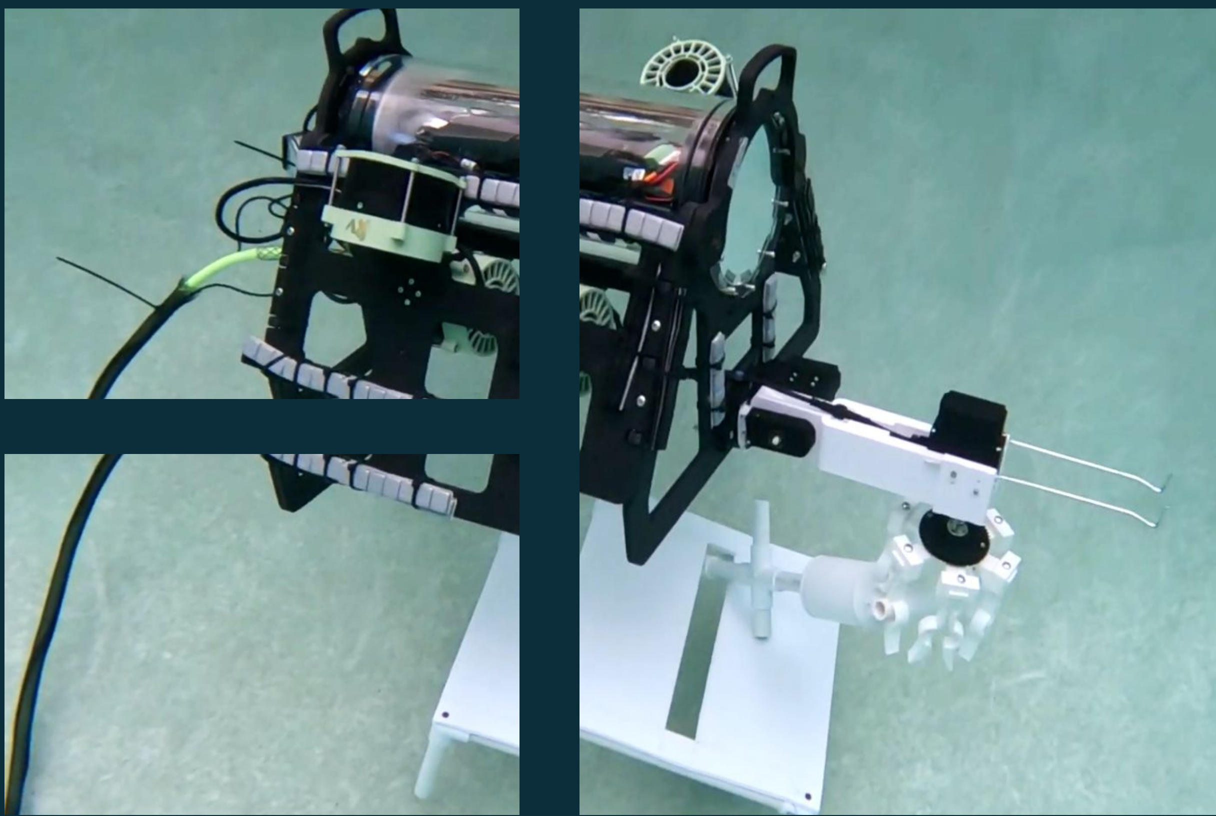
OCTOBOTS 25’ TECHNICAL REPORT

PASADENA, CA, USA



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Abstract

The Great Lakes have one of the highest concentrations of shipwrecks in the world. Since the sinking of Le Griffon in 1679, thousands of vessels have been lost, prompting the creation of the Thunder Bay National Marine Sanctuary to protect nearly 100 historic wrecks off the Michigan coast. Many remain unidentified or undocumented, and new discoveries are still possible. In response to the MATE Request for Proposals (RFP), the Pasadena City College Octobots developed a Remotely Operated Vehicle (ROV) to support historical preservation, scientific monitoring, and renewable energy maintenance in the Lake Huron region.

Fig. 1 Team's photo

Designed for use in both freshwater and saltwater environments, the ROV features a modular HDPE frame, corrosion-resistant components, and a tethered control system for low-visibility navigation. It is equipped with dual cameras and a precision claw to inspect and recover shipwreck artifacts, service SMART buoys, and deploy floats. Additional tools allow for collecting water samples to test for acidification and invasive species, replacing sacrificial anodes to prevent corrosion, placing hydrophones, and collecting biological samples like fish and medusa. Real-time data logging and onboard leak detection improve safety and reliability. The Octobots comprise 16 student engineers including first-generation college students and international scholars, bringing diverse perspectives and technical skills to the design process. Their ROV meets the RFP's core goals while promoting environmental stewardship, technical innovation, and preservation efforts across both inland and ocean waters.

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TEAMWORK

PROJECT MANAGEMENT

Now known as the Octobots, the 2024–2025 team carries forward this legacy with a renewed vision, structured collaboration, and a drive for sustainable engineering. The Octobots consist of 16 students from diverse cultural and academic backgrounds, multiple age groups, and international students from around the globe.

Development follows a semester-based timeline. The fall quarter is devoted to recruitment, training, and initial design. Winter is focused on prototyping and manufacturing. Spring is used for assembly, testing, and documentation.

The team holds structured meetings every Friday and Saturday afternoon. Fridays serve as hands-on build and testing days. During these sessions, subsystems come together for integration, troubleshooting, and mission simulations. These working labs allow departments to collaborate in real time. Saturdays are reserved for planning, updates, and cross-department coordination. Each department lead shares current status, discusses upcoming integration needs, and identifies any blockers.

The Octobots rely on a collection of digital tools that streamline communication, documentation, and collaboration. Discord serves as the team's primary communication hub where topics and resources are discussed in labeled channels. Notion is used to manage tasks, track weekly goals, log meeting notes, and centralize reference materials. For version control and technical documentation, the team utilizes GitHub to manage software code and ensure collaborative development without conflicts. Google Drive houses all design files, schematics, budget sheets, and administrative records in a well-organized, easily accessible format.

