mount

The gripper mount connects the manipulator system to the front section of the ROV. It was designed to support the gripper load while keeping the tool aligned with the pilot's camera view. The mount also provides enough clearance for the gripper pitch motion and prevents interference with the frame, thrusters, and tether.

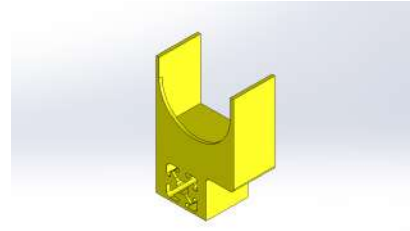


Fig. 11. Gripper mounts.

g) Worm Gearbox

We developed an external mechanism to the Newton gripper, allowing it to tilt up or down within a height limit. The mechanism works with a worm gearbox and an underwater motor, which reduces its speed and enhances its torque to support the weight of the gripper.[9] Its implementation greatly improves props manipulation and raises task completion chances.

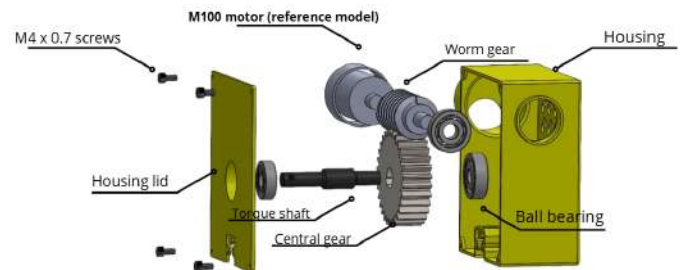


Fig. 12. Worm gearbox / movement axis.

4) Buoyancy and Ballast

The buoyancy system was designed using Archimedes' principle, where the buoyant force equals the weight of the displaced water [6]. The goal was to make SeaFox IX slightly negatively buoyant so

it could descend naturally while still requiring minimal thrust to maintain depth. The vehicle's buoyancy and ballast layout supports passive stability by placing buoyant elements, including the air volume inside the electronics enclosure, near the upper region of the frame, while heavier components and lead ballast are located lower in the chassis. This keeps the center of gravity below the center of buoyancy, increasing the restoring moment and reducing unwanted roll and pitch motion. Buoyancy was adjusted through water testing by modifying ballast amount and position after integrating tools, camera mounts, and other mechanical components. SeaFox IX also incorporates NACA 0015 profile fins as part of its passive stability and hydrodynamic strategy. These fins were inspired by stabilizing surfaces found in marine animals and help reduce unwanted roll motion without increasing electrical power consumption. Their placement supports the buoyancy and ballast configuration by helping the ROV maintain a more stable attitude while navigating, aligning with mission props, and operating the gripper. To validate this decision, a CFD analysis was conducted at 0.75 m/s, showing that the updated geometry reduced the estimated drag force from 5.259 N to 4.41 N, equivalent to a 16.1% reduction. The drag coefficient decreased from approximately 1.00 to 0.84, and the wake region was reduced by about 18%, indicating improved flow attachment, lower separation, and better directional stability. By combining upper buoyancy, lower ballast, and NACA 0015 stabilizing fins, SeaFox IX reduces its dependence on continuous thruster correction and becomes easier for the pilot to control during precise manipulation tasks [22].

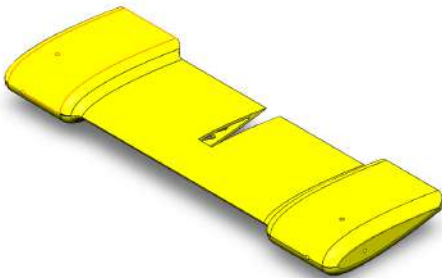


Fig. 13. Hydrodynamic fins.

The tether was also adjusted to reduce its influence on vehicle movement. A buoyant cable element was added to the tether bundle to prevent it from dragging on the ROV or sinking to the pool floor. This reduced tether tension and improved maneuverability during underwater operation.

5) Propulsion and Movement System

SeaFox IX uses six Blue Robotics T100 thrusters for propulsion, operating at 12 V. The six propulsion thrusters were selected to provide the movement required for mission tasks while respecting current draw, power availability, cost, and mechanical complexity. This configuration allows the ROV to perform controlled lateral movement, yaw control, vertical movement, pitch assistance, and limited roll response. The T100 model was selected because it is cost-effective, available, compatible with the company's power limitations, and reliable for underwater propulsion.[7] Using the same thruster model across the vehicle simplifies maintenance, spare parts, mounting design, and control logic. The thrusters were positioned to provide predictable movement while maintaining clearance from the frame, gripper, cameras, tether, and mission tools. During design evolution, the team kept the main thruster arrangement but modified nearby geometry to improve water flow and reduce obstructions around the propellers.

Option	Advantages	Limitations	Decision
Fewer than six propulsion thrusters	Lower cost, lower current draw, simpler wiring.	Reduced maneuverability and less control authority.	Discarded.
Six propulsion thrusters	Balanced movement, manageable current draw, sufficient control for mission tasks.	Less control authority than larger thruster configurations.	Selected.
More than six propulsion thrusters	Higher control authority and possible redundancy.	Higher cost, current draw, wiring complexity, ESC count, and weight.	Discarded.

Table 7. Propulsion configuration analysis.

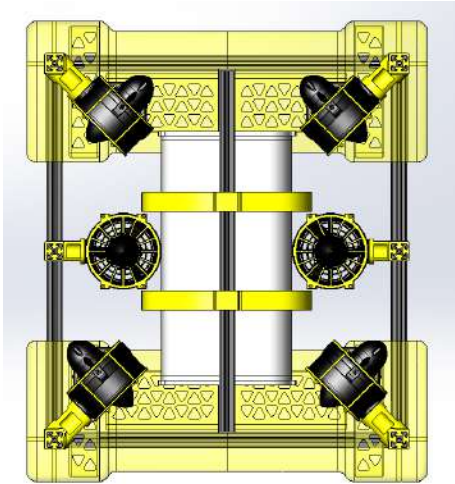


Fig. 14. Thruster configuration.



Fig. 15. Degrees of freedom (attachments removed for better viewing).

