

TECHNICAL DOCUMENTATION

MateROV 2026

Alexandria, Egypt



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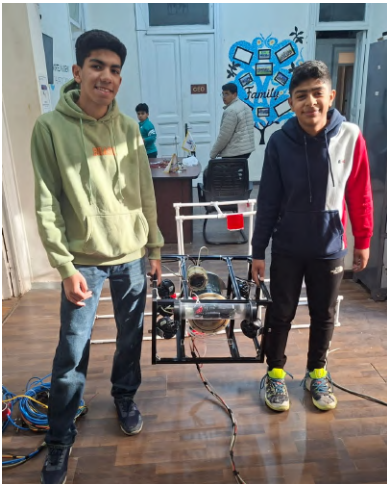
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1.0 Abstract

Atlantis, a 31-member marine technology company from Alexandria, Egypt, presents our newest ROV, Leviathon, and our autonomous float, Crystal, for the 2026 MATE competition. Embracing our namesake, Leviathon is envisioned as a giant mythical submarine journeying to the lost city, powered by Crystal's legendary radiant energy.

Building upon the legacy of our previous vehicle, "Kratos", Leviathon is the result of rigorous virtual validation and extensive pool testing. Engineered to address pressing environmental challenges, it is optimized to monitor cold-water coral ecosystems, measure iceberg keel depths, remove subsea biofouling, and support offshore wind-energy initiatives.

Leviathon features a compact 16 kg aluminum roll-cage frame housing a 45-degree vectored propulsion system. This highly stable architecture supports custom HDPE dual horizontal grippers and a specialized rotary tool. Electrical reliability is ensured by opto-isolated circuitry, a custom overvoltage protection PCB, and dynamic power allocation software that adheres to the 25A competition limit.

At the heart of our software architecture is a Raspberry Pi 5 and a Pixhawk flight controller that multiplexes four low-latency USB cameras. This system powers our advanced autonomous capabilities, including Tripo SR 3D modeling and a custom YOLO AI model trained for real-time detection of European Green Crabs. Together, Leviathon and Crystal merge mechanical resilience, electrical precision, and advanced computer vision to deliver safe, cost-effective robotics solutions for marine conservation.



Figure 1: The members of the Atlantis company, united in El Montazah Park, Alexandria, Egypt, for the 2026 MATE ROV season.

2.0 Teamwork and Organization

2.1 Company Overview:

Atlantis is a company mentored by Vortex Academy. Our organizational structure relies on collaborative teamwork and cross-disciplinary integration. By pairing the hands-on experience of returning old members with the fresh perspectives of recruits, we foster a strong mentorship environment. This deliberate dynamic ensures rapid knowledge transfer, efficient problem-solving, and seamless day-to-day operations across all of our sub-teams.

2.2 Personnel & Organizational Structure:

To execute our mission efficiently, Atlantis operates under a strict corporate hierarchy with clear roles designated to ensure accountability (**Detailed Leadership Structure in Appendix A**):

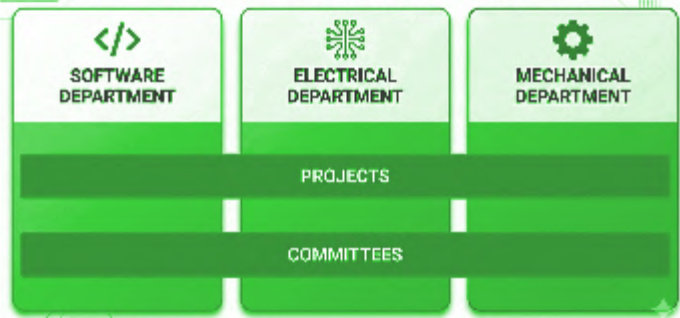


Figure 2: Atlantis company structure.

CEO & CFO: The CEO defines our strategic vision, directs operations, and manages safety and incident resolution. The CFO oversees the budget via weekly financial reports, strictly managing margins for consumables, assets, and logistics.

CTO & Technical Leads (Mechanical, Electrical, Software, Float): The CTO drives engineering decisions, ensures parallel development, and mitigates cross-disciplinary bottlenecks. Technical leads manage their respective departments, delegate tasks, and conduct rigorous reviews.

Deliverables Project Managers (PMs) & Committee Leads:

PMs and Committee Leads ensure engineering efforts yield a viable, reliable product. Project Managers oversee daily execution, resolving bottlenecks, and maintaining sub-team alignment with mission constraints. Committee Leads manage business and public operations, securing funding, driving fundraising, and reaching out to the community to expand real-world impact.

2.3 Schedule & Workflow Management:

Season Plan: To guide vehicle development, Atlantis utilized a detailed schedule (**Figure 3**) that divided the project into concurrent phases.

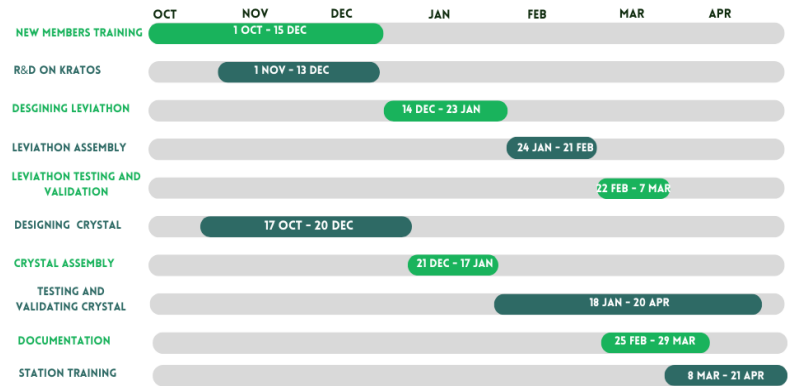


Figure 3: Comprehensive project timeline and Gantt chart detailing the 2026 development phases for Leviathon and Crystal.

The season plan began with new member training and comprehensive R&D on our previous ROV, Kratos. From there, we executed parallel design and assembly tracks for both Leviathon (ROV) and Crystal (Float). The season culminated in dedicated phases for rigorous testing, validation, and final documentation.

Team Workflow: To execute this overarching plan and solve day-to-day operational challenges, our sub-teams operate on fixed weekly schedules for core development. Cross-team alignment is maintained through mandatory weekly leadership syncs, where leads present their progress and collaborate to resolve any technical issues immediately.

Conflict Resolution in Action: Recognizing that a rigidly idealized schedule is rarely realistic, this workflow is designed for agility. For example, when mid-January exams caused a severe two-week delay in the mechanical assembly of Leviathon's frame, the CTO utilized the Workspace to re-allocate three idle Software team members to assist with frame deburring and assembly. This cross-training agility recovered 10 days of lost time and kept the critical path intact.

2.4 Procedures, Resources, & Task Management:

To efficiently manage our 31-member team and ensure cohesive day-to-day operations, Atlantis centralizes our communication, file storage, and project tracking within our proprietary virtual hub, the Vortex Rangers Workspace (**Figure 4**).

The Vortex Rangers Workspace: Beyond standard task tracking, the Workspace operates as a comprehensive, custom-built environment. Engineered entirely in-house utilizing cutting-edge AI-assisted development, this centralized

platform integrates our progress updates, internal communications, and scheduling alongside rigorous inventory and financial management. It even features a bespoke reservation system for physical workspace and hardware allocation. By consolidating these massive logistical demands into a single, AI-accelerated ecosystem, we achieve a level of superior cross-departmental coordination that off-the-shelf software simply could not provide.

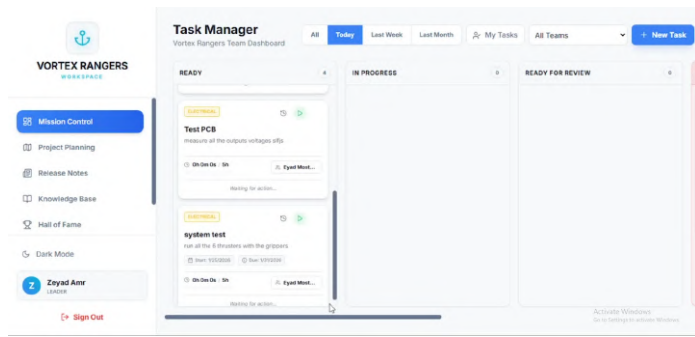


Figure 4: The Vortex Rangers Workspace interface, utilized for real-time task tracking and productivity management.

Engineering Resources: To support our physical development, we utilize a suite of professional, industry-standard tools.

SolidWorks is used for mechanical design and simulation, **Kicad** for custom PCB layout, and **VS Code** alongside **GitHub** for software development and strict version control.

Furthermore, we utilize **Google Colab** to provide the necessary GPU compute power for training our custom AI models. Integrating these tools with our Workspace enables rapid knowledge sharing and transparent progress tracking across all 31 members.

Protocols & Reporting: Atlantis operates on a highly agile, flat reporting structure to prevent corporate bottlenecks and ensure rapid problem-solving:

- **Flat Reporting Structure:** Functional engineering departments (Mechanical, Electrical, Software, Float) report technical progress directly to the CTO. The CTO acts as the central integration node, actively handling cross-departmental coordination to prevent siloed development. Conversely, Committee Leads and non-technical Project Managers report directly to the CEO, ensuring that our business, outreach, and documentation goals remain unhindered by technical roadblocks.

- **Meetings & Living Documentation:** We utilize an Agile methodology. Weekly all-hands meetings begin with a standup where members report progress and identify critical blockers for collaborative problem-solving. These updates, along with CAD iterations, test footage, and meeting minutes, are logged directly into the Workspace, serving as our centralized, day-to-day engineering notebook.
- **Cross-Disciplinary Agility & Task Gamification:** Every project requirement is broken down into actionable assignments within the Workspace. To promote an interdisciplinary culture, members are encouraged to claim tasks outside their primary departments if it prevents a bottleneck. To motivate efficiency, we employ a gamified point system for completed tasks. This transparent tracking allows leadership to view real-time workload distribution and instantly reallocate resources.
- **Resource Procurement:** To prevent delays in physical assembly, our Project Managers (PMs) take direct ownership of the supply chain. By proactively anticipating departmental hardware needs and consolidating requests within the Workspace, PMs drive the procurement process through a streamlined approval workflow managed by the CFO, ensuring critical components arrive exactly when they are needed.

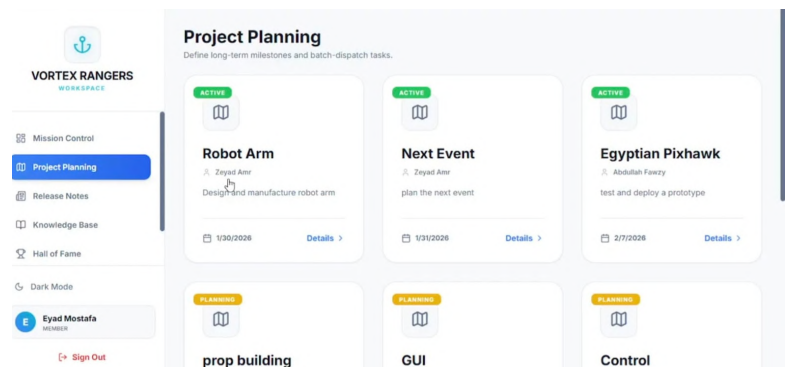


Figure 5: Vortex Rangers Workspace project tracking interface..