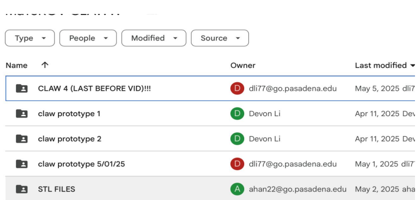


Fig 2. Claw's Google Drive

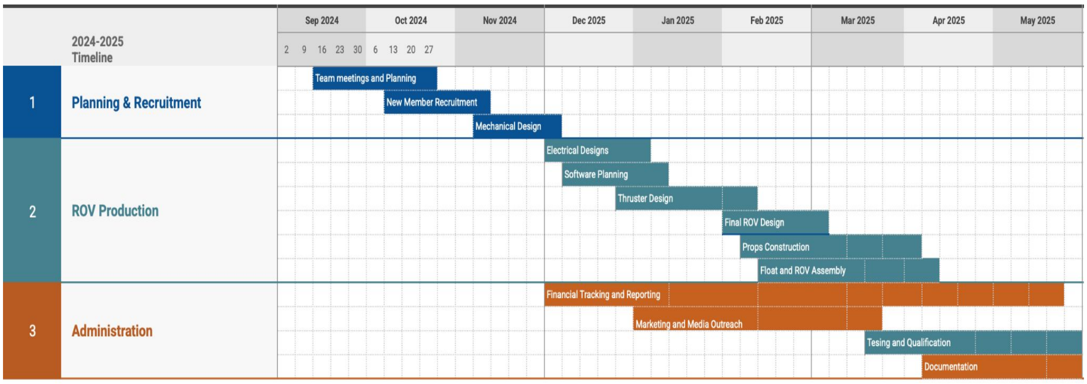


Fig 1. 2024-2025 Timeline

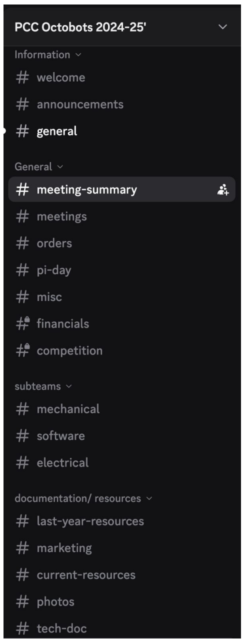


Fig 3. Team's Discord Channel

TEAMWORK

The Octobots consist of sixteen students specializing in several different technical groups . The team is organized into four key departments: Mechanical, Electrical, Software, and Administrative. Each department operates under a designated lead and functions semi-independently while maintaining close coordination with the broader team to ensure cohesive integration of subsystems.

The Mechanical Department is responsible for the structural and functional design of the ROV. From the HDPE chassis and thruster mounts to the manipulator claw and flotation systems, this team focuses on producing a durable, hydrodynamic vehicle. Members use CAD modeling, 3D printing, and hands-on prototyping to iterate designs and conduct real-world testing in simulated underwater environments.

The Electrical Department handles the internal circuitry and power systems. This includes managing our power distribution, integrating sensors, and ensuring waterproofing and safety in high-moisture environments.

Collaboration and communication with mechanical and software teams is essential for system-wide compatibility and real-time responsiveness.

The Software Department is responsible for programming the control system, and sensor data visualization. This team develops code that allows for precise navigation and manipulation. The custom software integrates multiple cameras, motor controllers, and a user-friendly dashboard that provides real-time feedback during missions.

Supporting all technical teams is the Administrative Department, which ensures the sustainability and visibility of the project. The administrative team ensures communication and manages budgeting, resource acquisition, documentation, and marketing. By maintaining clear communication channels, creating a solid timeline, organizing schedules, and representing the team to external stakeholders, this department is essential to keeping the project aligned with both deadline and competition requirements.

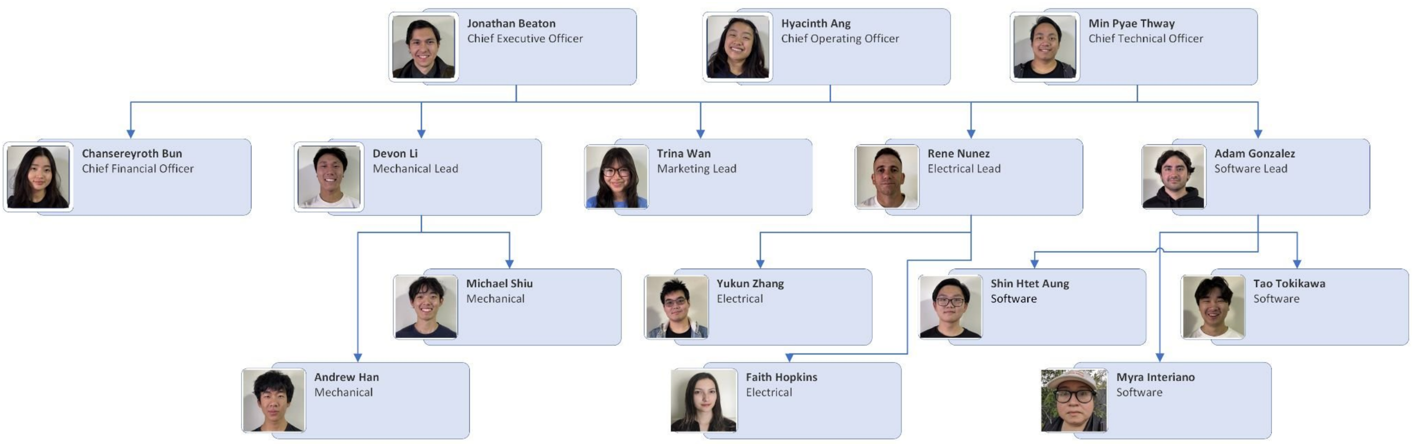


Fig 4: Team's Organization Diagram

VEHICLE DESIGN

Vehicle Design Rationale

The Octobots' ROV was developed through a structured and iterative design process, guided by performance requirements outlined in the MATE ROV 2025 competition and informed by lessons learned from previous team builds. From the outset, the team adopted a systems-level design philosophy—prioritizing integration, modularity, and mission adaptability across mechanical, electrical, and software domains.

Design Process

The team initiated the planning phase by evaluating legacy platforms—specifically the 2023 Hydra ROV—highlighting areas for improvement such as mobility, camera visibility, buoyancy control, and mechanical dexterity. Drawing inspiration from successful Eagle Ray-style layouts and MATE Barracuda kits, the team opted to retain proven structural elements while reengineering critical subsystems.

Initial brainstorming was conducted in cross-departmental design sprints, where each department (mechanical, electrical, software, and administrative) proposed solutions to fulfill this year's task list. Ideas were sketched, simulated in CAD, and evaluated based on feasibility, material cost, complexity, and integration potential. Using a trade study matrix, the team compared different frame geometries (PVC vs HDPE), actuator configurations (single vs dual claw degrees of freedom), and ballast concepts (dynamic vs static).

Key selection criteria included neutral buoyancy balance, frame durability, weight distribution, and adaptability to tool payloads.

Frame Design

After comparative analysis, the team selected ½-inch high-density polyethylene (HDPE) for the frame due to its corrosion resistance, machinability, and near-neutral buoyancy in freshwater environments like Lake Huron. The HDPE's density allowed the ROV to require minimal ballast, improving energy efficiency and reducing weight overhead. The frame was precision-cut using CNC machining, and designed with rounded edges to enhance safety and ergonomics.

To ensure structural integrity while maintaining modularity, frame components were standardized and bolted together, allowing quick disassembly for maintenance and transport. Hollow structural members provided internal routing paths for wires and tethers, keeping components streamlined and protected.