6) Tools & Manipulator Prototypes

The main mechanical payload of SeaFox IX is a modified Blue Robotics Newton Gripper designed to improve performance during manipulation-based mission tasks in the 2026 MATE competition. The gripper was selected for its reliability, watertight design, and proven underwater operation, then upgraded with an adjustable pitch degree of freedom that allows the pilot to modify the tool angle depending on the task requirements.[8]

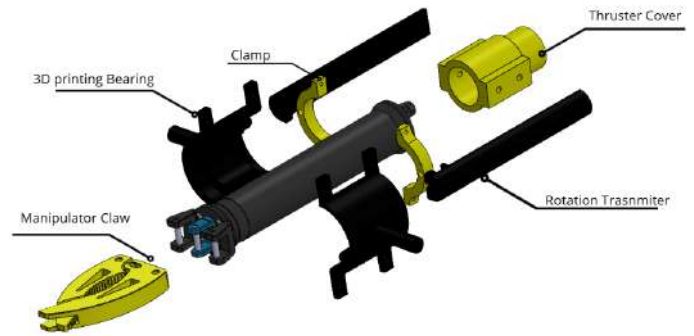


Fig. 16. Degrees of Freedom Roll Gripper.

This feature significantly improves alignment and approach precision during Task 1.1 Coral Species Collection, where corals must be collected carefully by the substrate, and during Task 2.5 Holyrood Subsea Observatory Service, which requires installing and connecting a new eDNA sensor. The adjustable pitch also improves interaction with PVC structures and object handling during Task 2.3 Whale Safe Fishing Gear and Task 2.4 Recover the Buoy Anchor by reducing the need to reposition the entire ROV for fine alignment. Several interchangeable claw concepts were evaluated during development, but the final design prioritized simplicity, reliability, and faster deployment by maintaining a fixed claw geometry while using the pitch degree of freedom to adapt to different mission scenarios. The gripper system was heavily influenced by mission requirements, particularly tasks involving coral recovery, sensor manipulation, and precise underwater alignment operations.

7) Mechanical Safety

Mechanical safety was considered in the frame, thruster guards, tools, tether strain relief, and assembly interfaces. The frame was designed to avoid unnecessary sharp edges, and all major subsystems are secured with fasteners so they can be inspected before operation. The thruster guards are one of the main mechanical safety features. They reduce the risk of direct contact with moving propellers and help prevent strings, tether elements, or mission objects from entering the thruster area. After testing showed that loose material could still reach the propellers, the guards were redesigned with smaller openings for better protection. Thruster warning label design is

shown in Appendix C. Tether strain relief was included to prevent mechanical pulling forces from being transferred directly to electrical connections or the enclosure. This protects the tether during deployment, recovery, and underwater movement. The modular design also improves maintenance safety. Components such as thrusters, cameras, guards, and the gripper can be removed or replaced without disassembling the entire vehicle. This reduces the risk of damaging wires, mounts, or waterproofed connections during repairs.

D. Electrical Systems

1) Electrical Design Evolution

For SeaFox IX, the electrical architecture was completely reworked to improve efficiency, reduce heat generation, and simplify integration. The previous system from last season was centered around a Jetson Nano as the onboard processing unit. Although it provided high computing capability, it also introduced several disadvantages, including higher power consumption, thermal buildup inside the sealed enclosure, longer startup time, and increased system complexity.

The new architecture was designed around three main goals: reallocating the power budget, integrating custom PCBs, and improving deployment and communication speed. By removing the Jetson Nano, the onboard system no longer requires a high-power computer inside the enclosure. This allows more of the available power budget to be used by the thruster system, including the six propulsion thrusters and the additional M200 motor used in the gripper mechanism. Instead of performing heavy computation onboard, SeaFox IX uses a distributed architecture where the surface station handles high-level processing, while the ROV focuses on real-time control, sensor acquisition, and actuator commands. For design alternatives and trade-offs analysis, see table 8. The full SID is provided in Appendix G.

Device	Advantages	Limitations
Jetson Nano	Provides high computing power for object detection and computer vision.[2]	Consumes significant power (10W when idle), generates heat inside the sealed enclosure, and adds unnecessary complexity for the onboard tasks required.
Raspberry Pi 5	Lower cost than the Jetson Nano, more GPIO headers, and lower power consumption. [17]	Linux boot overhead introduces latency, and using GPIOs for real-time control increases processing load.
LattePanda Mu	Offers high computing capability through an x86-based processor, runs Linux natively, and supports expansion such as NPU acceleration. [18]	Higher power draw, greater heat generation, and requires a larger carrier board for expansion and connections.
WT32-ETH01	Provides native Ethernet support, ESP32 dual-core real-time control, low power consumption, and strong community support. [19]	Does not support direct camera connections, so IP cameras and additional interface boards are required.
Power over Ethernet	Could simplify cable management by combining power and data transmission.	Discarded because the required hardware was too large for the enclosure and introduced voltage constraints incompatible with the ROV's form factor.

Table 8. Design alternatives analysis.

2) In-House and Outsourced Electrical Components

The company outsourced safety-critical and specialized components such as the Blue Robotics Basic ESCs, Bar30 pressure sensor, LSM6DS3 IMU, Ethernet switch, IP cameras, and DC-DC converters. These components were selected commercially because they provide proven reliability, warranties, and performance that would be difficult to match through in-house fabrication.

In-house work focused on components that benefited from customization. This included the custom PCBs, custom-length CAT6 patch cables, and firmware configuration. The PCBs were designed specifically for the ROV's electrical architecture, while the CAT6 cables were made to fit the limited space inside the capsule. Firmware was also developed in-house to support the static IP

configuration, communication protocol, and PCA9685 compatibility.

3) Power Distribution

The power system was designed in cascaded stages to isolate the high-power thruster rail from the lower-voltage logic and sensor systems. This reduces the possibility of electrical noise from the thrusters affecting communication, sensor readings, or microcontroller operation.

Converted Power	Circuits Powered	Purpose
48 V to 12 V, 30 A waterproof DC-DC converter	ESC/thruster rail and IP cameras	Provides the main 12 V power stage for high-current actuation and camera operation.
12 V to 5 V, 10 A DC-DC converter	Ethernet switch, WT32-ETH01 carrier board, and sensors	Powers the low-voltage communication and control electronics.
5 V to 3.3 V, 500 mA DC-DC converter	Logic-level components and I2C pull-up network	Provides 3.3 V logic power and works with 4.7 k Ω pull-up resistors for the I2C bus.

Table 9. Power distribution table.

All I2C devices share a single bus managed by the WT32-ETH01, with each device using a unique address to prevent communication conflicts. Pull-up resistors were added to maintain signal integrity. Ethernet traffic is handled through the TP-Link switch, which separates video streaming from control and telemetry communication, helping prevent camera data from saturating the control link.

4) Power Budget

The power budget was calculated using the main electrical loads of the ROV. The six Blue Robotics T100 thrusters, M200 motor, and ESCs represent the largest load because six are used for propulsion and one is used for the gripper degree of freedom. The remaining power demand comes from the gripper system, cameras, Ethernet switch, and WT32-ETH01 logic board. Since the majority of the system loads operate on the 12 V rail, the Full Load Amperage (FLA) was determined based on this rail, resulting in a maximum current draw of 25.5 A.