3.0 Engineering Design Rationale

3.1 Overall Vehicle Design:

Atlantis presents Leviathon (**Figure 7**), a highly maneuverable 16 kg ROV built on the legacy of our previous model, Kratos (**Figure 6**). Prioritizing mechanical stability and modularity, Leviathon features a wide-stance 50x40x35 cm aluminum extrusion frame that serves as a protective roll cage, enabling rapid, drill-free component adjustments. To withstand hydrostatic pressure, the vehicle utilizes a watertight tri-housing system equipped with a custom-machined aluminum faceplate and static axial O-ring seals. Propulsion is driven by six T200 thrusters mounted on impact-resistant, 45-degree custom aluminum brackets. Controlled by a streamlined electronics stack, the front chassis securely houses our mission-critical payload: two custom HDPE horizontal manipulators, a specialized biofouling rotary tool, and four multi-angle USB cameras.



Figure 6: SolidWorks CAD render of Kratos, our previous ROV model.

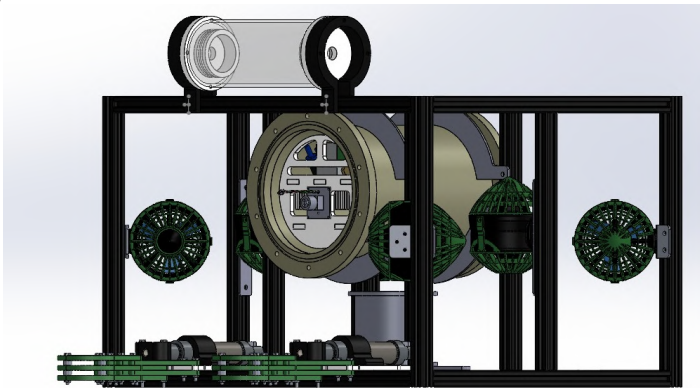


Figure 7: SolidWorks CAD render of Leviathon.

3.2 Step-by-Step Planning & Design:

To maximize scoring potential, Atlantis executed a rigorous design cycle:

Retrospective Analysis: Evaluated our previous ROV, Kratos, and last season outcomes to identify reusable assets and failure points.

Research & Ideation: Analyzed past MATE TDRs, challenge requirements and industry standards to brainstorm solutions.

Virtual Validation: Used CAD and simulation to test structural constraints and evaluate trade-offs cost-effectively.

Fabrication & Prototyping: Manufactured validated designs (e.g., bent-aluminum mounts) for prototyping and testing.

Primary Testing: Conducted initial subsea operational tests to ensure the vehicle and its subsystems successfully passed their primary functional constraints.

Stress Testing: Subjected the finalized designs to prolonged, high-load conditions during a month-long in-pool testing and station training period to verify the ROV's longevity and guarantee it consistently delivers the expected results.

3.3 Design Decisions & Trade-offs:

To support simultaneous multi-manipulation, a trade study dictated a massive shift from Kratos's compact frame to Leviathon's wide-stance geometry. Furthermore, we conducted a rigorous evaluation of camera systems to optimize our telemetry bandwidth.

Table 1: Frame Design Trade-off Analysis

Feature	Compact Frame (Kratos)	Wide-Stance Frame (Leviathon)
Footprint	Agile, but inherently unstable, operating multiple large tools. (Base Area: ~900 cm ²)	A large, massive increase in hydrodynamic stability. (Base Area: 2000 cm ² , increasing roll-stability moment by 35%)
Thrusters	Outside perimeter. Highly vulnerable to direct pool-wall impacts.	Inside perimeter. The aluminum frame acts as a protective roll-cage.
Payload	Lacked lateral space for simultaneous tool operation. (Weight: ~12 kg. Max Capacity: 2 Tools)	Accommodates dual horizontal grippers & a central rotary tool. (Weight: 16 kg. Max Capacity: 4 Tools)

Table 2: Camera System Trade-off Analysis

Feature	IP Cameras	USB Cameras
Latency	Noticeable delay due to the network encoding/decoding. (Average Latency: 150ms - 250ms)	Near-zero latency, crucial for precise manipulator tasks. (Average Latency: <40ms)
Network Architecture	4 independent IP cameras compete for tether bandwidth, requiring complex subsea IP routing and a dedicated network switch.	The Pi 5 acts as a central hub, efficiently compressing and multiplexing the 4 video streams alongside telemetry into a single, unified transmission.
Hardware Footprint	Requires an additional subsea networking switch and manual IP configuration. (Added ~150g weight & \$45 cost)	Plug-and-play simplicity directly into the Raspberry Pi 5. Eliminates the switch, reducing enclosure space by 10%.



Decision: We ultimately chose USB cameras. While IP cameras offer independent networking, the USB cameras provide the zero-latency responsiveness and system simplicity required for complex underwater manipulation without bogging down the Raspberry Pi.

3.4 Innovation

Dynamic Power Allocation: Ranger-class vehicles are strictly capped at a 25A draw (300W at 12V). Operating six T200 thrusters concurrently with logic electronics easily exceeds this limit. Historically, our previous ROV (Kratos) relied on a hard, global PWM cap across all thrusters, severely restricting our maximum pushing and lifting force to just 1.28 kgf per motor.

For Leviathon we engineered a custom dynamic power allocation algorithm. The software continuously reserves a strict 60W baseline for logic and safety systems, leaving a dedicated 240W for propulsion. Instead of globally throttling the vehicle, the algorithm actively monitors pilot inputs and dynamically isolates movement axes, funneling the full 240W exclusively to the active thrusters.

Horizontal Planar Flight: We can now safely push horizontal thrusters to 1736 PWM, producing 1.67 kgf of forward thrust per motor—a **30.5% increase** in horizontal pushing power.

Vertical Heavy-Lift: By isolating the heave axis during payload operations, we can push vertical thrusters to 1800 PWM, producing 2.46 kgf per motor—a massive **92.2% increase** in lifting capacity without tripping the 25A competition breaker.

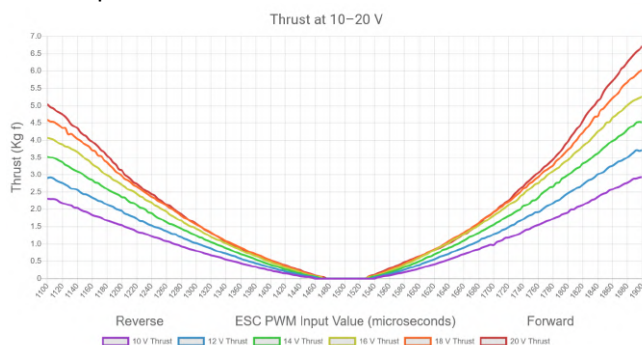


Figure 8: T200 Thruster characteristics.

Dynamic Role Assignment & Rapid Failover: Rather than running separate, hardcoded "Pilot" and "Co-Pilot" applications, our system utilizes dynamic role assignment. The unified app automatically detects if a physical controller is plugged into the machine; if detected, it instantly assigns that computer the active "Pilot" role. This provides critical failover redundancy. If the primary pilot computer crashes during a competition run, the pilot can simply plug their controller into any other station on the network and regain full vehicle control in under 10 seconds.

Onboard Profile Storage: To complement this rapid-switching capability, customized pilot profiles (containing individualized button and axis mappings) are no longer tied to specific topside laptops. These profiles are stored internally on Leviathon's companion computer. When a machine is dynamically designated as the Pilot station, the ROV automatically reports and pushes the preferred configuration to it. This ensures a seamless flight experience without forcing the pilot to manually remap their controls during an emergency hardware swap.

Overvoltage "Crowbar" Circuit: To protect logic electronics, we innovated a 2.5 x 2.5 cm PCB (Figure 9). A Zener diode monitors for voltage spikes. If triggered, a thyristor latches a short circuit to ground, instantly blowing our primary 25A fuse before spikes reach the Raspberry Pi or Pixhawk.

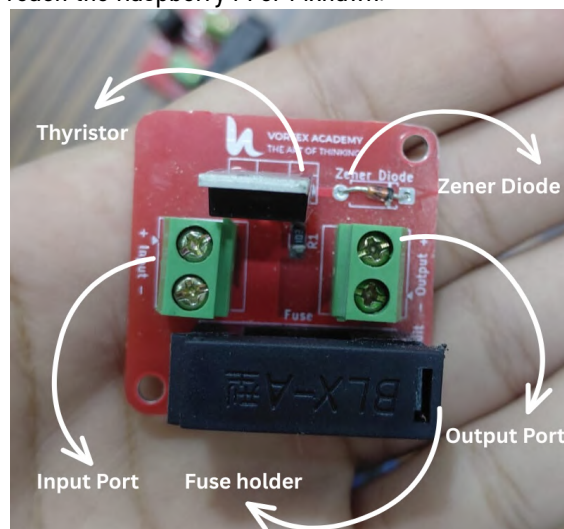


Figure 9: Custom "crowbar" Safety PCB.

3.5 Problem Solving:

Brainstorming & Cross-Industry Integration:

In our whiteboard sessions, we actively seek alternatives from outside the marine engineering field. For example, while struggling to design a suitable, low-profile bladder for our float's variable-buoyancy system, we looked to the medical field. We discovered that a standard leg-mounted urine collection bag provided the exact mechanical properties we required.

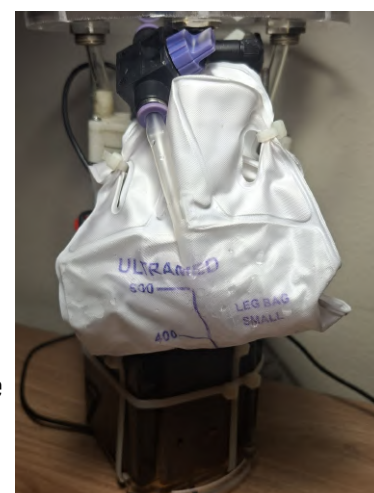


Figure 10: Crystal's Internal Bladder

Constructed from durable, high-frequency welded PVC, it offered a fully sealed, vacuumable internal capacity with pre-integrated dual ports—an anti-reflux inlet and a drainage spigot—, By



applying minor modifications to the tubing interfaces, we seamlessly repurposed this highly reliable, cost-effective medical device into the core of Crystal's active ballast system.

Fluid Flow Optimization (Hydrodynamic Trade Study): During our retrospective analysis of Kratos, we identified that standard 2D flat-plate thruster guards severely restricted volumetric flow. Pushing fluid through a sharp, non-profiled 2D mesh produces a vena contracta and massive boundary-layer separation. This turbulent wake choked the inflow and bottlenecked our total thrust.

We evaluated the drag coefficients of standard flat-plate geometries ($C_d \approx 2.0$) against custom hydrofoil cross-sections ($C_d \approx 0.04$). Applying this data, we manufactured custom 3D-printed guards featuring contoured meshes with precisely radiused leading and trailing edges. This scientific approach delays boundary layer separation, ensures attached flow, and minimizes thrust loss from turbulent wakes—maximizing our propulsion efficiency while remaining strictly compliant with MATE IP20 finger-safety regulations. (*Reference: Munson, Fundamentals of Fluid Mechanics*).