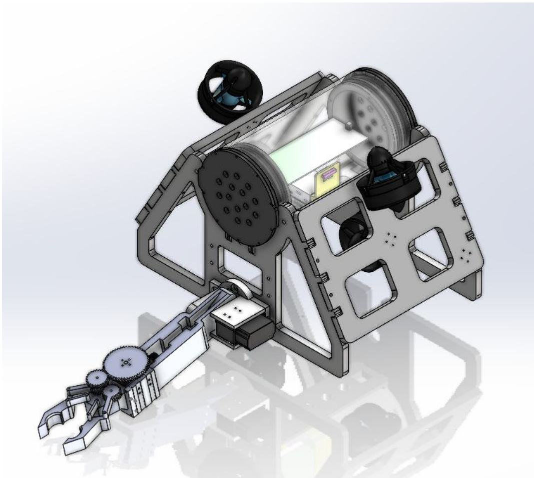


Fig 5: ROV's CAD Design

VEHICLE SYSTEM

Integrated System and Trades-offs

A key trade-off decision was the placement of thrusters and ballast. By positioning vertical thrusters closer to the ROV's center of mass and horizontal thrusters at the lower corners, the team achieved stable ascent/descent behavior while minimizing torque-induced drift. The ballast container was engineered to sit directly beneath the ROV's geometric center to align mass and buoyancy. This container also featured segmentable compartments for redistributing weight when additional tools, like the claw or float, altered balance during missions.

The claw design integrated waterproof servos enclosed in Blue Robotics casings, offering two degrees of motion: open/close and vertical articulation.

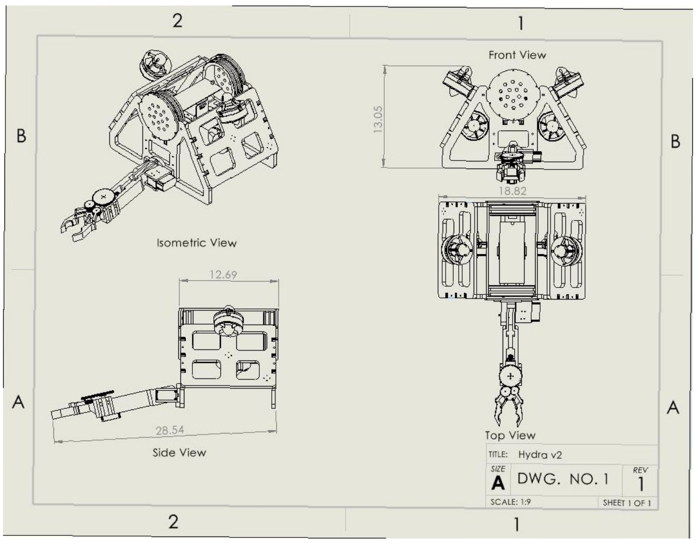


Fig 6: ROV Technical Drawing (Orthographic & Isometric Views)

The team experimented with various pincer geometries and selected an angled design lined with rubber tape to grip both rigid and smooth surfaces, such as PVC pipes and tent pins. This enabled precise manipulation without damaging mission props.

Build vs. Buy, New vs. Used

To maintain the balance between structural integrity and ease of access for maintenance, the frame continues to use a bolted modular construction. This allows for rapid assembly and disassembly during testing and repair. Placement of thrusters and ballast was re-evaluated to accommodate new tool attachments without compromising stability. All modifications were prototyped in CAD and validated through dry-assembly trials prior to implementation.

The decision to reuse the frame reflects a thoughtful trade-off between development time and mission performance. It allowed the team to focus engineering effort on payload tools, sensor systems, and control logic—areas most critical to mission scoring—while retaining a structurally proven and field-tested platform.

ELECTRICAL SYSTEM

The ROV's electrical system is centered around an Arduino Mega 2560 microcontroller, which provides digital control for all thrusters and servos. This microcontroller is mounted on a main PCB developed by SeaMATE for the Eagle Ray System. The board is responsible for managing control signals and distributing power to peripheral components such as servos, cameras, and sensors.

Power to the ROV is supplied through a 48V DC source, which is delivered via a 10-meter tether. Since the thruster motors operate strictly at 12V, the system includes two daughter boards (shown in Figure 5) to perform voltage step-down from 48V to 12V DC. Each daughter board is configured to handle two thrusters, ensuring balanced and efficient power distribution.

The SeaMATE Eagle Ray main board (shown in Figure 6) is a purpose-built PCB that supports integration of the Arduino Mega 2560, simplifying electrical layout and improving system reliability. This board includes dedicated ports for motor controllers, sensors, and DC-DC converters. Its standardized design reduces wiring complexity and minimizes failure points.

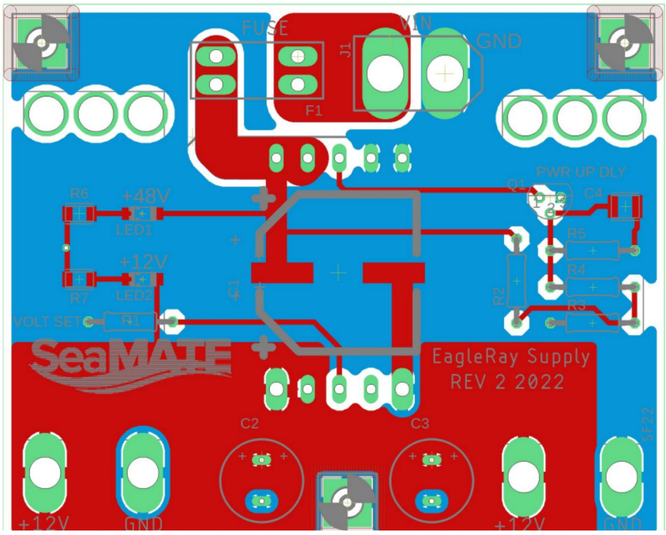
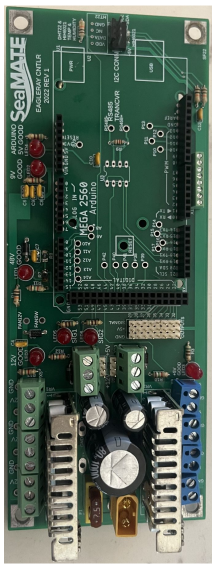


Fig 7: Thruster PCB Layout

Power input, signal routing, and grounding are clearly separated on the board to minimize electrical noise and improve safety.

The board layout was optimized for clear trace routing and heat dissipation, with critical power and control lines isolated for improved performance. The use of a pre-designed and tested SeaMATE board allowed the team to focus on ROV integration and software control, while still benefiting from a compact and robust electrical backbone.