Component	Voltage	Current	Power
6× Blue Robotics T100 Thrusters + M200 Motor + ESCs	12 V	24 A	288 W
Blue Robotics Newton Gripper	12 V	0.5 A	6 W
3× Revotech I706-4 Cameras	12 V	1 A	12 W
TP-Link LS1005G Ethernet Switch	5 V	0.75 A	3.75 W
WT32-ETH01 Logic Board	5 V	0.2 A	1 W
Total			310.75 W

Table 10. Power budget table.

Rail	Loads	Power	Current
12 V	Thrusters, gripper, cameras	306 W	25.5 A
5 V	Ethernet switch, logic board, sensors	4.75 W	0.95 A
48 V	Total system + converter losses	327.66 W	6.83 A

Table 11. Total rail power draw.

5) Custom PCBs

Custom PCBs were designed and implemented to improve the organization and reliability of the electrical system. The boards were designed using KiCad 9.0 and Altium Designer, with the purpose of integrating the required connections between the WT32-ETH01, sensors, PWM module, leak detection system, and power regulation components. The custom PCB supports the WT32-ETH01 and connects it to the PCA9685 PWM module, LSM6DS3 IMU, Blue Robotics Bar30 pressure sensor, and Blue Robotics SOS Leak Sensor. The PCA9685 centralizes PWM signal generation over I2C, reducing the number of GPIO pins required from the WT32-ETH01. This is necessary because the microcontroller must control all six T100 thrusters, and the gripper system while still maintaining sensor communication. The custom PCB also improves cable

organization inside the enclosure by reducing loose wiring and providing dedicated ports for the ROV's specific electrical layout. Since commercial boards did not fully match the size, connection, and integration needs of SeaFox IX, the team chose to design the PCB in-house for better compatibility with the vehicle.

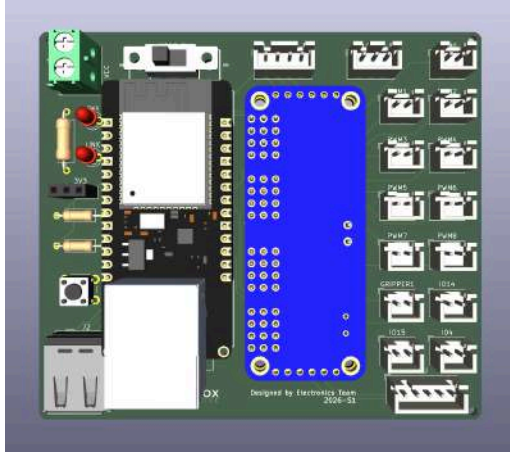


Fig. 17. Final PCB.

6) Sensor Suite

Sensor	Description and use
STMicro LSM6DS3 IMU	Provides six-degree-of-freedom inertial sensing through a three-axis accelerometer and three-axis gyroscope. It communicates over I2C and provides orientation feedback that helps compensate for underwater disturbances. [12] [15]
Blue Robotics Bar30 pressure sensor	Provides pressure-based depth measurement and temperature readings over I2C. It was selected because it is designed for underwater robotics and rated for depths up to 100 meters, making it reliable for the competition environment.[11][14]
Blue Robotics SOS Leak Sensor	Monitors the inside of the electronics capsule using four probe points. Its digital output allows the system to detect water intrusion before water reaches critical electronics, giving the operator time to recover the ROV.

Table 12. Sensor suite table.

7) Cameras

Revotech I706-4 fisheye IP cameras provide wide field-of-view video for navigation and mission

tasks. Since they are IP cameras, they integrate directly into the Ethernet network without requiring additional onboard video encoding hardware.



Fig. 18. Revotech IP Camera.

8) PCA9685 PWM module

It is a critical electrical interface. It centralizes sixteen PWM channels over I2C, allowing the WT32-ETH01 to command the ESCs and gripper-related actuation through a single communication bus.

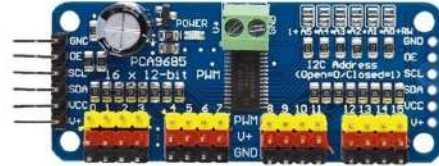


Fig. 19. PCA9685 PWM Module.

9) Communication Architecture

SeaFox IX uses a master-slave communication architecture. The surface station computer acts as the master system, centralizing high-level decision-making, operator input, image processing, and object detection. Commands are sent through a CAT6 Ethernet cable in the tether. Onboard the ROV, the WT32-ETH01 acts as the slave controller. It receives instructions from the surface station and redistributes control signals to the sensors and actuators through I2C, PWM, and digital signals. This architecture keeps the ROV lightweight in terms of onboard processing while maintaining low-latency communication between the pilot interface and the vehicle. A TP-Link LS1005G Gigabit Ethernet switch is used to connect the WT32-ETH01 and the IP cameras within the onboard network. Custom-length CAT6 patch cables were made in-house to fit the

limited space inside the capsule and improve internal cable routing.

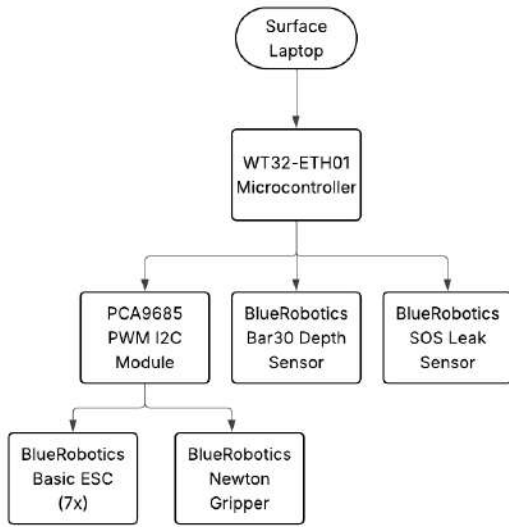


Fig. 20. Master-slave Architecture of SeaFox-IX.

10) Tether

The ROV tether is approximately 25 meters long and serves as the physical connection between the vehicle and the surface station. It carries both power and data and is composed of multiple bundled elements.

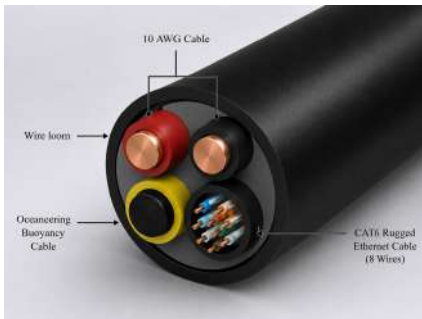


Fig. 21. Tether.