3.6 Systems Approach & Integration:

Atlantis employs a concurrent systems engineering approach, designing mechanical, electrical, and software components together rather than in isolated silos. By making calculated compromises across departments, we maximize total vehicle performance for the 2026 MATE tasks. The following are key examples of this methodology in action:

Virtual Integration & Task-Specific Design: Before physical assembly, we modeled Leviathon and the specific MATE competition props in SolidWorks. This electromechanical CAD integration allowed us to verify camera visibility and manipulator reach digitally. By simulating the ROV interfacing with the 2-inch PVC coral props, we accurately scaled our custom HDPE horizontal grippers. Furthermore, we positioned our flat acrylic faceplate in CAD to guarantee a distortion-free 1:1 pixel ratio for our Computer Vision (CV) measurements, ensuring our algorithms would function accurately before the ROV ever touched the water.

Cross-Disciplinary Problem Solving (Power Budget): The strict 25A vehicle limit presented a system-wide constraint. Rather than making a mechanical compromise (downsizing thrusters and losing lifting capability) or risking electrical failure, we solved this limitation through software. Our Dynamic Power Allocation algorithm actively manages the power budget across the system, allowing us to safely push the mechanical hardware to its maximum limit during heavy payload operations without exceeding the electrical threshold.

Hydrodynamic Efficiency & Control: The mechanical decision to replace standard flat-plate thruster guards with custom 3D-printed hydrofoil meshes had system-wide benefits. Delaying boundary-layer separation did not just improve fluid dynamics; it directly lowered the electrical current drawn by the T200 thrusters during sustained operations. This conservation of the power budget provides our Pixhawk flight controller with more overhead to maintain a highly stable depth hold in turbulent pool conditions.

3.7 Vehicle Structure:

When designing Leviathon, we fundamentally evaluated the trade-offs between size, weight, and cost against the demanding payload requirements of the 2026 mission. Our previous ROV, Kratos, featured a compact frame weighing approximately 12 kg. While this smaller footprint was highly agile, we found it was inherently unstable and lacked the lateral space necessary to operate multiple large tools simultaneously.

For Leviathon, we deliberately increased the vehicle's weight to 16 kg and expanded to a 50x40x35 cm wide-stance geometry. We accepted the trade-off of a larger drag profile to achieve a 35% increase in our roll-stability moment and to physically accommodate our dual horizontal grippers and central rotary tool. Despite this increase in mass, Leviathon's 16 kg weight remains well within safe handling limits, allowing for smooth poolside deployment without requiring a crane. To ensure this structural expansion did not compromise our financial budget, we rigorously reused 70% of Kratos's structural and propulsion hardware, keeping the vehicle's total cost highly efficient.



Figure 11: Physical assembly of Leviathon's modular aluminum extrusion frame.



Modular Chassis: We use a wide-stance 50x40x35 cm aluminum extrusion frame (**Figure 11**) that serves as a protective roll cage. The extrusion profiles are rigidly assembled using aluminum 90-degree angle brackets, screws, and T-nuts. This fastening method allows rapid internal component adjustments and modular repositioning without drilling. The front base of the frame securely houses the two HDPE horizontal manipulators and the central rotary tool.

Watertight Enclosures: To protect the electronics, Leviathon uses three watertight housings. The main cylinder uses an HDPE body, a flat, transparent acrylic front, and a highly rigid, custom-machined aluminum rear faceplate (**Figure 12**), fitted with Agro cable glands to prevent flexing under hydrostatic pressure. Two smaller housings (one acrylic tube, one HDPE cylinder) isolate the various cameras.

Sealing Mechanism: The main enclosure ensures watertight integrity with an industry-standard static axial face seal. The custom-machined aluminum faceplate mechanically compresses an O-ring seated within a groove on the HDPE cylinder, strictly adhering to specifications in the *Parker Hannifin O-Ring Handbook*.



Figure 12: Custom laser-machined rear aluminum face.

Propulsion Mounting: Six Blue Robotics T200 thrusters provide propulsion. These are mounted using custom-bent 45-degree aluminum brackets, intentionally replacing brittle 3D-printed mounts for significantly better durability and impact resistance in the water.



Figure 13: Photo of Leviathon's assembled structure.

3.8 Vehicle Systems:

For the 2026 season, we deliberately evolved Leviathon's vehicle systems from our previous ROV, Kratos, to satisfy a more demanding mission profile that required simultaneous manipulation, accurate visual measurement, stable station-keeping, and reliable operation under a strict electrical budget. Rather than redesigning every subsystem from scratch, we evaluated each component according to four criteria: mission fit, durability, integration simplicity, and cost. This process allowed us to preserve proven hardware where performance was already sufficient, while redesigning only the systems that limited last year's vehicle in the field.

Payload Systems: The largest system-level evolution was in the payload architecture. Kratos was built around a mixed-axis manipulator arrangement that was effective for the 2025 tasks, where one horizontal and one vertical gripper supported connector handling, mission item deployment and retrieval, and object pickup. For Leviathon, that arrangement was no longer optimal. The 2026 mission set required handling larger PVC-based structures, controlling objects in front of the vehicle, and performing multi-step manipulation while keeping the tool interaction inside the pilot's primary field of view. We therefore replaced the mixed-axis layout with two enlarged horizontal manipulators and a central rotary biofouling tool. This gave the pilot a more intuitive working envelope, allowed simultaneous stabilizing-and-gripping actions, and matched the geometry of this year's 2-inch PVC props far better than last year's narrower acrylic end-effectors.



Figure 14: Leviathon's gripper in open position.

Material selection for the manipulators was also driven by direct failure analysis. Kratos used laser-cut acrylic grippers mounted on an acrylic base; while these offered fast fabrication and visual alignment, acrylic proved too brittle for repeated handling, transport, and accidental impact. In contrast, Leviathon's manipulators were remanufactured



from 9 mm HDPE, which we selected because it is more impact-tolerant, easier to machine into thick monolithic jaws, and less likely to crack under local stress concentrations. This change was not cosmetic; it was a targeted durability upgrade based on a real failure mode from last season. The result was a manipulator set that could better survive poolside transport, repeated clamping cycles, and contact with rigid mission props without forcing us into the higher cost and unnecessary complexity of commercial underwater manipulators.

The central rotary tool was designed specifically for the observatory biofouling task. Because the mission required continuous unidirectional rotation of the fouled panel rather than puncturing, scraping, or high-force cutting, we selected a forked rotary engagement profile instead of a more aggressive toothed cutter. This geometry gives two important advantages: first, it positively engages a rotating target without slipping; second, it spreads contact load over a larger area, reducing the chance of jamming or pushing the vehicle backward during the required repeated rotations. In practice, this meant the tool could perform the three full rotations demanded by the mission while the two side grippers remained available for alignment or secondary tasks.

Cameras & Tether Optimization: Leviathon's camera system was another major evolution. Kratos relied on a more complex visual architecture that included dome- and tube-based camera groupings and a larger number of views. For Leviathon, we simplified the vehicle to four HD USB cameras with clearly separated operational roles: a front camera for navigation and gross alignment, a gripper camera for connector and manipulator tasks, a top/wide camera for spatial awareness and pilot situational context, and a benthic camera for transect observation, coral imaging, crab detection, and seabed-relative positioning. This arrangement preserved overlapping coverage where needed, but removed redundant views that increased bandwidth, sealing complexity, and operator overload. It also directly supports the vision tasks in the competition, including classical photogrammetry, 3D reconstruction, and YOLO-based crab detection.

We paired this camera reallocation with a full IP-to-USB architecture change. Last year's more network-heavy vision strategy offered flexibility, but this year it would have added unnecessary latency and subsea hardware. Our trade study showed that USB cameras reduced average latency from roughly 150–250 ms for IP-based streaming to less than 40 ms, while also removing the need for a dedicated internal network switch. That single decision simplified integration across three subsystems at once: it reduced cabling count, freed approximately 10% of enclosure space, and removed about \$45 and 150 g of networking hardware from the vehicle. More importantly, it improved pilot confidence during connector

insertion and close-range manipulation, where delayed video has a direct performance penalty.

Control System Evolution: The tether and internal logic architecture were simplified for the same reason: remove anything that did not directly increase mission performance. By eliminating the subsea switch and moving to a Raspberry Pi 5-centered USB hub strategy, we were able to remove one CAT6 line from the tether, lowering drag and reducing parasitic handling load on the pilot. We also replaced the intermediate Arduino-based signal translation stage with low-cost industrial optocouplers. This reduced PCB footprint and wiring complexity while improving electrical isolation from motor back-EMF and solenoid noise. In other words, we did not just make Leviathon cheaper; we made it easier to troubleshoot, easier to package, and more robust under competition conditions. At the sensing level, we intentionally kept the stack minimal. Instead of adding extra sensors with marginal value, we selected only the Bar30 pressure sensor and Pixhawk IMU, because together they addressed the vehicle behaviors that mattered most this season: depth stability, pitch/roll awareness, and repeatable camera pose during photogrammetry and station-keeping. This was a cost-effective decision as much as a technical one. Additional sensors would have increased integration burden and failure points without improving the core mission actions as much as stable control and reliable visual data already did.

Finally, Leviathon's vehicle systems were designed around a reuse-first philosophy. We inherited the six Blue Robotics T200 thrusters, the Pixhawk, major enclosure elements, and much of the aluminum frame stock from Kratos, which allowed us to concentrate new spending on the systems that actually expanded mission capability, particularly the Pi 5, custom manipulators, custom PCB protections, and hydrodynamically improved thruster guards. This decision had a measurable budget effect. Reusing six T200 thrusters alone avoided roughly **\$1,380 USD** in repurchase cost at current Blue Robotics pricing, before considering shipping or ESC-related overhead; more than 70% of Kratos's hardware was reused overall. That is exactly the balance we aimed for: buy reliability where it is hard to outperform commercial parts, and build in-house where mission geometry, packaging, or cost demanded a custom solution.

3.9 Electrical System:

The electrical system of Leviathon was designed to provide highly reliable power distribution, precise signal control, and seamless communication. By migrating away from disorganized point-to-point wiring, we integrated our hardware into a unified network organized around a custom central control board, supported by robust voltage regulation and rapid-response



safety protocols. A complete schematic of Leviathon's is provided in our SID (**Check Appendix C**).

3.9.1 Internal Enclosure Layering & Cabling Layout:

To maximize both electromagnetic interference (EMI) isolation and physical water-ingress protection, the internal components of our main cylindrical enclosure (**Figure 15**) are strictly divided into three physical tiers:

Bottom Layer (High-Noise/Low-Cost): Houses the Directional Control Valve (DCV) solenoids and the 12V-to-5V buck converters. Because water naturally pools at the bottom of a cylinder during a micro-leak, placing the least expensive, most robust components here physically protects the rest of the ROV.

Middle Layer (Power Distribution): Contains the main power busbar and the six Electronic Speed Controllers (ESCs).

Top Layer (Sensitive/High-Cost): Houses the 5V logic system, including the Raspberry Pi 5, Pixhawk, and USB camera hubs. Placed at the highest point, these expensive components are isolated from both EMI noise and potential water pooling. This internal layering precisely dictates the layout of our rear aluminum faceplate gland. Pneumatic hoses enter through the bottom glands, heavy 12V power and thruster cables through the middle, and sensitive tether communication cables through the top, completely separating high-voltage lines from data lines.



Figure 15: The internal structure.

3.9.2 Custom Main Control PCB & Signal Architecture:

To eliminate wiring clutter, we designed a custom Printed Circuit Board (PCB) (**Figure 16**) that acts as the central nervous system for Leviathon. It securely receives 5V from the buck converter and distributes it to the logic boards. Furthermore, it consolidates the PWM signal pins from all six ESCs into a single, unified data cable routed to the Pixhawk. Crucially, the PCB houses our isolated tool control array. It receives 3.3V signals from the Pixhawk and routes them through onboard optocouplers. These optocouplers provide essential isolation, stepping the signal up to 5V while protecting the sensitive logic system (Raspberry Pi/Pixhawk) from the severe

electrical noise and flyback voltage generated by the DCV solenoids and the payload bilge pump.