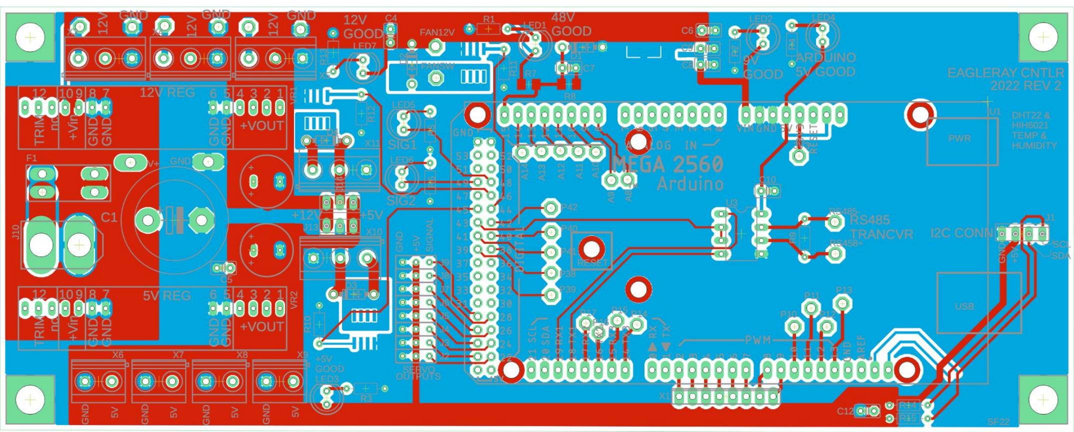


Fig 8: Main Board PCB Layout (left) and actuarial (right)

ELECTRICAL SYSTEM

Tether

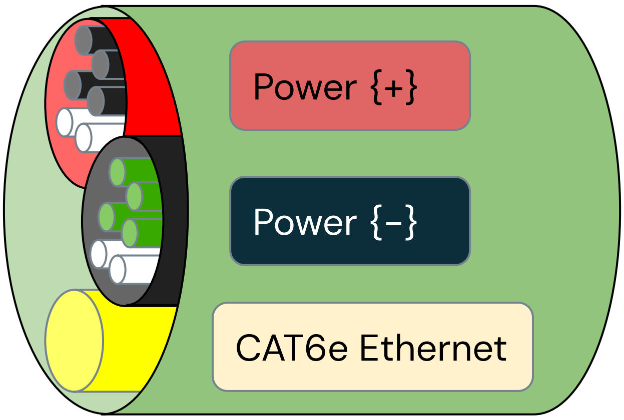


Fig 9: Tether Cross Session

The ROV tether is a 50-foot cable that delivers 48V DC power and data between the surface control station and the vehicle. It contains 12 conductors (12–20 AWG), arranged with 4 black and 2 white wires for power (+), and 4 green and 2 white wires for ground (–). The tether includes two shielded CAT6e Ethernet cables—one built into the main cable insulation and another housed within the braided outer sheath—to ensure reliable, low-interference data transmission. A durable, abrasion-resistant sleeve protects the entire assembly, and built-in strain relief at connection points helps prevent mechanical stress and damage during deployment and retrieval.

Tether Safety and Handling

- **Inspect** the tether before deployment for damage and secure connections.
- **Deploy** carefully to avoid tangles and ensure steady communication.
- **Monitor** tether tension throughout the mission to avoid overloading.
- **Adjust** length and routing dynamically based on vehicle movement.
- **Retrieve** methodically to prevent twisting.
- **Check** the tether post-mission for wear or damage.

Canister

The central electronics canister is constructed from a clear acrylic pressure tube sealed with O-rings and penetrators to ensure waterproofing. All critical electrical components, including the main control board, converters, and ESCs, are securely mounted inside this canister. The clear body allows internal visibility, while an internal camera faces forward to monitor the front of the ROV during operation.

Wiring within the canister was optimized for clarity and serviceability. Unlike previous designs that used stiff, bulky wires, this year's build utilizes flexible, labeled wiring to improve visibility and ease of adjustment. Components are spaced to avoid overheating, and high-voltage and signal lines are routed separately to reduce noise and interference. The modular card cage system allows for quick access and streamlined maintenance of the entire electrical stack.

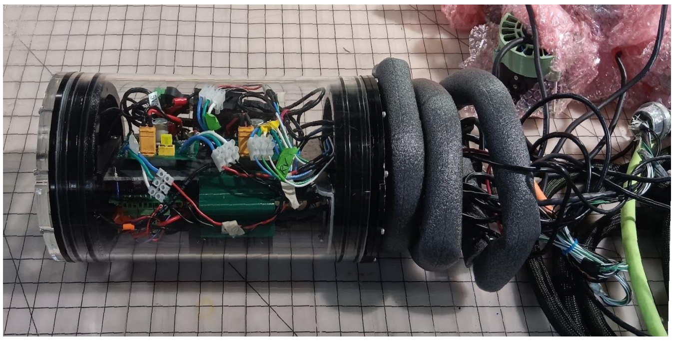


Fig 10: The Canister

CONTROL SYSTEM

The Octobots' ROV control system consists of a two-part architecture: a Surface Station for operator input and feedback, and an Embedded System for direct control of actuators and sensors. Communication between these systems occurs over a 115200 bps USB serial link sending raw binary commands to the arduino from our laptop.

Surface Station and Embedded System

At the Surface Station, a C++ based graphical user interface (GUI) captures joystick and slider inputs. These inputs are processed into command dictionaries, converted into raw binary, and sent via USB to the onboard microcontroller. The GUI also receives telemetry, displaying sensor feedback (temperature, voltage, PWM status) in real time.

The embedded controller, based on the Arduino Mega 2560, receives and parses incoming bits. It converts command values into precise PWM signals using [servo.writeMicroseconds()] to drive the thrusters and claw.

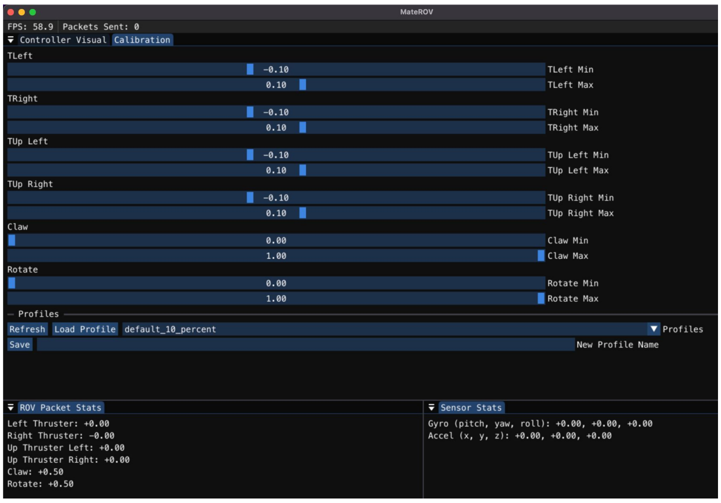


Fig. 11: Controller Visual Calibration Code

Float System

For sensor logging, the float system now employs a depth-triggered logging mechanism. Previously controlled by a static timer, it now relies on sensor input to log data only when the float reaches a specified depth, ensuring measurement accuracy and relevance for mission data collection.
For Task 1.3, the team integrated a computer vision model to analyze underwater footage for identifying the spread of invasive carp species. This model enhances the ROV's data collection capabilities and demonstrates the adaptability of the system to ecological applications.