A pair of 10 AWG copper conductors provides 48 V power from the surface supply to the ROV. This gauge was selected because of its current-carrying capacity and suitability for the expected load. A rugged CAT6 cable carries all data communication, including control commands from the surface station to the WT32-ETH01 and video streams from the three

IP cameras back to the operator. Since CAT6 cable supports gigabit communication over distances greater than the tether length, signal integrity is not expected to be a limitation. A yellow cable donated by Oceaneering runs alongside the power and data conductors. Its purpose is to improve tether buoyancy and prevent the tether from sinking or dragging on the vehicle during operation. Testing showed that this reduced the effective tension felt by the ROV, improving maneuverability and reducing the load required from the thrusters to compensate for tether drag. All tether elements are covered by a wire loom to keep the bundle organized. Strain relief is included at both the ROV and surface station ends to prevent mechanical stress from being transferred directly to electrical terminations during deployment, retrieval, and operation. The tether management protocol is provided in Appendix D.

11) Control Station

Our control station was designed as a compact and portable system focused on reliability, low-latency operation, and efficient operator interaction during competition missions. The station is built around a high-performance personal laptop equipped with 16 GB of RAM, an AMD Ryzen 7000 series processor, and an NVIDIA RTX 4050 GPU, providing sufficient computational power for simultaneous ROS2 operation, camera streaming, sensor monitoring, and real-time computer vision processing. A secondary computer can additionally interface with the system through a compact external switch, enabling collaborative operation without requiring modifications to the onboard network architecture.

The operator interface displays live camera feeds, sensor telemetry, and controller input feedback in real time, allowing the pilot team to maintain situational awareness throughout operation. The station supports dynamic camera switching and real-time image adjustment, including brightness, saturation, and scaling controls, while also allowing any of the three camera feeds to run the crab detection vision pipeline. Operational responsibilities are divided between two operators: the pilot, responsible for direct vehicle control, and the copilot, responsible for mission-specific analysis tasks such as crab detection, iceberg assessment, eDNA-related operations, and

photogrammetry support. The physical layout of the control station prioritizes simplicity and rapid deployment by minimizing external hardware requirements and consolidating all critical vehicle interaction into a single centralized workstation. Due to this streamlined architecture, the complete control station can typically be deployed and fully operational in under five seconds.

12) Electrical Safety

Electrical safety was considered throughout the design of the power, communication, and control systems. The 48 V thruster bus is physically and electrically separated from the 5 V and 3.3 V logic and sensor domains through cascaded DC-DC converters. This separation reduces the risk of a fault in the thruster rail propagating directly to the control electronics. The Blue Robotics SOS Leak Sensor continuously monitors the inside of the electronics capsule. If water is detected, the system sends an alert to the surface station so the operator can stop operation and recover the ROV before water reaches critical components. The Blue Robotics Basic ESCs require an explicit PWM arming sequence before the thrusters can activate. This prevents accidental thruster movement during power-up, handling, or transportation.[13] Removing the Jetson Nano also reduced thermal risk inside the sealed capsule. With the main heat source eliminated, the enclosure experiences less thermal stress and a lower risk of condensation caused by heat buildup in a cold-water environment. Firmware upload procedures are also controlled for safety. The CP2102 USB-to-TTL programmer is only connected during bench updates and is physically removed before any water testing session.[16]

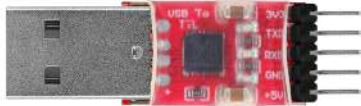


Fig. 22. CP2102 Programmer. [22]

E. Software Systems

1) Software Design Evolution

The software architecture of SeaFox IX was redesigned to reduce system complexity, improve startup speed, simplify troubleshooting, and increase operational reliability during mission execution. During the previous season, the ROV relied on a Jetson Nano onboard computer running multiple ROS2-based processes, including camera streaming and control communication. Although functional, the system introduced long boot times, increased power consumption, thermal buildup, and operating system overhead that complicated deployment and debugging during testing and competition operation.

Onboard Task	Purpose
Sensor acquisition	Read depth, orientation, and leak detection data.
Motor control	Send PWM signals to thrusters and gripper-related actuation.
Camera streaming	Transmit visual feedback to the surface station.

Table 13. Essential onboard system tasks.

This redesign reduced boot time from approximately two minutes to around five seconds, decreased power consumption by nearly 2 A, and improved camera stability. The final architecture is simpler, more modular, and easier to troubleshoot.

2) Key Software Innovations

Innovation	Purpose
Ethernet-based architecture	Improves communication speed and reliability between the ROV and surface station.
UDP communication protocol	Replaces serial communication with lower-latency bidirectional data exchange.
No onboard computer	Reduces power consumption, heat generation, boot time, and system complexity.
Custom embedded firmware	Allows the WT32-ETH01 to manage sensors, PWM control, and communication.
Commercial Ethernet cameras	Provide camera feeds through the network without requiring onboard video processing.

Camera configuration tuning	Factory settings were adjusted to optimize latency and resolution for mission tasks.
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Table 14. Key software innovations.

3) In-House and Commercial Software Components

The team developed the main software systems in-house, including the control architecture, communication protocol, graphical interface, and embedded firmware. Commercial off-the-shelf components were used when developing a custom alternative would add risk without providing major benefits. This included the Ethernet cameras, WT32-ETH01 embedded module, network switch, and PWM driver board.

Component	Approach	Reasoning
Control architecture	In-house	Needed to match the ROV's specific movement and actuation requirements.
UDP communication protocol	In-house	Allowed custom command and telemetry handling.
Graphical interface	In-house	Needed custom camera, telemetry, and control integration.
Embedded firmware	In-house	Required compatibility with WT32-ETH01, PCA9685, sensors, and static IP configuration.
Ethernet cameras	Commercial	Reliable and avoided custom video hardware development.
WT32-ETH01	Commercial	Provided Ethernet-enabled embedded control with low power consumption.
PWM driver board	Commercial	Simplified multi-channel PWM generation.

Table 15. In-house and commercial software components.

4) Software Architecture

The ROV uses a distributed software architecture. The surface station handles high-level operations, while the onboard embedded controller manages real-time vehicle functions. The surface station is responsible for the graphical interface, pilot commands, image processing, object detection, and

overall system monitoring.[10] This allows computationally heavier tasks to run outside the ROV, where power and heat are not major restrictions. The WT32-ETH01 onboard controller receives commands from the surface station and manages sensor reading, motor control, and communication. This embedded controller was selected because it provides Ethernet connectivity, low power consumption, and real-time control without requiring a full operating system. This separation keeps the onboard system focused on essential tasks and reduces the risk of delays caused by unnecessary software processes.

5) Communication Integration

SeaFox IX uses a custom UDP-based communication protocol over Ethernet. This replaced the serial communication approach used in the previous season. UDP was selected because it has lower overhead than serial-based communication and supports faster bidirectional data exchange between the surface station and the onboard controller. In the controlled network environment of the competition, this improves responsiveness for telemetry, control commands, and system feedback. The surface station sends pilot commands through the tether to the WT32-ETH01. The onboard controller then distributes commands to the required subsystems through I2C, PWM, and digital signals. Sensor and status data are sent back to the surface station for monitoring.