Figure 16: Leviathon's custom main control PCB.

3.9.3 Equipment Safety Circuitry:

Our electrical safety architecture uses a dual-tier approach to ensure compliance with competition regulations and the survival of components.

System-Wide Protection: To comply strictly with Ranger class rules and protect the entire ROV's 12V main line, a primary 25A inline fuse is installed on the tether within 30 cm of the topside power supply.

Logic Isolation: Our sensitive 5V logic system (Raspberry Pi, Pixhawk, and USB cameras) draws approximately 12A. To protect this specific rail, we installed a dedicated 15A inline fuse. This acts as our standard overcurrent and short-circuit protection for the logic tier.

Modular Overvoltage Defense (Crowbar Circuit): To protect against catastrophic voltage spikes on the 5V line, we engineered a custom "crowbar" circuit. To ensure maximum modularity and reusability across future projects, this safety circuit is manufactured as a standalone, highly compact 2.5 x 2.5 cm PCB (**Figure 9**), kept physically separate from the main control board. A Zener diode continuously monitors the voltage rail. If an overvoltage event occurs (exceeding the Zener diode's breakdown voltage), the diode conducts current to the thyristor's gate. The thyristor immediately turns on and latches, creating a direct, low-impedance short circuit to ground. This deliberate short forces a massive inrush of current that instantly blows the dedicated 15A logic fuse, physically severing the power connection and protecting the expensive logic microcontrollers before the voltage spike reaches them.

3.9.4 Tether Design & Specifications:
 Leviathon operates on a custom-built, neutrally buoyant 20-meter tether (**Figure 17**) tailored specifically for the 2026 mission requirements.

Power Transmission: To safely transmit up to 25A to the subsea busbar, we use heavy-duty 12 AWG marine-grade stranded copper wire. This minimizes resistance across the 40-meter total circuit loop, preventing severe voltage drop and heat generation and ensuring a stable 12V supply.

Data Transmission & EMI Shielding: A Shielded Twisted Pair (STP) CAT6E Ethernet cable connects the topside laptops to the subsea Raspberry Pi 5. The shielding actively rejects Electromagnetic Interference (EMI) from the adjacent high-current power lines, ensuring zero packet loss or latency for our HD video and telemetry.

Pneumatic Supply & Diagnostics: Two highly flexible 6mm polyurethane (PU) hoses are integrated into the tether:
Hose 1 (Actuation): Supplies compressed air to the dual horizontal grippers via an internal T-fitting.
Hose 2 (Diagnostics & Relief): Serves a critical dual purpose. Pre-dive, we use it to apply positive pressure and submerge the ROV to check for leaks visually. Mid-dive, it acts as a vent for internal pressure buildup.

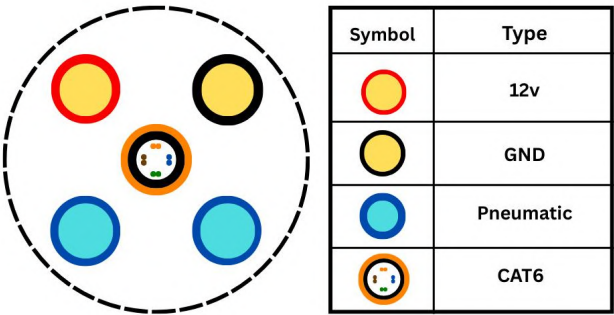


Figure 17: Cross-sectional diagram of the 20-meter tether.

3.9.5 Tether Management Protocol:
 To ensure operational safety, prevent entanglement, and protect the delicate internal conductors from strain, Atlantis strictly adheres to the following end-to-end management protocol:

Phase 1: Pre-Dive Setup & Connection
Inspection & Unspooling: The tether is visually inspected for damage and smoothly unspooled directly from our custom rotary cable reel (**Figure 18**). Loose coiling on the pool deck is strictly prohibited to eliminate tripping hazards and prevent anyone from stepping on the cable.

Strict Connection Sequence: To prevent catastrophic damage, the mechanical strain relief is securely anchored to both the ROV and the surface station first. Only after the strain relief is verified on both ends are the power, Ethernet, and pneumatic lines connected.

Phase 2: In-Water Operations
The Dedicated Tetherman: A specific team member is designated as the Tetherman for the duration of the dive.
Slack Management: The Tetherman actively monitors and adjusts the cable, feeding the exact length necessary to allow unhindered movement to working depths. Too little slack inhibits the ROV's maneuverability, while too much creates hazardous loops and snag points.

Pilot Mitigation: The Pilot actively avoids unnecessary 360-degree rotations and maintains a safe perimeter around pool obstacles to mitigate internal wire twisting and external tangling.

Phase 3: Post-Dive Teardown
Strict Disconnection Sequence: Once the ROV is safely surfaced and powered off, the Tetherman disconnects the topside power supply first, followed by the data and pneumatic lines, and finally removes the strain relief.

Storage: The tether is immediately and evenly spooled back onto the rotary reel to avoid kinks, twists, and tangles during transport and storage.



Figure 18: custom topside rotary cable reel.

3.10 Control System Architecture:
 Leviathon's control system was designed to provide stable, predictable vehicle handling during precision manipulation, visual inspection, and station-keeping tasks. The vehicle uses six thrusters arranged to provide five controllable axes of motion: surge, sway, heave, yaw, and limited attitude stabilization through the flight controller. Low-level vehicle stabilization is handled by a Pixhawk 1.4 flight controller running ArduSub firmware, while high-level coordination, camera



handling, and mission software run on the companion computer. Communication between the companion computer and the flight controller is performed through the MAVLink protocol using pymavlink, allowing the onboard software and topside systems to exchange telemetry, mode, and control information in a standardized and reliable way. This control architecture integrates propulsion with the vehicle's manipulators, four USB cameras, and payload actuators while preserving a clear separation between safety-critical control and high-level software tasks.

3.10.1 Computing Hardware & "Build vs. Buy"

Justification:

Main Computing Unit: A Raspberry Pi 5 manages high-level processing tasks. It runs custom-developed Python software that handles sensor data processing, system coordination, real-time YOLO AI, and communication between onboard components.

Build vs. Buy (Flight Controller): we selected a Pixhawk 1.4 flight controller running ArduSub instead of developing a custom control board because this subsystem is safety-critical and already well validated for underwater vehicle stabilization. Using a commercial flight controller reduced technical risk, shortened integration time, and gave the team immediate access to proven IMU-based stabilization, PWM motor output, configurable vehicle modes, and compatibility with QGroundControl and MAVLink tools. This decision allowed the team to focus its in-house development effort on mission-specific software, camera handling, operator tools, and power-management logic rather than reproducing a mature autopilot stack from scratch.

Future R&D (Custom Controller): While the Pixhawk is an industry standard, it limits our hardware footprint. As part of our continuous R&D, Atlantis has begun designing a proprietary flight controller architecture. This custom board will feature an integrated Raspberry Pi 4, onboard IMU sensors, and an I2C-to-PWM module to connect the ESCs directly to the board. This custom board is fully slated for integration next season.

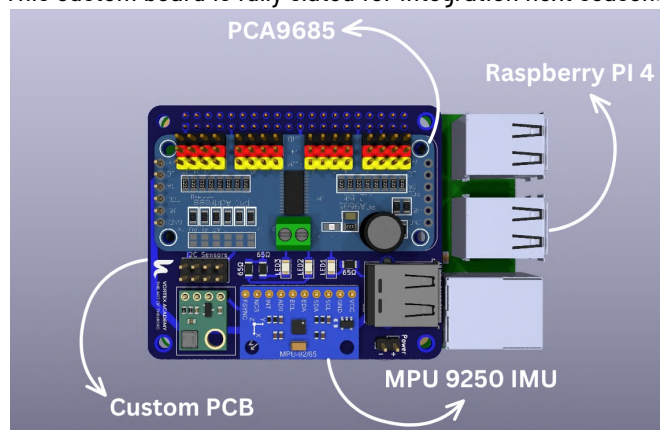


Figure 19: CAD layout of our Future flight controller PCB.

3.10.2 Software Architecture & Development Process:

Requirements & Verification: Software requirements were derived directly from the 2026 mission tasks and the constraints of the vehicle hardware. The control stack had to support stable piloting during camera-based inspection, reliable manipulator operation, low-latency telemetry exchange, and safe power-aware actuation under the competition current limit. For example, operation of the rotary cleaning tool and simultaneous thruster loading required software-side power management to avoid exceeding the 25 A limit. These requirements were verified progressively through bench testing of MAVLink communication, actuator response, and telemetry reporting before being validated during integrated pool testing under mission-like conditions.

Development & Version Control: Atlantis used GitHub-based version control to manage the software stack. New features were developed on isolated branches, tested independently, and merged only after bench and in-water validation. This workflow reduced integration risk between vehicle control, telemetry, and GUI modules, and allowed the team to keep a stable competition-ready release available at all times. Maintaining a known-good software baseline was especially important because the system combines a flight controller running ArduSub with custom Python tools running on the companion computer and topside station.

Software Integration & Operator Navigation: The control system is built around a layered software architecture. The Pixhawk 1.4 with ArduSub handles low-level vehicle control and stabilization, while companion-computer software communicates with it over MAVLink using pymavlink. QGroundControl is used for configuration, arming, telemetry monitoring, and flight-mode management, while the custom operator interface provides mission-specific visualization and control functions. In operation, the flight controller maintains vehicle stability and reduces pilot workload, especially during close-range manipulation and inspection tasks where maintaining heading and depth consistency is critical.

Advantages & Limitations: As detailed in our data flowchart (**Appendix B**), The main advantage of Leviathon's control architecture is the separation between low-level vehicle control and high-level mission software. Because stabilization and motor control remain on the Pixhawk, failures in companion-computer applications such as AI processing, camera handling, or the custom GUI do not remove the operator's ability to control and recover the vehicle. This improves operational safety and simplifies debugging.



3.11 Custom Graphical User Interface(GUI):

To prevent pilot sensory overload and ensure a clear, efficient platform for real-time operation, we developed a custom GUI (**Figure 20**) using PySide6 and Pygame. Adopting a consistent silver and olive grey color scheme for optimal visibility and a professional appearance, the layout prioritizes accessibility, allowing both the pilot and co-pilot to quickly access essential controls, video feeds, and system data. The architecture is highly modular (`main.py`, `cam.py`, `rov.py`), ensuring clean, easily debuggable code.

Advanced Video & AI Processing: The GUI integrates four live video streams. Operators can use keyboard shortcuts or mouse controls to switch between individual camera views or display up to three zero-latency streams simultaneously, enhancing situational awareness. A dedicated recording function allows operators to capture and store footage during the mission for later analysis and documentation. Additionally, a specialized vision module processes real-time video to automatically detect and count European Green Crabs.

Dynamic Operating Modes & Task Management: The GUI supports distinct operating modes for pilot and co-pilot use. Pilot mode prioritizes vehicle movement, arming state, and actuator access, while co-pilot mode emphasizes video monitoring, task observation, and mission-support functions. A standby state is maintained before active operation to reduce the chance of unintended commands during setup. The interface also includes an integrated mission timer to help the team manage task pacing within the competition time limit.