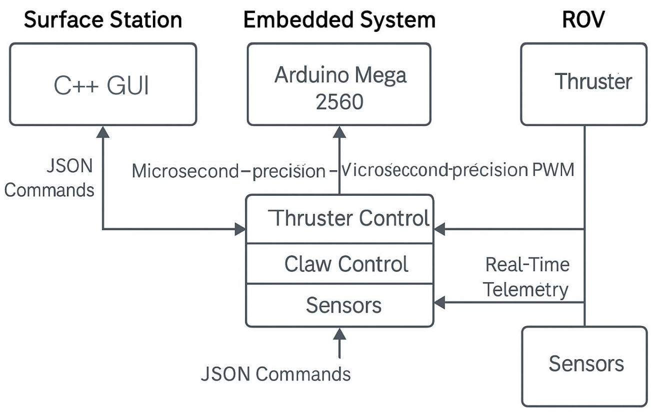


Fig. 12 ROV's summarized Control System

Optimization

To improve responsiveness, key portions of the client interface and firmware were rewritten in C++, reducing latency and improving serial communication efficiency. The system is also fully PlayStation controller compatible, offering ergonomic, intuitive control for pilots.

BUOYANCY AND BALLAST

The Octobots' ROV implements a carefully engineered buoyancy and ballast system designed to maintain neutral buoyancy, improve maneuverability, and support specific mission tasks such as anode rotation and object retrieval. Our design process began with the principle that the ROV should maintain a stable equilibrium in water, where the buoyant force equals the vehicle's weight, ensuring neutral buoyancy without excessive reliance on vertical thruster power.

To achieve this, we first identified the geometric center of the ROV and designed the chassis so that the center of mass aligned with this point, reducing unintended tilting or rotation. A custom 3D-printed ballast container was mounted directly beneath this point, allowing weight adjustments to be made precisely at the core of the ROV's frame. Through iterative testing and temporary ballast trials (e.g., with fishing weights), we determined that approximately 1.6 kg of ballast was needed to bring the vehicle into neutral buoyancy.

Our ballast system also addresses asymmetric buoyancy introduced by unevenly distributed payloads, such as cameras and the claw mounted on opposite sides of the vehicle. To compensate, the ballast container is sectioned internally, allowing steel wheel weight strips to be positioned selectively to counteract any imbalance. This adaptability ensures horizontal trim and smooth motion across all axes.

Furthermore, we incorporated buoyancy control principles when selecting materials for both the frame and tools. For example, HDPE was chosen for its naturally buoyant but lightweight properties, and all penetrators and housings were sealed to prevent water ingress, maintaining internal air volume critical to buoyancy stability.

The system also serves a secondary mechanical function related to Task 2's anode rotation challenge. Hooks were mounted on the underside of the ballast container, enabling the ROV to approach, lift, rotate, and detach the anode using pivot-based movement around its stable center of mass. This multifunctional use of the ballast area allowed the team to reduce structural complexity and weight while enhancing task performance.

Vertical maneuverability is assisted by two upward-facing thrusters placed near the upper sides of the ROV and close to the center of mass. This positioning allows for stable ascents and descents with minimal torque and drag. Complementary horizontal thrusters mounted lower on the frame facilitate efficient forward/backward motion and yaw control, benefiting from the neutral balance provided by the ballast system.

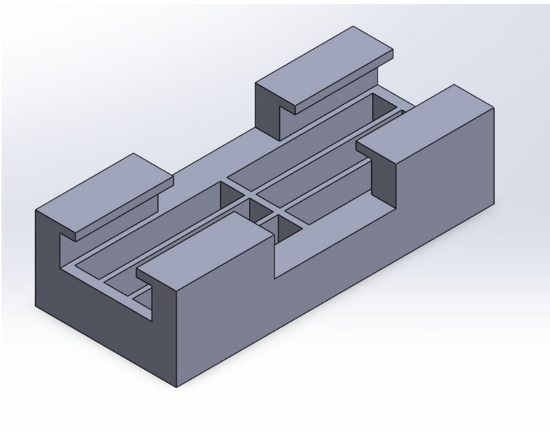


Fig. 13: ROV's Ballast CAD design

PROPULSION

Thruster Specifications

Our ROV uses four Blue Robotics T200 Thrusters for propulsion. Each T200 Thruster alone can provide up to 6.4 lbf, more than enough to move the ROV. This level of speed and acceleration will ensure the ROV is not sent off course by any stray sea current. Furthermore, each thruster only requires 12V to achieve said maximum thrust, so the required power can be conveniently delivered by a step-down voltage converter. They are also rated for up to 200m of depth, making them nearly indestructible for our purposes. Their simple mounting system of 4 M3 tapped holes allow for versatility and customizability. However, we still decided to add custom 3D printed thruster guards. We believe that our ROV should be suitable for deployment in any benthic environment, which requires tighter gaps.

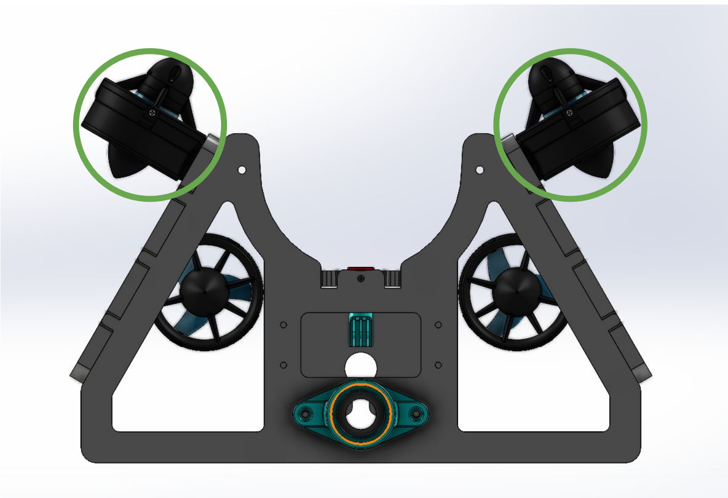


Fig 14: Side - Mounted Thrusters

Thruster Configuration

Our 4-thruster configuration is based on a trapezoidal frontal cross-section. The first two thrusters are mounted inward onto the side plate. They face forward, enabling the ROV to move forward and backward. The two thrusters are also aligned with the ROV's center of mass. This allows for seamless pivoting of the ROV by powering one thruster forward and one thruster backward. It also has the potential to turn as well.