6) ROS2 Integration

During the previous season, much of the software stack depended on ROS2, including camera streaming. For SeaFox IX, the team reduced ROS2 dependency to avoid unnecessary complexity. ROS2 was retained only where it provided a clear advantage: the control subsystem. Its modular communication structure supports organized control logic and reliable integration with the graphical interface. However, camera streaming was separated from ROS2 and redesigned to operate independently. This reduced middleware overhead, simplified debugging, and improved video handling. By limiting ROS2 to the parts of the system where it is most useful, the software architecture became more efficient and easier to maintain.

7) Sensor Integration

The onboard firmware integrates the ROV's main sensors through the WT32-ETH01. These sensors provide the surface station with important feedback for navigation, safety, and vehicle control. The sensors communicate through the onboard embedded system, allowing the software to organize telemetry data and send it to the surface station. This supports real-time monitoring without requiring high onboard processing power.

8) Graphical Interface

The surface station interface was developed using PyQt5. The team decided to continue using this framework because of previous experience, compatibility with Python, integration with ROS2, and efficient handling of multiple video feeds. The interface provides the pilot with vehicle feedback, camera views, control status, and telemetry. Since PyQt5 allows rapid development of desktop applications, it reduces implementation risk and allows the team to focus on reliability instead of learning a new framework. A web-based interface was considered in previous development cycles, but it was discarded. A dedicated desktop application was selected because it provides lower latency, better resource efficiency, and greater reliability for real-time vehicle operation.

9) Camera Streaming and Visual System

The ROV uses commercial Ethernet cameras connected to the onboard network. These cameras operate independently from the WT32-ETH01, which prevents the embedded controller from handling unnecessary video processing. The camera configuration was adjusted from factory settings to improve latency and resolution for mission operation. This was important because the pilot needs stable video feedback for navigation, object manipulation, and gripper alignment. By separating camera streaming from ROS2 and from the onboard controller, the system reduces processing load and improves video stability. This also makes camera troubleshooting easier because the video system can be tested independently from sensor acquisition and motor control.

10) Systems Equilibrium and Modularity

The software architecture was designed so each subsystem performs a specific task. This reduces processing load, simplifies integration, and makes troubleshooting easier.

Subsystem	Main Function
Ethernet cameras	Dedicated video streaming.
WT32-ETH01	Sensor acquisition, UDP communication, and motor control.
PCA9685 PWM driver	Generates PWM signals for ESCs and actuation.
Surface station	GUI, high-level processing, object detection, and pilot control.
ROS2 control subsystem	Organizes control communication where modularity is useful.

Table 16. Subsystems and their main functions.

The ESP32 dual-core architecture allows the workload to be divided efficiently. One core can prioritize bidirectional UDP communication, while the other handles sensor reading and motor actuation. Network equilibrium was also considered. The tether communication link provides enough bandwidth for three camera feeds and continuous UDP communication at 10 Hz. Stress tests were performed to verify that the communication system could operate without saturating the network. Subsystem-level testing was completed before full integration. Cameras, sensor acquisition, motor control, and communication were validated independently before being combined into the final software system.

11) Software Safety

The SeaFox ROV software was developed with multiple fail-safe mechanisms intended to minimize the risk of unintended vehicle behavior during operation. All thruster outputs are software-clamped to prevent unsafe command values from being transmitted to the propulsion system. Controller inputs are normalized before processing, and a $\pm 30 \mu\text{s}$ PWM deadzone is implemented to eliminate unintended motor activation caused by minor joystick drift or electrical noise. In the event of communication loss between the topside control

station and the onboard embedded system, the ESP32 automatically commands all thrusters to their neutral state, preventing uncontrolled motion of the vehicle. Similarly, if ROS2 nodes stop responding or require restarting, the control system returns all motor outputs to neutral during the recovery process. Sensor availability is continuously monitored, and the operator is notified whenever a sensor fails to initialize or stops publishing valid data during operation. Camera systems additionally implement automatic reconnection loops to recover from temporary interruptions without requiring operator intervention.

IV. TESTING AND TROUBLESHOOTING

A. Testing Methodology

SeaFox IX was validated through progressive subsystem testing before full vehicle integration. Electrical components, including the Blue Robotics T100 thrusters, Basic ESCs, Bar30 depth sensor, and SOS Leak Sensor, were bench-tested individually to verify communication stability, sensor response, PWM control, and power consumption against datasheet specifications before installation into the ROV. Mechanical testing focused on measurable performance factors such as buoyancy balance, passive stability, thruster response, tether drag, gripper alignment, camera visibility, and mission-task execution. Early pool tests showed excessive positive buoyancy after integrating cameras, tools, and flotation materials, causing unstable ascent behavior and poor depth control. To correct this, flotation volume was reduced, lead ballast was redistributed,

and counterweight positions were adjusted until the vehicle achieved a slightly negative buoyancy condition with improved roll stability and more consistent station-keeping performance. Camera testing also revealed blind spots around the gripper workspace during manipulation tasks, leading to changes in camera angle and mounting position to improve visibility during coral collection and sensor installation missions.

B. Troubleshooting Techniques

Troubleshooting followed an iterative engineering process based on identifying failures, isolating the subsystem involved, modifying the design, and retesting under operational conditions. One major issue identified during tethered pool testing was thruster entanglement caused by loose string and debris entering the propeller area, reducing thrust efficiency and creating the risk of motor blockage. The team redesigned the 3D-printed thruster guards by decreasing opening spacing and increasing inlet and outlet coverage, then retested the system to verify improved protection without significantly restricting water flow. Additional integration testing revealed cable routing interference between internal electronics and mechanical supports, complicating maintenance access and increasing assembly time. In response, the internal layout and PCB mounting positions were redesigned to reduce cable clutter and improve accessibility. These iterative tests directly influenced the final vehicle configuration, improving reliability, stability, maneuverability, and operational efficiency during mission-task execution.

V. BUDGET AND RESOURCE MANAGEMENT

Budget planning prioritized efficiency through strategic reuse, sponsor collaboration, and a structured acquisition process. A preliminary audit of legacy components identified reusable materials, minimizing new purchases and directing funds toward mission-critical items. Financial oversight was led by the CEO, in coordination with department leads. Detailed cost accounting is provided in Appendix A.