Live Telemetry & Active Safety: A real-time telemetry panel displays the values most relevant to safe and effective operation, including depth, voltage, current, vehicle mode, and propulsion gain. These indicators help the operators monitor the electrical load, verify vehicle state, and respond quickly to abnormal conditions. The GUI also provides arm/disarm controls linked to the Pixhawk and a controlled remote shutdown function for the subsea computer, reducing the risk of improper shutdown or file corruption after operation.

Pilot Customization Profiles: Recognizing differing ergonomic needs, the GUI utilizes a `settings.json` file. Pilots can instantly load customizable profiles to adjust control settings, remap joystick buttons, and invert thrusters without altering the core hardcoded software.



Figure 20: Atlantis UI's Copilot tasks interface.

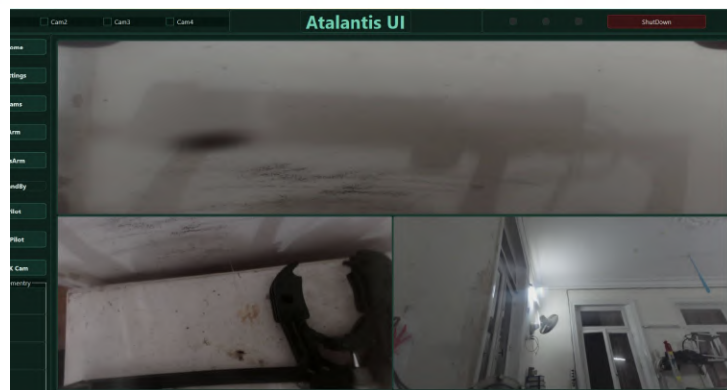


Figure 21: The custom Atlantis topside GUI live telemetry.

3.12 Computer Vision & Software:

Leviathon uses a task-specific computer vision strategy designed to maximize scoring value while avoiding the bandwidth, latency, and thermal overhead of a stereo or IP-camera architecture. Instead of relying on one universal vision pipeline, Atlantis implemented three separate approaches: classical image-based measurement for dimensional estimation, YOLO-based object detection for invasive crab identification, and multi-image reconstruction for coral-garden CAD generation. This separation reduced computational load and allowed each method to be matched to the mission task it served best.

To support these functions, we strategically distributed four Rapoo USB cameras across the vehicle. The front main camera, mounted behind the flat acrylic faceplate of the main enclosure, serves as the primary navigation camera and the main scientific optical sensor. It captures the high-resolution imagery used for coral-garden length estimation, iceberg keel measurement, and the overlapping image set required for 3D reconstruction. The gripper camera, housed in the secondary acrylic tube and angled downward toward the dual horizontal manipulators, provides the close-range visibility needed for precision tool operation. The top-facing camera, also mounted in the secondary acrylic tube, provides overhead spatial awareness and helps the pilot maintain orientation relative to the pool wall and surface station. The benthic camera, installed in a dedicated downward-facing HDPE enclosure, continuously observes the pool floor and supplies the image stream used for crab detection along the transect.

For coral-garden length and iceberg keel depth estimation, Leviathon uses a classical pixel-ratio method rather than stereo triangulation. This was made possible by selecting a flat acrylic faceplate instead of a dome for the primary scientific camera, reducing optical distortion and preserving a more reliable image scale for measurement tasks. During coral-garden



measurement, the pilot positions the ROV to achieve the most parallel practical viewing angle, captures a high-resolution image, and processes it using a custom Python script. The script estimates target dimensions against several known prop references, including the 45 cm, 25 cm, 21 cm, and 15 cm PVC segments and the 1.27 cm pipe diameter. By calculating the target dimension relative to multiple known references and averaging the results, the method reduces error caused by perspective variation and local image-scale inconsistency. The same principle is applied to iceberg keel estimation using visible known geometry in the task scene.

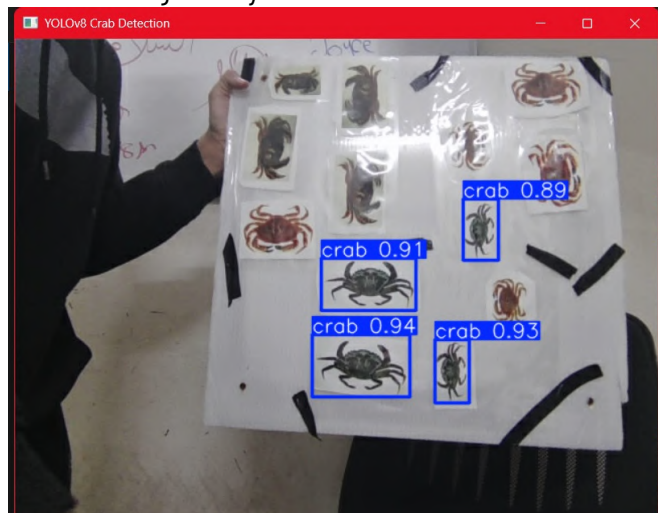


Figure 22: Our custom YOLO model detecting invasive crabs during training.

Crab Detection (YOLO): For invasive European Green Crab detection, Atlantis trained a custom YOLO object-detection model using an underwater dataset collected with Leviathon's own benthic camera rather than relying on generic internet images. This gave the model training data that matched the actual competition environment more closely, including underwater color shift, reflections, suspended-particle noise, and refraction effects. Model performance was evaluated using mAP (mean Average Precision), which is the more appropriate metric for object detection than plain classification accuracy. In validation, the model achieved an mAP of approximately 0.937, demonstrating strong detection performance under the same visual conditions expected during operation. The model runs on the topside laptop and processes the benthic video feed in real time to assist the operators in detecting and counting invasive crabs along the transect.

3D CAD Generation: For 3D coral-garden reconstruction, Atlantis uses the Tripo SR model to generate a CAD-ready spatial representation from a set of overlapping images captured by the front main camera. Because single-view imagery is insufficient for reliable reconstruction, the pilot intentionally maneuvers Leviathon around the target to capture images from multiple angles and sides with adequate feature overlap

between frames. This gives the reconstruction algorithm enough shared visual features to estimate geometry more reliably and produce a usable 3D representation of the coral structure for mission submission (**Figure 23**). Rather than depending on specialized stereo hardware, this method allowed Atlantis to meet the modeling requirement using the same low-latency USB camera architecture already selected for piloting and measurement tasks.

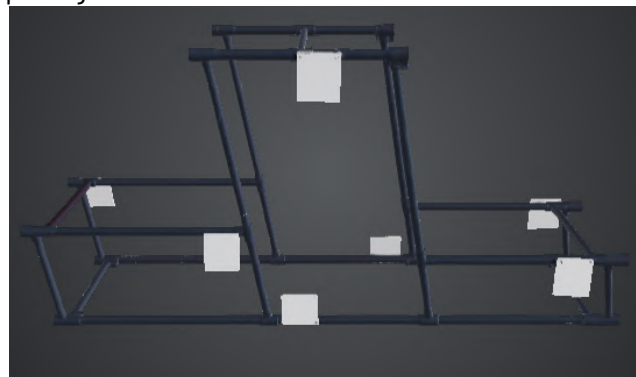


Figure 23: The final 3D CAD model generated by the Tripo SR algorithm, constructed using the multi-angle images.

3.13 Propulsion:

To maintain precise 6-DOF maneuvering, Leviathon utilizes an optimized six-thruster configuration featuring commercial Blue Robotics T200s inherited from last year. We reused these thrusters because their proven reliability and thrust output easily satisfy mission requirements while conserving significant budget for custom developments.

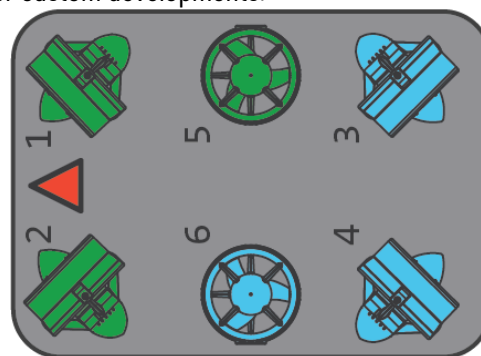


Figure 24: Our six thruster vectored configuration.

Placement & Rationale: Four planar thrusters, vectored at 45 degrees, provide omnidirectional movement without a dedicated lateral thruster. Two vertical thrusters are strictly used to provide heave during manipulator operations.

Trade-offs: CAD simulations confirmed the 45-degree angle perfectly balances planar thrust. However, testing revealed that 3D-printed mounts were brittle. We opted for bent metal, sacrificing marginal gains in fluid flow for superior impact durability. **Power Validation:** To prevent exceeding the strict 25A limit, software dynamically isolates axes. During simultaneous maximum heave and surge testing, this logic successfully clamped total draw to exactly 24.3A.



3.14 Buoyancy and Ballast:

To ensure absolute stability, Leviathon is engineered with a massive positive metacentric height. All heavy components (aluminum base, grippers) are mounted at the lowest possible points to lower the Center of Gravity (CG). In contrast, our flotation is mounted at the highest possible points to raise the Center of Buoyancy (CB), preventing uncontrolled pitch or roll.

Modular Ping-Pong Ball System: We are planning to transition from high-density foam to a ping-pong ball buoyancy system. Housed in a custom containment module, these rigid spheres provide uniform, predictable units of displacement. Trimming is completely non-destructive; the ROV assistant simply adds or removes individual balls to achieve perfect neutral buoyancy.

Buoyancy Displacement Methodology: To determine the exact number of spheres required, we apply Archimedes' Principle (*Reference: White, F. M., Fluid Mechanics*). We first measure the ROV's submerged weight in freshwater to account for the natural displacement of our aluminum and HDPE frames. We then divide this specific in-water weight by the mathematically constant net buoyant force of a single 40 mm ping-pong ball. This calculation provides our exact baseline sphere count, eliminating guesswork before we begin final physical trimming poolside.

3.15 Payload and Tools:

Our payload array was designed specifically to execute the 2026 MATE mission tasks.

Cameras: We integrated four HD USB cameras (Front, Gripper, Top, Benthic). This configuration multiplexes visual data for YOLO AI crab detection, providing the pilot with overlapping, blind-spot-free coverage.

Manipulators: The dual horizontal grippers (*Figure 25*) and specialized rotary fork were custom-engineered from HDPE to interact perfectly with the massive 2-inch PVC coral props and biofouling targets. The pneumatic system uses a strict pressure regulator to prevent overpressurization of the actuators (*See Appendix D for the complete pneumatic system*).



Figure 25: Photograph of the custom- machined HDPE Grippers.

Sensors: A Bar30 pressure sensor and the Pixhawk IMU were selected to provide the absolute depth-holding and wave-compensation stability required to execute precise classical photogrammetry without crashing into the pool floor.

3.16 Build vs. Buy & Component Lifecycle:

To maximize our operational budget, every component was evaluated through a rigorous resource allocation matrix. New vs. Inherited: We minimized e-waste by reusing 70% of the hardware from our previous ROV, Kratos (including the T200 thrusters, Pixhawk, aluminum extrusions, and enclosures). Our primary New investment was upgrading from a Raspberry Pi 4 to a Pi 5. The Pi 4 lacked the CPU and USB bandwidth required for this year's tasks; the Pi 5 provides the massive processing power needed to run YOLO object detection, 3D Tripo SR generation, and four HD video streams simultaneously without latency.