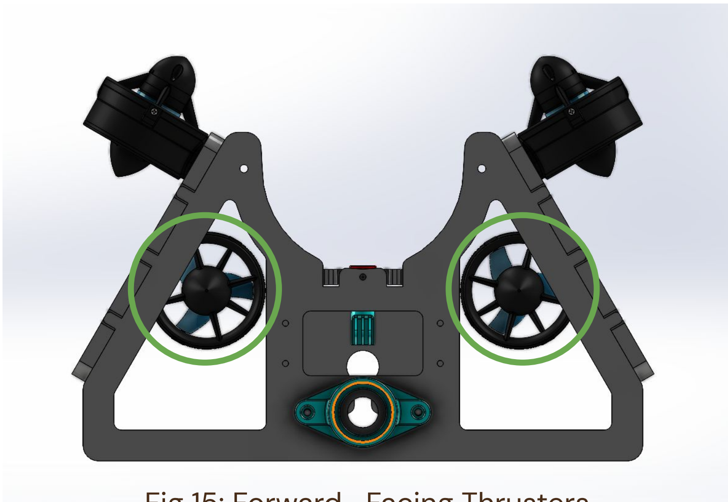


Fig 15: Forward- Facing Thrusters

The two other thrusters are positioned at the top of the trapezoidal frame. This allows the ROV to go up and down due to the fact that both thrusters sit at the same opposing angle, allowing their y-vectors to be cancelled out when giving both thrusters the same amount of throttle and power. The angle that the thrusters are at also enables the ROV to yaw with slight modifications to the position of the thrusters or ballast system.

PAYLOAD AND TOOLS

Manipulator (Claw)

The Octobots' claw was custom-designed to meet the specific demands of the 2025 MATE ROV mission, including object retrieval, pin pulling. The claw was engineered with one degree of freedom: vertical movement (up/down) and precise actuation for opening and closing.

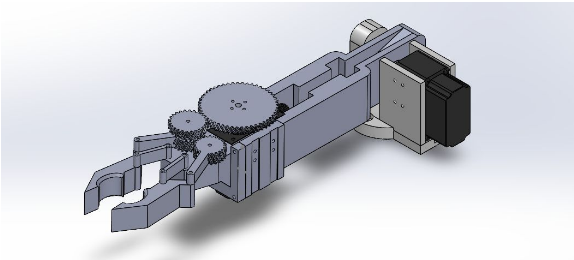


Fig 16: CAD Assembly for Claw Components

The two servos within the claw are different to best accommodate for their functional purpose. For claw actuation, we used a GoBilda servo enclosed within Blue Robotics waterproof casings to ensure durability and reliable underwater performance. Due to the higher stress from the weight of the claw, we used ECOPOWER WP120T High-torque servos, to control vertical movement. The pincer servo operates using a low-torque gear ratio, enabling swift control for grasping small objects and props underwater, which don't need a high torque grip to complete tasks in the current environment.

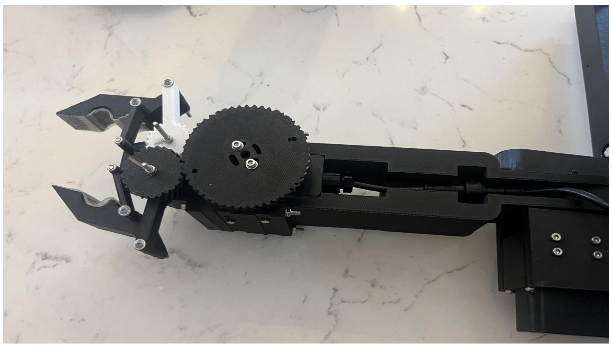


Fig 17: Fully- Assembled Claw Components

The claw also features angled pincers with flat grip surfaces and oval channels, specifically designed to easily grip the most common cylindrical PVC surfaces, while maintaining versatility to grab other surfaces such as tent pins as needed in one of the tasks. To enhance grip and minimize slippage, the inner surfaces of the pincers are lined with rubber grip tape. This ensures strong, stable contact with both soft and rigid materials, supporting a wide range of mission tasks that involve picking, placing, or retrieving items from complex underwater environments.

Camera

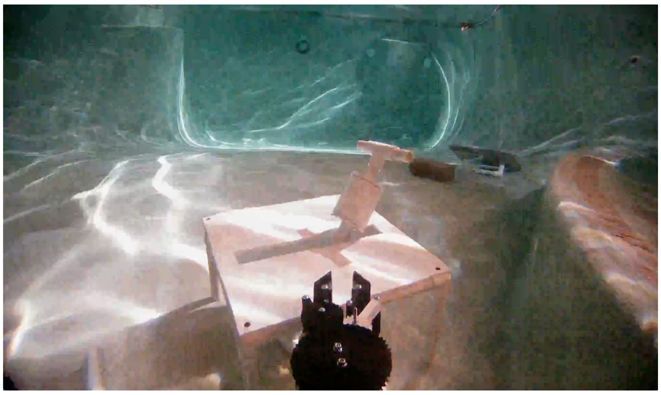


Fig 18: Front Camera POV

The Octobots ROV is equipped with two strategically placed cameras, chosen to maximize visibility and control without overcomplicating the pilot interface. The first camera is mounted directly above the manipulator claw. Its purpose is to provide the pilot with a clear, top-down view during delicate object manipulation tasks. This camera enables precise coordination of claw positioning, especially when working with small, irregularly shaped, or partially obscured mission props.

PAYLOAD AND TOOLS

The second camera is mounted on an adjustable arm attached to the main ROV frame and housed in a waterproof GoPro case. This camera provides a broader field of view for environmental navigation and situational awareness.

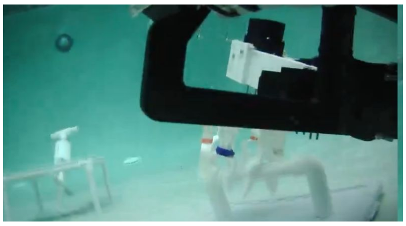


Fig 19: Second Camera Underwater POV

This is especially important to allow visibility to tools that work underneath the frame of the ROV such as when the claw faces down outside of the reach of the main camera. Its main purpose however serves to guide the hook system attached to the bottom of the frame, giving the pilot the visibility it properly needs to secure objects in an otherwise blind spot. Exact positioning was determined through iterative testing to ensure minimal obstruction from tether lines or structural components. The dual-camera setup enables both close-quarters manipulation and wide-angle navigation, allowing the pilot to maintain full spatial awareness during all stages of a mission.

Fig 20: Second Camera

To enhance post-mission analysis and mapping, the camera system is integrated with PTGui, a panoramic stitching software that combines multiple camera angles into wide-field visuals.