SeaFox Inventive 2026 Budget				
Income				
Source		Amount (USD)		
Remaining balance from 2025 season		\$8,000.00		
Expenses				
Category	Description	Amount (USD)	Qt.	Subtotal
World Championship Travel	Round-trip airfare to St. John’s, Canada	\$800.00	12	\$9,600.00
World Championship Travel	7-night, 4-person hotel room	\$1,400.00	3	\$4,200.00
World Championship Travel	Car rental (Turo)	\$850.00	3	\$2,550.00
World Championship Travel	ROV Shipping	\$300.00	1	\$300.00
MATE ROV Competition Fees	Explorer class registration fee	\$600.00	1	\$600.00
Company Operations	Company employees uniform, merch and marketing display printing cost	\$350.00	1	\$350.00
LAB Equipment	2 Bambu Lab 3D Printers, 48 V Voltage Source, soldering station	\$200.00	1	\$200.00
Safety Items	Safety glasses, work gloves, first aid kit, Personal Flotation Devices (PFDs)	\$100.00	1	\$100.00
ROV Total Cost	Surface station, vehicle structure, power electronics	\$1,000.00	1	\$1,000.00
Non-ROV Device	DC brushed motor, ESP32, BAR 02 SENSOR, CUSTOM PCB, watertight enclosure	\$100.00	1	\$100.00
		Total expenses:		\$19,000.00
		Total income:		\$8,000.00
		Income needed:		\$11,000.00

Table 17. SeaFox Inventive 2026 budget.

A. Build VS Buy

SeaFox IX used a mixed build-and-buy strategy based on reliability, cost, and customization. Commercial components were purchased when waterproofing, electrical safety, or proven performance were critical. In-house fabrication was used when custom geometry, compact routing, or rapid iteration was needed.

B. New VS Reused

Components were reused when they still met performance, safety, and integration requirements. Reused parts were inspected or bench-tested before installation, including the T100 thrusters, Basic ESCs, Bar30 sensor, and SOS Leak Sensor.

Component/System	Decision	Reasoning
T100 thrusters	Buy	Proven waterproof propulsion and reliable thrust performance.
Basic ESCs	Buy	Compatible with the thrusters and safety-critical for motor control.
Bar30 pressure sensor	Buy	Commercial underwater sensor for depth and temperature data.
SOS Leak Sensor	Buy	Reliable early leak detection inside the electronics enclosure.
DC-DC converters	Buy	Stable power conversion under load.
Ethernet switch / WT32-ETH01	Buy	Reduced development time and supported the Ethernet architecture.
Custom PCBs	Build	Needed ROV-specific connections and compact internal organization.
Custom CAT6 patch cables	Build	Reduced cable clutter inside the enclosure.
3D-printed mounts and guards	Build	Required custom fit and fast design iteration.
Camera housings	Build	Reduced cost compared to waterproof cameras and fit the ROV geometry.
Firmware and GUI	Build	Required custom communication, telemetry, and control integration.

Table 18. Build vs. buy decisions.

Component/System	Status	Reasoning
T100 thrusters	Reused	Passed bench testing and remained compatible with propulsion and gripper use.
Basic ESCs	Reused	Verified before integration and compatible with the control system.
Bar30 pressure sensor	Reused	Continued to meet depth-sensing requirements.
SOS Leak Sensor	Reused	Continued to provide enclosure leak detection.

Blue Robotics 6-inch enclosure	Reused / Modified	Reduced cost and remained compatible after reinforcement.
Newton Gripper	Reused / Modified	Adapted for the updated manipulator system.
Custom tether	Reused / Modified	Continued to support power/data transmission with buoyancy and strain-relief adjustments.
Surface-station laptop and controller	Reused	Still met control-station requirements.
WT32-ETH01	New	Replaced the Jetson Nano with a lower-power embedded controller.
Ethernet switch	New	Enabled onboard Ethernet communication.
LSM6DS3 IMU	New	Added orientation feedback.
Custom PCBs	New	Integrated sensor, PWM, leak detection, and controller connections.
Revotech IP cameras	New	Provided Ethernet-based video without onboard video processing.
Custom CAT6 cables	New	Supported compact internal routing and Ethernet communication.

Table 19. New vs. reused decisions.

VI. SAFETY

A. Training

Training was organized across mechanical, electrical, and software areas so members could understand the risks of each subsystem. Mechanical training focused on tool use, frame assembly, gripper handling, buoyancy adjustment, and thruster safety. Electrical training covered soldering, PCB handling, multimeter use, cable management, power testing, and safe procedures around high-current systems. Software training covered version control, firmware upload procedures, sensor integration, and communication testing.

To promote cross-functional knowledge and safety, all company members were encouraged to attend training sessions across mechanical, electrical, and software areas, regardless of their primary role.

This ensured a well-rounded understanding of the ROV's systems during integration and testing.

B. Lab Safety Protocols

At the start of the season, a safety workshop was held to orient new and returning members on the proper use of tools, emergency procedures, and personal protective equipment (PPE). The lab is equipped with clearly marked safety infrastructure, including a fire extinguisher, a first aid kit, an eye wash station and PPE charts.



Fig.23. SeaFox members after successfully completing the safety workshop.



Fig. 24. Some of the PPE available to company members.

Pre-power, power-up, water immersion, lost communication, and abnormal bubbling procedures are listed in Appendix B.

Testing rotating propellers/thrusters	Safety glasses, gloves, hearing protection
Pool or underwater testing	Non-slip shoes, life vest (if required)
Cutting tools	Safety glasses, cut-resistant gloves
Painting	Respirator mask, gloves, safety glasses
Soldering	Safety glasses, smoke extractor
Drilling and machining	Safety glasses, ear protection, gloves
Frame assembly	Safety boots, gloves

Table 20. Required PPE for different task types.

VII. ACKNOWLEDGEMENTS

SeaFox Inventive would not exist without the people and organizations who believed in this project. We thank MATE ROV Competition for giving us the stage; CETYS Universidad gave us both the foundation and the financial backing that made this season possible. Our mentors, PhD. Luis Carlos Básaca, Mario Ramos (MS), and Leonardo Ortega (M. Eng.) gave us direction when the path was unclear.

To our sponsors: Polymaker supplied the filament behind every custom mount; Altium provided the professional PCB design tools that enabled our custom electronics; SolidWorks powered the mechanical design and simulation behind every structural component. Collins Aerospace, Intuitive Surgical, Gruas Cimarrón, Car Wash Premier, Naturabio, and Uniformes Milán made it possible for us to compete on an international stage through their generous financial support.

Finally, to our families, friends, and community your support during fundraising and throughout the season reminded us why this work matters.

Task Type	Required PPE
Electrical wiring	Safety glasses, insulated gloves
Epoxy application	Nitrile gloves, safety glasses, respirator mask
Sanding	Safety glasses, dust mask, gloves

VIII. REFERENCES

Our project has been informed and supported by a variety of resources, including academic publications, industry standards, and previous research in the field of underwater robotics. Below is a list of references that have been instrumental in our project development.