The "Buy" Decisions: We deliberately bought highly complex, standardized components (T200s, Pi 5, Pixhawk). This project management decision saved hundreds of development hours, ensured core vehicle reliability, and freed our software team to focus on AI and dynamic power innovations.

The "Build" Decisions: Components requiring specific mission conformity were built in-house. Commercial grippers are expensive and are not scaled correctly for the 2026 props, so we built our HDPE manipulators. Commercial power distribution boards are bulky, so we built highly compact, custom opto-isolated PCBs and Crowbar safety circuits. Finally, we 3D-printed custom hydrofoil thruster meshes to eliminate boundary-layer drag, a hydrodynamic efficiency impossible to achieve with standard commercial flat plates.

3.17 Autonomous Float System "Crystal":

For the 2026 season, Atlantis engineered a major architectural overhaul of our standalone active buoyancy float, *Crystal*. Transitioning from a heavy pneumatic piston to a dual-pump, bladder system allowed us to significantly reduce the float's physical footprint while vastly improving its operational range.

Physical Evolution & Capacity: By eliminating the bulky pneumatic cylinder, we reduced the float's overall height from 70 cm to 28 cm and its weight from 17 kg to a highly portable 4 kg (*Figure 26*). Despite this 4x size reduction, the new bladder system doubled our water intake capacity from 150 ml to 300 ml. This expands our variable density range (0.92 to 1.07), allowing Crystal to seamlessly transition between slightly positive, neutral, and slightly negative buoyancy states for incredibly smooth vertical profiling.



Electrical Architecture: *Crystal* operates entirely independently of *Leviathan*. It is powered by an onboard 12V battery and controlled via an ESP32 microcontroller mounted on a custom, compact PCB (See Appendix E for the standalone float SID). We designed a custom MOSFET switching circuit to safely handle the high-current demands of the two 12V water pumps (one for intake/descent, one for drain/ascent) without frying the logic board.

Operating Principle & Efficiency: The ESP32 continuously polls a Bar30 pressure sensor for high-resolution depth telemetry. To eliminate vertical overshooting, we programmed a custom PID control algorithm. By calculating the exact error between current and target depth, the PID logic dynamically pulses the MOSFETs to regulate flow rates. This smoothly tapers water displacement as the float approaches its setpoint. In-water validation confirmed that this logic eliminated depth oscillation, maintaining neutral buoyancy within a ± 4 cm margin during a continuous 5-minute autonomous hold. This active approach is vastly more energy-efficient than using continuous downward vertical thrust, conserving battery life and reducing mechanical stress during missions.



Figure 26: *Crystal*.

4.0 Safety

4.1 Safety Philosophy & Culture:

At Atlantis, safety is a core value embedded in every aspect of our engineering cycle. Our philosophy is simple: protect people, preserve equipment, and ensure reliable operations. By adhering to industry best practices and MATE ROV competition regulations, we foster a culture of accountability where every team member is empowered to identify hazards and propose mitigations.

4.2 Training & Lab Protocols:

To ensure a uniformly high level of safety awareness, all members complete a structured safety training program before interacting with *Leviathan*.

Inductions & Drills: Members undergo rigorous inductions covering lab rules, emergency protocols, and the proper use of Personal Protective Equipment (PPE) (Figure 27).

Supervised Operations: We enforce a strict "No Solo Operation" rule; no member may operate power tools or conduct live electrical testing alone.

Jobsite Safety and Environmental Analysis (JSEA): Before major manufacturing tasks, members conduct a JSEA to assess potential risks (electrical shorts, entanglement) and define immediate mitigation strategies.



Figure 27: Mechanical member adhering to mandatory PPE protocols (safety goggles, gloves) during the mechanical assembly phase.



4.3 Physical Vehicle Safety Features:

Leviathon was engineered to mitigate operational hazards inherently:

Electrical Protection: To comply strictly with Ranger class specifications, a primary 25A inline fuse is installed within 30 cm of the surface power supply. Furthermore, our custom Overvoltage "Crowbar" PCB instantly shorts and blows the logic fuse in the event of a dangerous voltage spike, protecting the microcontrollers. Topside AC and subsea DC wiring systems are physically isolated.

Thruster Guards: Protective 3D-printed hydrodynamic meshes encompass all six T200 thrusters. These guards comply with the IP20 standard, ensuring objects larger than 12.5 mm (such as fingers or tether lines) cannot enter the propeller wash.



Figure 28: our 3d-printed thruster guards.

Mechanical Safety: Leviathon's aluminum extrusion frame was manually deburred to eliminate sharp edges, and exposed bolt threads are fitted with rounded cap nuts to prevent cuts or snagged tethers.

Pneumatic & Pressure Relief: The pneumatic tool system uses a pressure regulator to prevent overpressure in the actuator.

4.4 Warning Labels & Operational Protocols:

High-visibility warning labels (**Figure 29**) are applied to critical components to identify pinch points on the HDPE grippers, high-voltage junctions, and spinning thruster guards. During pool deployment, the topside station is secured away from moisture, and cables are routed under high-traction rubber mats. A closed-loop communication protocol is strictly maintained; the ROV is never armed until the Tetherman verbally confirms the water is clear of divers. (*The complete, mandatory Construction and Operational Safety Checklists are provided in Appendix F*).



Figure 29: High-visibility hazard labels placed on Leviathon to warn operators of mechanical moving parts at the thrusters.

5.0 Critical Analysis: Testing & Troubleshooting:

To guarantee reliability, Atlantis enforces a strict "isolate before integration" methodology. By verifying each component independently before it interfaces with the broader ROV network, we prevent cascading integration failures and resolve technical challenges rapidly.

5.1 Testing Methodology & Prototyping:

Mechanical Testing: To guarantee watertight integrity at our 5-meter operational depth, we apply a 1.2x safety factor. Using a topside compressor, we pressurize the main enclosure to 0.6 bar (simulating 6 meters) and submerge it to inspect for micro-leaks. For structural reliability, we conduct Finite Element Analysis (FEA) on aluminum extrusions before manufacturing. These virtual models are then validated through physical load testing of our HDPE prototypes to ensure maximum payload capacity.

Electrical Testing: Using multimeters, we independently test every custom PCB trace for continuity and isolation, specifically hunting for microscopic solder bridges and rogue ground loops before applying power. We then verify that our buck converters deliver the exact required voltage under peak-load conditions before connecting expensive payloads, such as the Raspberry Pi 5.

Software & Control Testing: We utilize a phased testing pipeline, transitioning from dry-bench simulations at home to full in-water pool testing. We employ Hardware-in-the-Loop (HIL) simulations via QGroundControl to validate sensor-actuator synchronization before the vehicle ever touches the water.

Integration Testing & "Divide and Conquer": Before finalizing the ROV assembly, Atlantis strictly adheres to a "divide and conquer" methodology. Each major subsystem is isolated and validated independently before full-system integration to prevent cascading failures. For example, the entire propulsion network—including the custom PCB, ESCs, and T200 thrusters—was fully wired, powered, and stress-tested on a dry bench (**Figure 30**) before being permanently mounted inside the

watertight enclosure. This modular approach ensures component-level faults are identified and resolved before they are buried deep within the vehicle's internal structure.

5.2 Troubleshooting Protocol:

When post-integration anomalies occur, we execute a disciplined, domain-specific isolation protocol to pinpoint the root cause without dismantling the entire ROV:

- 1. **Identify & Isolate:** Immediately isolate the problematic module based on live telemetry.
- 2. **Domain Analysis:** Categorize the fault as mechanical, electrical, or software, and perform targeted variable elimination.
- 3. **Independent Verification:** Extract the faulty component, repair it, and re-validate it on a test bench before reintegration.

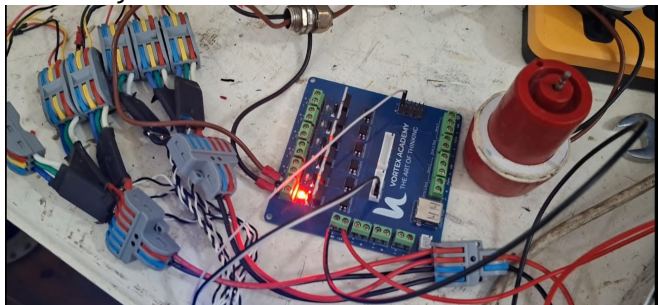


Figure 30: Propulsion and manipulators testing before creating the internal structure.

5.3 Practical Application:

Actual Failure Analysis: ESC Burnout During a maximum stress test in January, a T200 thruster suddenly stopped spinning. Following our domain-specific protocol, we initiated a fault tree: To demonstrate this protocol, if a T200 thruster fails to spin during a pre-deployment check, we systematically narrow the fault tree across all three domains:

- Step 1: Mechanical Isolation:** Inspect the physical interfaces to ensure the Cobalt Series bulkhead connector is fully seated and the cable glands are secure.
 - Step 2: Electrical Visuals:** Verify that the main power cables from the busbar and the ESC signal cables on the custom PCB are physically connected and undamaged.
 - Step 3: Multimeter Diagnostics:** Measure the circuit to confirm that 12V is reaching the ESC, that the PWM signal is present, and that the 3-phase output pins show proper continuity without internal shorts.
 - Step 4: Software Verification:** Check QGroundControl to ensure the specific ESC servo pins are correctly mapped to the thruster channel and that the thruster channel is receiving the active arming command.
- If it still fails, we extract the ESC from the ROV network entirely. We power it via a bench supply and drive it with an external

Arduino PWM signal. This definitive test proves whether the ESC hardware is dead or if a deeply hidden network conflict exists.

6.0 Budget & Cost Accounting

6.1 Financial Planning & Travel Budget:

To ensure absolute transparency and effective resource management, Atlantis developed a comprehensive 2026 budget baselined against historical costs from our previous ROV, *Kratos*. All departmental purchase requests are subject to a strict approval workflow evaluated by the company CFO and Vortex Academy mentors to guarantee necessity and cost-effectiveness. Furthermore, our finance team developed meticulous travel expense estimates to deploy a specialized 10-member operational team to the MATE World Championship in St. John's, Canada. We established a strict baseline travel budget of **\$28,328 USD**, which serves as our primary corporate fundraising target. This estimate covers international round-trip flights from Alexandria, Egypt (**\$10,420**), cost-effective residential lodging (**\$6,320**), local van rentals for ROV transport (**\$2,708**), visa processing, and team per diems. A fully itemized breakdown of these travel logistics is provided in Table 3 below.

Table 3: Travel Budget Breakdown:

Expense Category	Description	Qty	Unit Cost (USD)	Total Cost (USD)
Visas	Canadian Visa fees	10	\$148.00	\$1,480.00
Flight tickets	Round-trip airfare	10	\$1,042.00	\$10,420.00
Local Transportation	7-day passenger van rental for the team and ROV transport	2	\$1,354.00	\$2,708.00
	7-day residential house rental for 10 members	1	\$6,320.00	\$6,320.00
Per Diem / Stipend	Weekly pocket money and meal allowance	10	\$740.00	\$7,400.00
TOTAL TRAVEL BUDGET				\$28,328.00

6.2 Cashbook Accounting & Resource Management:

Atlantis utilizes a centralized Cashbook tracking system to log every project expenditure, ensuring real-time budget monitoring and financial accountability. To demonstrate sustainable resource management, our Cashbook strictly categorizes every item into one of three classifications: New (Purchased), Reused, or Donated. As detailed in our Build vs. Buy analysis (**Section 3.16**), our most effective use of funds was the strategic reuse of over 70% of *Kratos*'s hardware (including six T200 thrusters and the Pixhawk), which saved thousands of dollars. This allowed us to reallocate capital toward critical new purchases, such as the Raspberry Pi 5. All revenue streams, including team dues and corporate sponsorships, are fully acknowledged in our financial



ledgers. For in-kind donations (such as access to CAD software), we calculated a reasonable Fair Market Value (FMV) of **\$60.00** USD based on standard commercial rates.