Hook mounts

The Hook system is attached to the ballast cage on the bottom of the ROV, to allow further rotational freedom to certain tasks where the 1 axis claw may not be sufficient. Due to constraints of the current thruster configuration, crabbing is not possible, making free rotation of an object about an axis difficult with use of the claw. However, by placing the hook system at the center of mass of the ROV, we can achieve the desired rotational freedom to complete tasks by instead attaching to objects by use of the hooks, and rotating the entire ROV itself. This tool was built to rotate an anode back and forth 90 degrees from a stationary position. The entire part was 3D printed using PLA filament and assembled from multiple parts.

Anode gripper

In the case that both the claw, and the hook system are having difficulty with completing the anode task, this specific payload was designed to attach to the rotational servo that controls claw grip. While this gripper does make the specific anode task easier to complete, Its usage became somewhat obsolete after further prototypes of both hook and claw systems were completed.

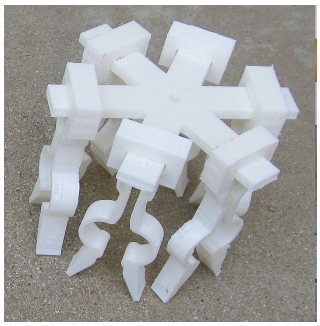


Fig 21: Anode Gripper

SAFETY

Philosophy

At Octobots, safety is not just a requirement—it is a core principle that informs every stage of our engineering process. We recognize that a safe working environment protects not only individual team members but also the integrity of our equipment and the success of our mission. We follow MATE safety regulations alongside internal protocols designed to promote accountability, preparedness, and situational awareness in both workshop and testing environments. Proper handling of tools, materials, and power systems is emphasized in all procedures, and first aid kits and fire extinguishers are maintained in easily accessible locations at all times.

Standards

The Octobots follow comprehensive safety standards that align with MATE competition guidelines. Before gaining access to the lab space or participating in system testing, all team members must complete a safety orientation that includes proper PPE usage, equipment handling procedures, and workspace expectations. Specific protocols are in place for soldering, chemical use, and mechanical machining. Additionally, each subteam—Mechanical, Electrical, and Software—conducts internal checks prior to integration to ensure all components meet safety and operational standards

During construction and testing phases, we utilize the safety checklist (See Appendix A) to minimize risk. A one-hand rule is enforced during electrical work, and sharp edges on fabricated components are filed and anodized where necessary to reduce injury risk. All high-voltage and underwater-exposed systems are protected with fuses, proper strain reliefs, and weatherproofed or waterproofed enclosures.

Features

Our 2025 ROV includes multiple embedded safety features. Electrical connectors are equipped with fuses and protective housings, while thruster ducts prevent foreign object intrusion and reduce risk to operators. Cameras and sensitive electronics are isolated within sealed housings using O-rings, and diagnostic data such as temperature and power usage is actively monitored through the control interface. In case of emergency, the pilot is able to shut down all active systems from the topside unit.

Together, these standards and systems reflect our commitment to engineering excellence and safe operation. Safety is not a final step in our process—it is a continuous practice embedded in the way we design, build, and operate.

CRITICAL ANALYSIS

Testing Methodology

Testing began with a rigorous inspection of inherited systems from the previous year's team. The primary focus was the ROV's power system, which included AC-to-DC and DC-to-DC modules. These components were tested under full operational load, confirming consistent voltage output and thermal stability with no signs of overheating or performance degradation.

The main control PCB, assembled from the original ROV kit by the previous team, includes 20 signal interfaces and regulated 12V and 5V outputs. Testing under load confirmed stable voltage, reliable signal performance, and no thermal issues. As a result, the board was approved for continued use without modification, saving time and resources while maintaining flexibility through available expansion headers.

Propulsion systems, including four thrusters, the original ESC, and the power distribution board, were tested in both dry and submerged environments. These tests verified consistent response to input commands, no current surges, and stable thermal behavior, confirming their capacity to meet the demands of competition tasks.

Troubleshooting

To diagnose and resolve performance inconsistencies, the team used a layered troubleshooting model: isolate, verify, and iterate. Electrical troubleshooting was carried out using multimeters, oscilloscopes, and serial monitoring tools to detect voltage irregularities, thermal spikes, and signal dropouts. One notable issue occurred during camera testing, where a USB-connected unit failed. After testing, it was determined that the failure may have been caused by a voltage surge or aging hardware. The faulty component was replaced, and additional testing of power paths and grounding was conducted to prevent recurrence.

Software debugging relied on serial logging and Arduino sketch print-statements to trace stuck loops and command timing errors. When input lag was detected between joystick commands and motor response, baud rates and buffer sizes were adjusted on both the GUI and the Arduino firmware. These optimizations improved signal reliability and reduced latency, especially during fine manipulator control.

Mechanical tools such as the manipulator claw and float system were developed using CAD and rapidly prototyped via 3D printing. An unforeseen obstacle to claw function was skipping of gears on the compression of the claw, leading to slippage of grip. Helical gears were utilized to ensure better efficiency with slightly higher friction, and several components were repeatedly modified until tolerance between gears allowed for fluid motion, whilst not compromising the tight fit needed for proper gear functionality, solving the gear slippage issue.

MEDIA OUTREACH

PCC's Pi Day

As part of our commitment to STEM outreach and education, the Octobots participated in the 2025 Pi Day Conference hosted by Pasadena City College. Our mechanical subteam led a hands-on workshop titled *"Underwater Robotics: Introduction to ROVs"*, designed to educate students and community members about the engineering principles behind remotely operated vehicles (ROVs) and their real-world applications.

The presentation began with an accessible explanation of what an ROV is, its key components—such as frames, thrusters, tethers, sensors, and manipulators—and its various uses in commercial, scientific, and military sectors.

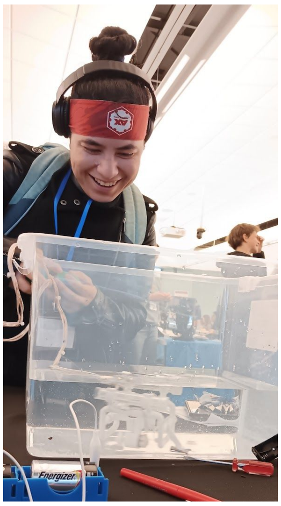


Fig. 22: Attendees maneuvering the mini-ROV

To reinforce the technical concepts, the team introduced participants to Ohm's Law and the basics of electrical circuits using ROV control box diagrams and multimeter demonstrations.

Attendees measured battery voltage, wire resistance, and motor voltage drop across a simple series circuit. This exercise helped bridge the gap between theory and application, showing how basic physics and electronics govern real ROV performance.

Fig. 23: Mechanical Lead explaining to high school students

The workshop concluded with a mini-ROV activity, where participants observed how components like motors and wires interact in a submerged environment. Students were invited to explore the control box, identify power flow, and understand how voltage drops influence motor behavior. This outreach activity interest in marine robotics, electronics, and systems engineering. It served as an opportunity for the Octobots to represent the MATE ROV program and engage directly with students who may be future engineers, technicians, or scientists.