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IX. APPENDIX

A. Cost Accounting

SeaFox Inventive 2026 Cost Accounting		
2026 Season funds		
Category	Source	Amount (USD)
Previous Season Surplus	Remaining balance from 2025 season	\$8,000.00
Grant	CETYS School of Engineering	\$8,000.00
Sponsorship	Intuitive Mexicali	\$1,200.00
Sponsorship	Collins Aerospace Mexicali	\$1,200.00
Sponsorship	Gruas Cimarrón Mexicali	\$750.00
Sponsorship	Naturabio Mexicali	\$750.00
Sponsorship	Car Wash Premier Mexicali	\$250.00
Fundraising	2025-2026 Company fundraising sales	\$5,000.00
	Total:	\$25,150.00

Table 21. SeaFox Inventive 2026 Cost Accounting.

2026 ROV Total Cost			
Category	Type	Name	Amount (USD)
Surface station	Reused	XBOX controller	\$25.00
Surface station	Reused	Gaming Laptop	
		Lenovo LOQ	\$900.00
Surface station	Reused	Logitech mouse	\$20.00
Vehicle structure	Purchased	T-Slotted Framing Rails	\$180.00
Vehicle structure	Purchased	T-Slotted Framing Structural Brackets	\$85.00
Vehicle structure	Purchased	Stainless steel screws and nuts	\$20.00
Vehicle structure	Donated	3D Printer PETG Filament	\$300.00
Vehicle structure	Reused	Blue Robotics 6" Watertight Enclosure	\$450.00
Power Electronics	Reused	Blue Robotics Newton Gripper	\$720.00
Power	Reused	Blue Robotics T100	\$1,200.00

Electronics		Thruster x 6	0
Power Electronics	Reused	Blue Robotics M200 Motor	\$150.00
Power Electronics	Reused	48V-12V Step Down Converter	\$30.00
Power Electronics	Reused	12V-5V Step Down Converter	\$15.00
Power Electronics	Reused	Blue Robotics Basic ESC x 7	\$280.00
Power Electronics	Purchased	Mini IP Camera x 4	\$130.00
Power Electronics	Purchased	WT32-ETH01 ESP 32	\$15.00
Power Electronics	Purchased	TP-Link 5 Port Gigabit Ethernet Switch	\$10.00
Power Electronics	Reused	Blue Robotics BAR 30 Sensor	\$80.00
Power Electronics	Reused	Blue Robotics SOS Leak Sensor	\$40.00
Power Electronics	Purchased	PCA9685 PWM Motor Driver	\$15.00
Power Electronics	Reused	ROV custom tether	\$120.00
		Total:	\$4,785.00

Table 22. SeaFox Inventive 2026 ROV total cost.

2026 Company Expenses				
Category	Items	Total spending	Budgeted	2026 Spending
World Championship Travel	Airfare, lodging, car rental, ROV shipping	\$20,000.00	\$16,650.00	\$20,000.00
MATE ROV Competition Fees	Explorer class registration fee	\$650.00	\$600.00	\$650.00
Company Operations	Company employees uniform, merch and marketing display printing cost	\$500.00	\$350.00	\$500.00

LAB Equipment	2 Bambu Lab 3D Printers, 48 V Voltage Source, soldering station	\$1,050.00	\$200.00	\$1,050.00
Safety Items	Safety glasses, work gloves, first aid kit, Personal Flotation Devices (PFDs)	\$100.00	\$100.00	\$100.00
ROV Total Cost	Surface station, vehicle structure, power electronics	\$4,785.00	\$1,000.00	\$455.00
NON ROV DEVICE	DC brushed motor, ESP32, BAR 02 SENSOR, CUSTOM PCB, watertight enclosure	\$550.00	\$100.00	\$120.00
	Total:	\$27,635.00	\$19,000.00	\$22,875.00
	Balance:	\$2,275.00		
	* Total spending includes reused, purchases or donated items			

Table 23. SeaFox Inventive 2026 Company Expenses.

B. Safety Checklist

Pre-Power Checklist	
☐	Verify that the ROV's internal wiring is properly connected and clean.
☐	Inspect all cable connectors for damage or looseness.
☐	Confirm that the electronics capsule is fully sealed.
☐	Check that the tether is untangled and free from obstructions.
☐	Use a manual vacuum pump to reach 10 inHg pressure via the vent penetrator.
☐	Wait 15 minutes; if pressure is stable, remove the pump and seal the vent.
☐	Keep battery/power supply dry and safely distanced from water.
☐	Confirm that the surface station (computer, router, monitor) is powered and connected.
☐	All team members must wear PPE: safety glasses, closed-toe shoes, and secure clothing/hair.

Table 24. Pre-power Checklist.

Power-up Checklist	
☐	Connect the tether to the power supply.
☐	Verify successful GUI connection.
☐	Confirm camera feeds are live and stable.
☐	Ensure control system communicates with all thrusters.
☐	Listen for audible cues signaling thruster power readiness.

Table 25. Power-up checklist.

Water Immersion Checklist	
☐	Inspect all seals, gaskets, and penetrators for wear or damage.
☐	Submerge the ROV slowly with assistance from two team members.
☐	Watch for abnormal bubbling and verify buoyancy stability. If abnormal bubbling is detected, refer to ABNORMAL BUBBLING RESPONSE.
☐	Regularly check the leak detector for signs of intrusion.
☐	Conduct a functionality test to ensure all systems operate correctly after immersion.
☐	Document any issues or anomalies observed during the water immersion check for further assessment and action.

Table 26. Water Immersion checklist.

Lost Communication Response Checklist	
☐	Immediately disconnect power and retrieve the ROV via the tether.
☐	Reboot control systems to attempt reconnection.
☐	Collaborate with the surface station team to troubleshoot.
☐	Log the incident with observed symptoms and recovery steps taken.

Table 27. Lost communication response checklist.

Abnormal Bubbling Response Checklist	
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- | | |
|--------------------------|---|
| ☐ | Immediately disconnect power and retrieve the ROV via the tether. |
| ☐ | Inspect the leak sensor for water ingress confirmation. |
| ☐ | Examine the ROV to identify the point of water entry within the capsule seal. |
| ☐ | Use a multimeter to verify the presence of 0V across internal systems. |
| ☐ | Log the incident and repair or replace any damaged electronics. |
| ☐ | Restore vacuum integrity by resealing the capsule. |

Table 28. Abnormal bubbling response checklist.

D. Tether Management Protocol

Phase	Protocol
Preparation	Visual inspection for tension, twisting, or wear; implementation of strain relief.
Implementation	Secure routing through the ROV structure, proper connector locking, and final verification.
Testing	Monitoring buoyancy behavior and resistance during field tests.
Post-use	Cleaning, drying, and maintenance review with the safety team to ensure long-term reliability.