2026 Financial Summary (USD)

To demonstrate effective resource management, our strict reuse of components allowed us to execute this project for a fraction of its total market value while maintaining a positive cash flow.

Project Costs & Savings:

Total Project Value (If built from scratch): \$5,519.80

Total Savings (Reused Parts + In-Kind Software): -\$2,532.00

Actual Cash Spent (Build + Logistics + Fees): \$2,987.80

Project Income & Net Result:

Total Cash Income (Self-Funds from Team): \$3,700.00

Net Cash Surplus: +\$712.20

A comprehensive breakdown of our Profit & Loss sheet, Fair Market Value estimates, and categorized component expenses is available in **Appendix G: Project Budget & Costing Sheets**.

7.0 References:

- [1] Blue Robotics, *T200 Thruster Technical Specifications*, 2025. [Online]. Available: <https://bluerobotics.com>
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8.0 Acknowledgements:

Atlantis extends our deepest gratitude to the MATE Center, MATE II, and AASTMT (Arab Academy for Science, Technology & Maritime Transport) for organizing this incredible platform and hosting our regional competition. We owe a special, profound

thanks to the Marine Technology Society (MTS) and the esteemed international sponsors of the MATE ROV competition. Without the visionary financial and operational support of MTS, the National Science Foundation (NSF), Fugro, the Innovators Support Fund (ISF), NTRA, and the dedicated judges and volunteers, the global advancement of student-led marine robotics would not be possible. We are honored to recognize their contributions below.



Our sincere appreciation also goes to Vortex Academy and our esteemed mentors for their unwavering technical guidance and moral support throughout the 2026 season. We are equally grateful to our families, friends, and the dedicated members of Atlantis for their steadfast encouragement.

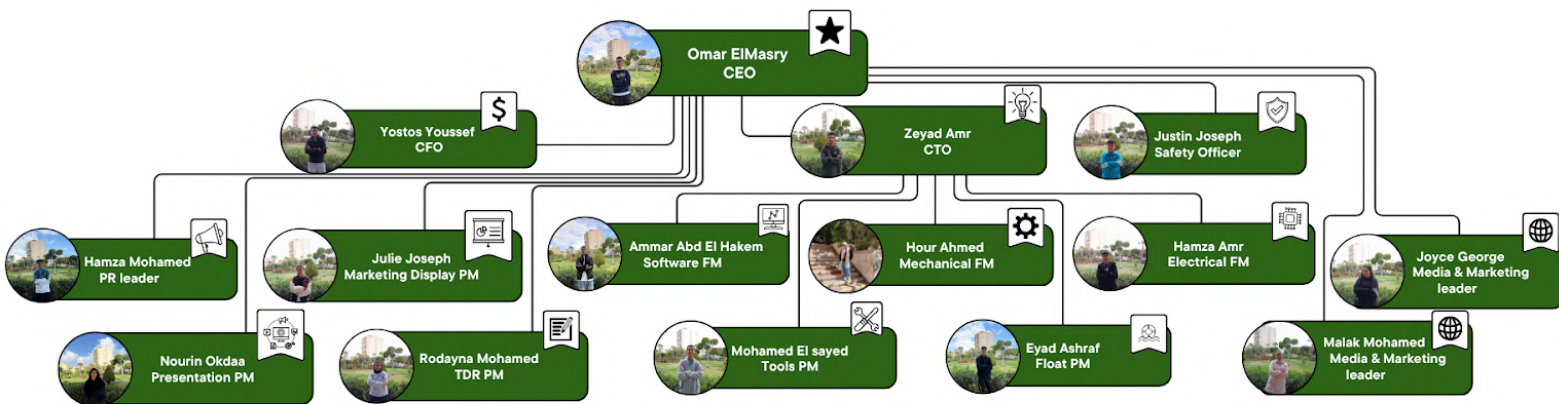


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Finally, we acknowledge the pivotal resources and corporate partners that made *Leviathon* a reality. We also thank our hardware and software enablers: Blue Robotics, the Raspberry Pi Foundation, and Pixhawk for their cutting-edge components; Google Colab for supplying the GPU compute power required to train our custom deep learning models; and SolidWorks, Ansys, Altium, GitHub, VS Code, and Adobe for providing the student licenses and platforms that fundamentally advanced our engineering capabilities.

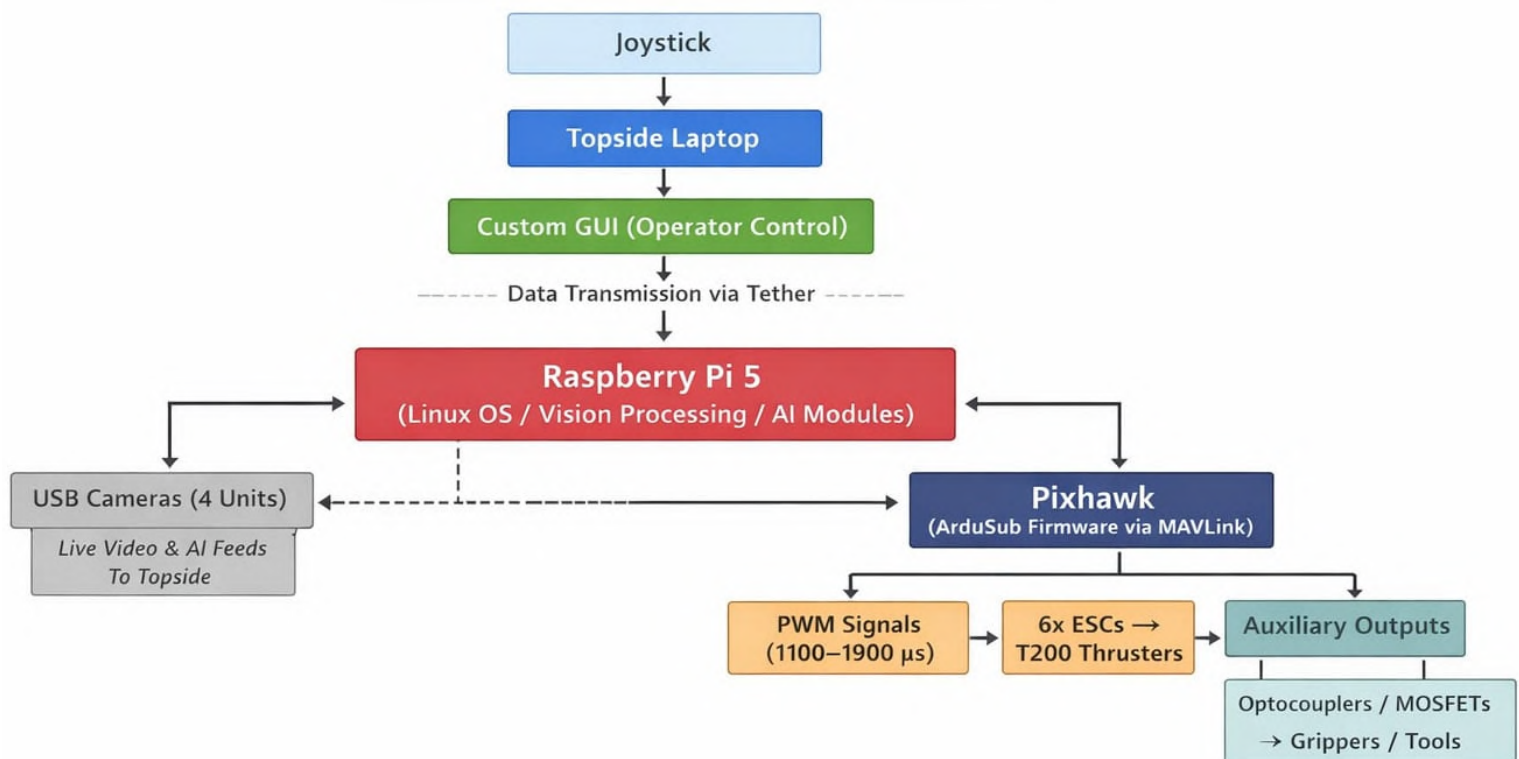
9.0 Appendices:

9.1 Appendix A (Hierarchy Chart)

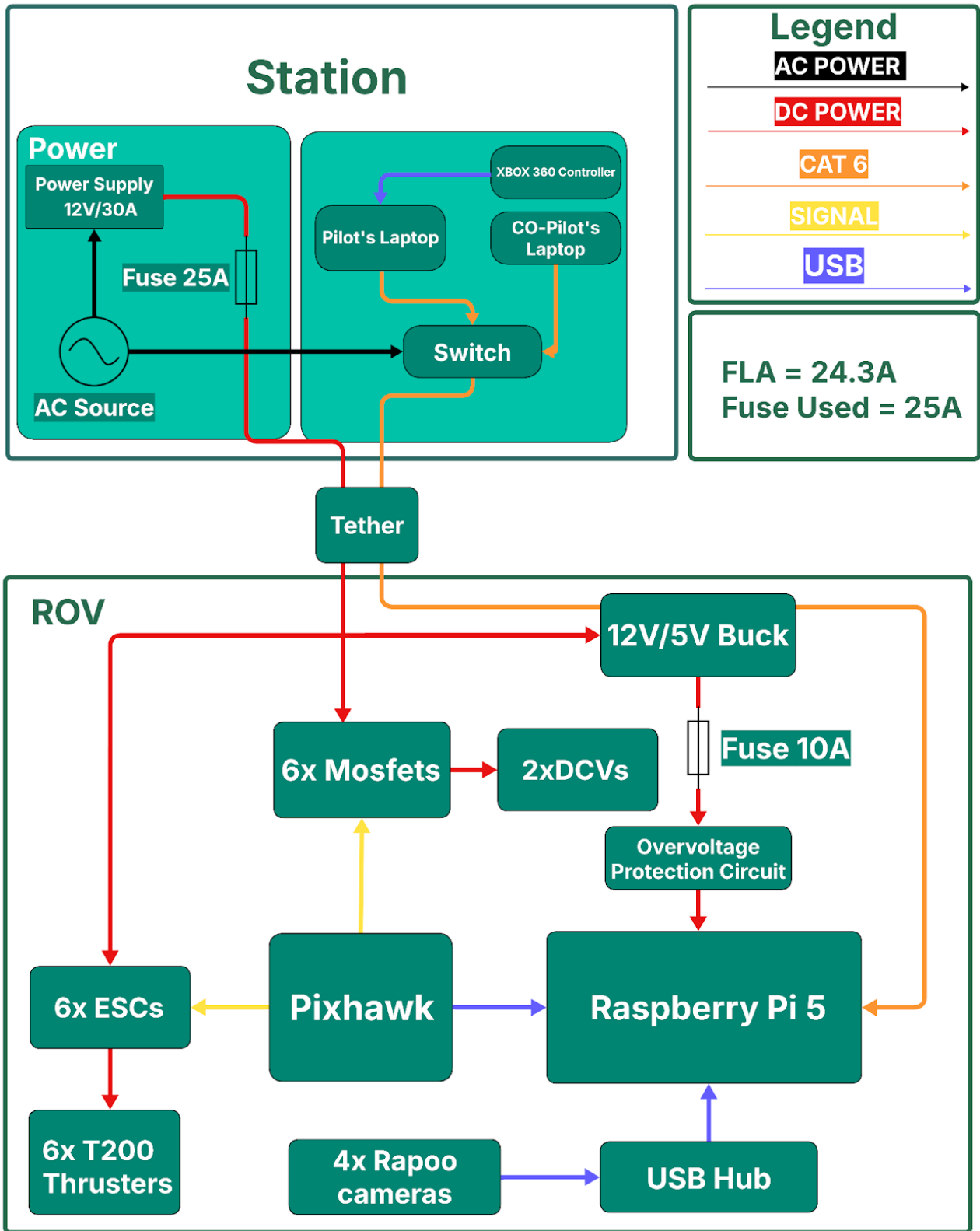


9.2 Appendix B (Software Flowchart)

Control System Data Flow Architecture

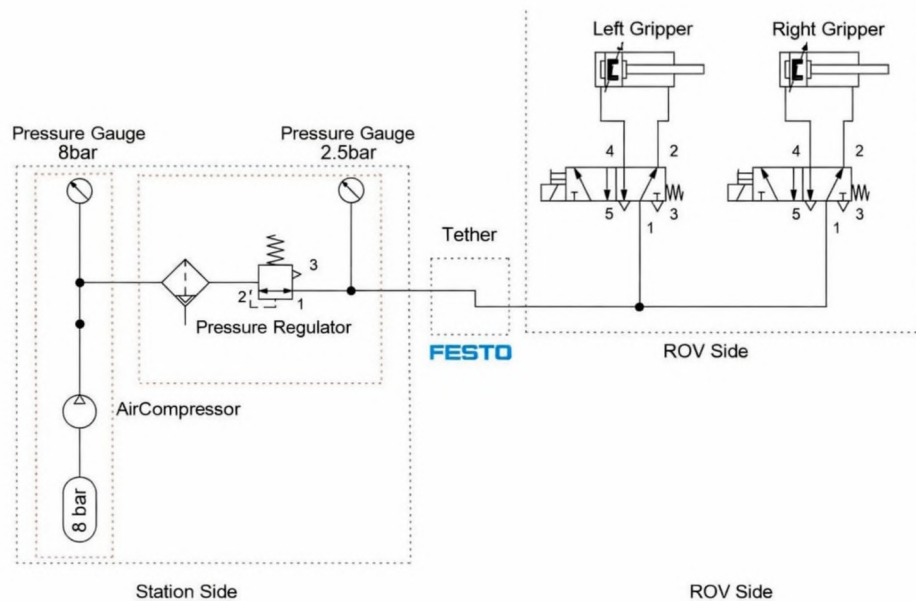


9.3 Appendix C (Leviathon SID)

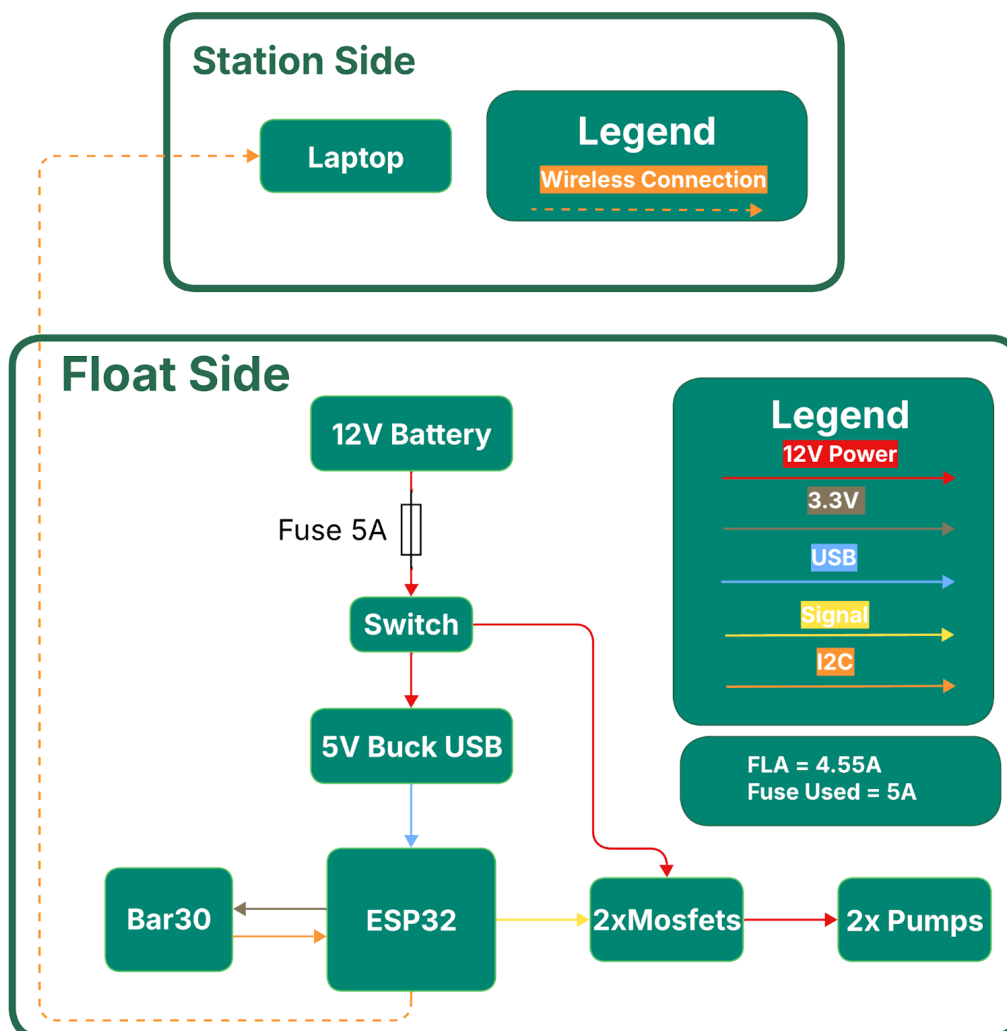




9.4 Appendix D (Pneumatic SID)



9.5 Appendix E (Float SID)





9.6 Appendix F (Safety Checklists)

Procedure	CheckMark
Pre-Power Checks	
Station members are wearing safety gear	
Check that Thrusters and Manipulators are not obstructed by anything	
No running at the pool	
Before conducting the safety check, power is turned off	
Make sure the fuse isn't blown.	
Clear obstructions from propellers, shafts, and manipulators.	
Electrical connections are waterproofed, and cables are tied down.	
Make sure the working environment is clear of obstructions	
"Safe" say it loudly.	
Pre-Water Checks	
Connect tether to the control panel	
Test the video system	
Compress the electronics enclosure to the called dive's rated depth.	
Check that compressor pressure is below 2.75 bars	
Lower the ROV into the pool by two team members and the tether man	
"In Water," say it loudly.	
In-Water Checks	
Check the warning lights after turning on the system.	
Verify that the internal pressure is steady at the surface.	
Check for air bubbles and look for leaks visually.	
"Pilot in Command," say it loudly.	
Communication breakdown	
Restart the ROV	
Send another test package.	
If there is no communication, turn off the ROV.	
Bring the ROV to the surface with the tether and inspect it for damage or leakage.	
Recovery Checks	
Make sure the ROV is at the surface and looking away from the pool wall.	
Turn off the system and say, "Crew in Command."	
Lift the ROV from the pool onto land by two crew members and a tether guy.	
Rearrange the tether neatly	
Safety Keeper Signature:	
ENTERING THE LAB OR WORKSHOP	
Wear the facemask and PPE provided by the company	
Sign and timestamp the Signing Sheet for Employees	
Operating Power tools	
Wear all PPE necessary for the tools	
Always keep your hands away from the tool's head	
Keep long hair tied back and spinning sections free of strings, ropes, and flexible fabrics/materials.	
Working with Electrical Components and Soldering.	
Use a solder fume extractor	
keep the soldering iron or hot air hand tool in its holder, When not in use.	
Check all electrical connections to ensure they are not in contact with liquids	
Employee Signature:	





9.7 Appendix G (Budget Sheet)

Category	Type	Description	Projected Cost	Cash Spent
Income	Cash	Self-Funds from Team Members	\$3,700.00	+ \$3,700.00
	Donation	SolidWorks Student Edition License (FMV)	\$60.00	\$0.00
Operations & Logistics	Purchased	Internal Logistics & Training Villa	\$930.00	\$930.00
	Purchased	Regional Registration Fee (9,000 EGP)	\$187.50	\$187.50
	Purchased	International Registration Fee	\$270.00	\$270.00
Tether	Purchased	Power Cable (30 Meters)	\$45.30	\$45.30
	Re-used	Pneumatic Cables (32 Meters)	\$22.30	\$0.00
	Re-used	Cat 6 (30 Meters)	\$45.60	\$0.00
	Re-used	Anderson Connector	\$19.00	\$0.00
Electronics	Purchased	ESCs (6 Units)	\$240.00	\$240.00
	Purchased	Main PCB	\$62.50	\$62.50
	Re-used	Raspberry Pi 5	\$104.00	\$0.00
	Re-used	Pixhawk	\$193.00	\$0.00
	Purchased	Rapoo Cams (4 Units)	\$80.00	\$80.00
	Purchased	Buck Converter	\$4.00	\$4.00
	Re-used	Bilge Pump	\$60.00	\$0.00
	Re-used	Power Supply 30A	\$82.00	\$0.00
	Purchased	Bar30 Pressure Sensor	\$85.00	\$85.00
	Re-used	Materials & Fabrication	\$63.50	\$0.00
Float Engine	Re-used	ESP32	\$11.60	\$0.00
	Purchased	Pumps (2 Units)	\$12.00	\$12.00
	Purchased	Bar30 Pressure Sensor	\$85.00	\$85.00
	Purchased	PCB	\$33.30	\$33.30
	Purchased	Batteries	\$52.00	\$52.00
Hardware	Re-used	Main Enclosure Material (PMMA & PA type 6)	\$190.00	\$0.00
	Re-used	Camera Box (Face Seal)	\$80.00	\$0.00
	Re-used	Camera Box (Piston Seal)	\$35.00	\$0.00
	Purchased	Grippers Material (PMMA)	\$41.00	\$41.00
	Purchased	Grippers Manufacturing (Laser-Cutting)	\$29.00	\$29.00
	Purchased	Aluminum Extrusion	\$112.00	\$112.00
	Re-used	Agro Glands (22 Units)	\$100.00	\$0.00
	Purchased	O-Rings	\$5.60	\$5.60
	Re-used	DCVs (2 Units)	\$51.00	\$0.00
	Re-used	Pneumatic Piston, fittings	\$90.00	\$0.00
	Purchased	Bolts & Nuts	\$70.00	\$70.00
	Purchased	3D Printed Parts	\$152.00	\$152.00
	Re-used	T200 Motors (6 Units)	\$1,200.00	\$0.00
	Re-used	Compressor	\$135.00	\$0.00
Customs	Purchased	Customs & Shipping for Imported Items	\$465.00	\$465.00
		Total Savings (Reused Parts)	-\$2,532.00	
		Total Cash Income (Self-Funds)		\$3,700.00
		Total Cash Spent (Build + Logistics + Fees)		-\$2,987.80
		NET CASH SURPLUS		+\$712.20