Table 29. Tether Management Protocol.

C. Warning Label on Thrusters



Fig. 25. Warning label design for thrusters: ISO 7010 – Standard for safety symbols used in ISO 3864. ANSI Z535. Corresponding American standard for safety signage, product warning labels and product instruction.

E. Build Schedule

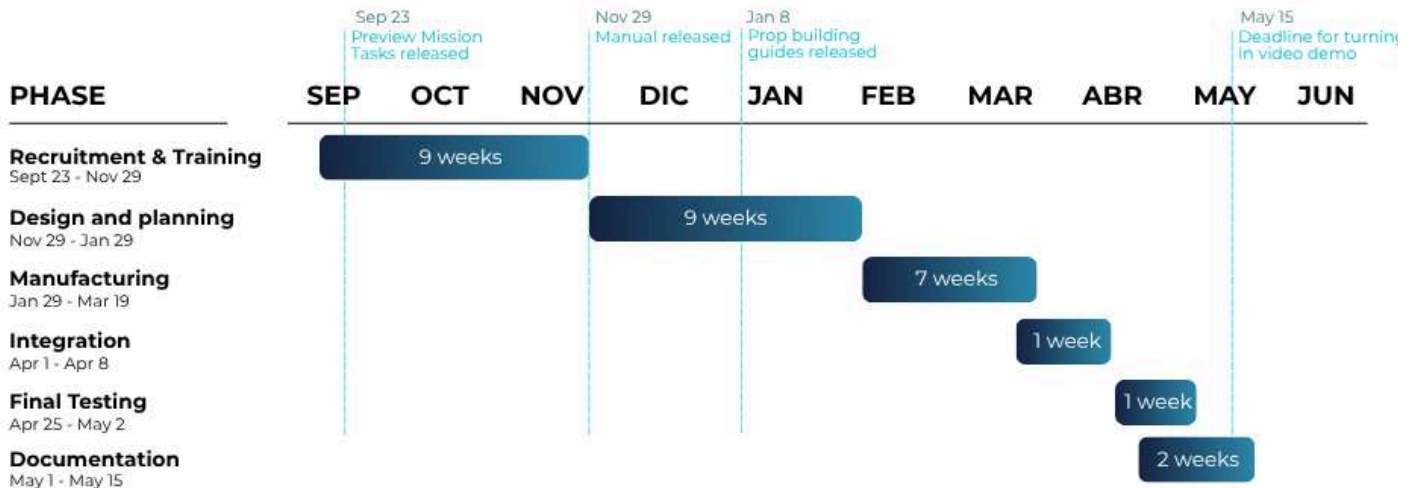


Fig. 26. Company Build Schedule.

F. Organizational Chart



Fig. 27. Company organizational chart.

G. ROV SID

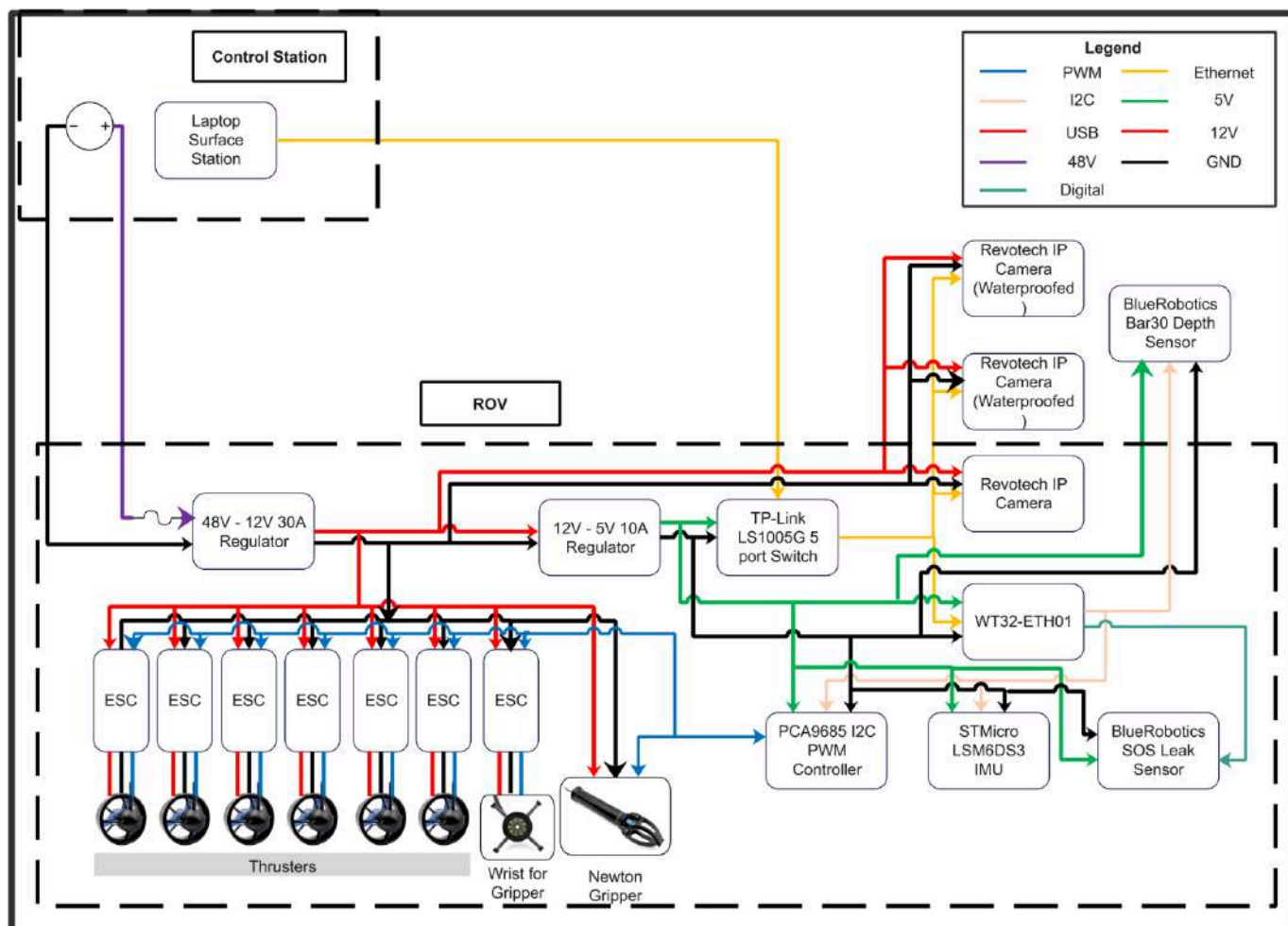


Fig. 28. ROV SID.