ACCOUNTING

The Octobots approach budgeting not as an afterthought, but as an integral part of the engineering process. Financial planning begins alongside early design discussions, with the team identifying essential components, prioritizing reusable parts, and mapping out a phased spending plan tied directly to our build timeline. Each department—Mechanical, Electrical, Software, and Administrative—is responsible for forecasting its own needs, which are reviewed collectively to ensure spending aligns with mission-critical tasks and competition requirements.

Rather than relying on high-end commercial solutions, the team emphasizes cost-efficiency and creativity. When a part can be reused, repurposed, or substituted with an off-the-shelf alternative, it is. For example, PVC and marine-grade adhesives were selected over specialized structural components, and many of the ROV's internal electronics were recovered from previous builds. This not only reduces financial overhead but reinforces one of the team's core values: engineering through constraint.

To maintain oversight and accountability, all purchases are reviewed and approved by the leadership team. A shared budget tracker is updated in real time, allowing department leads to monitor expenses and avoid redundancy. When large purchases are proposed—such as new servo systems for the manipulator claw—they are justified through design testing, feasibility analysis, and alignment with task performance goals. In this case, investing in reliable waterproof servos was deemed essential for claw precision and durability during mission operations.

The team also phases its spending to match development progress. Early stages focus on prototyping materials and reusable items, while high-cost components—such as connectors, motor drivers, and control systems—are delayed until design choices are finalized. This reduces waste and ensures that funds are committed only when technically necessary.

Funding from external grants is managed responsibly, with separate allocations set aside for travel, registration, materials, and contingency. Any unspent funds are rolled into reserve categories to support unexpected design changes or competition logistics.

Catergories	Items	Type	Amount (USD)
ROV Expenses			
Mechanical	HDPE Sheets	Re-used	72.38
Mechanical	Brushless Waterproof Servos	Purchased	67.96
Mechanical	T200 Thrusters w/ Penetrator	Re-used	600.00
Mechanical	Duplicolor Primer	Purchased	10.99
Mechanical	End Cap	Re-used	327.00
Mechanical	SER 2000 Servo Kit	Purchased	215.00
Mechanical	Speed Controller	Re-used	144.00
Electrical	Servo Programmer	Purchased	9.99
Electrical	USB Camera	Re-used	64.99
Electrical	22-Gauge Power Cable	Purchased	15.98
Electrical	Wire Battery Cable Lug Terminal	Re-used	45.90
Electrical	Splicing Connector	Purchased	23.95
Electrical	USB Hub for Camera	Re-used	59.99
Electrical	10-Gauge Power Cable	Purchased	19.99
Electrical	Circuit Breakers 30A	Re-used	41.72
Electrical	Penetrator socket	Purchased	23.95
Electrical	Switching Power Supplies 48V 42A	Re-used	515.00
Electrical	Penetrator PLUG socket	Purchased	14.00
Electrical	Littlefuse Holder	Re-used	80.00
Electrical	Wetlink Penetrator M10	Purchased	11.99
Electrical	Littlefuse	Re-used	7.00
Software	Arduino Mega 2560 Rev3	Re-used	62.00
			Total: $413.81
Float Expenses			
Mechanical	PHT Sensor	Re-used	16.99
Mechanical	RF Transceiver Antenna	Re-used	12.84
Mechanical	12V Battery Pack	Re-used	49.99
Mechanical	Air Pump	Re-used	19.99
Mechanical	Analog Pressure Sensor	Re-used	21.10
Mechanical	Bladder	Re-used	29.95
			Total: 0
Miscellaneous Expenses			
Miscellanous	Olive Oil	Purchased	8.23
Miscellanous	Flex Seal Spray	Re-used	14.87
Miscellanous	JB Marine Weld	Purchased	6.05
Miscellanous	Marine Crease	Re-used	11.99
Miscellanous	Zip ties	Purchased	5.99
Miscellanous	PVC Pipes	Re-used	182.2
			Total: $229.33
Travel Expenses			
Competition Expenses	Flight tickets	Purchased	9131.25
Competition Expenses	Hotel Lodging	Purchased	7360.58
Competition Expenses	Transportation	Estimated	300.00
Competition Expenses	Food	Estimated	2000.00
			Total: $18791.83
Income			
Grant	PCC: McKenzie Scott	Funded	10000.00
Grant	NSF: MNT-EC	Funded	10000.00
			Total: $20000
			Total Expenses: $19434.97
			Surplus: $565.03

Table 1: Octobots' Budget Chart

ACKNOWLEDGEMENTS AND REFERENCES

Sponsors:

The Octobots respectfully acknowledge the individuals and organizations whose guidance and support made this project possible. We thank Mr. Doug Foster for his consistent mentorship throughout the season. We thank Eamon Conklin for giving the team free reign of the Fab Lab for 3 hours each Friday from October 2024 until the present. We are also grateful to Dr. Yu-Chung Chang-Hou, who facilitated the purchase of essential materials and supported the team's outreach efforts. Her collaboration with the Marketing Lead ensured effective communication of our work within the college and beyond the college. Special thanks also go to Professor Jared Ashcroft, who provided critical organizational leadership. He oversaw the team structure, managed budget coordination, and served as the primary liaison between the Octobots and the MATE ROV competition.

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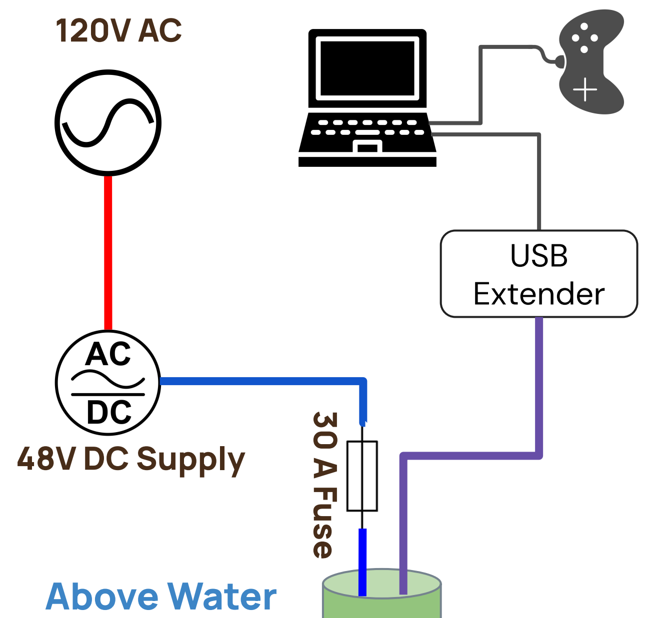
APPENDIX A: Safety Checklist

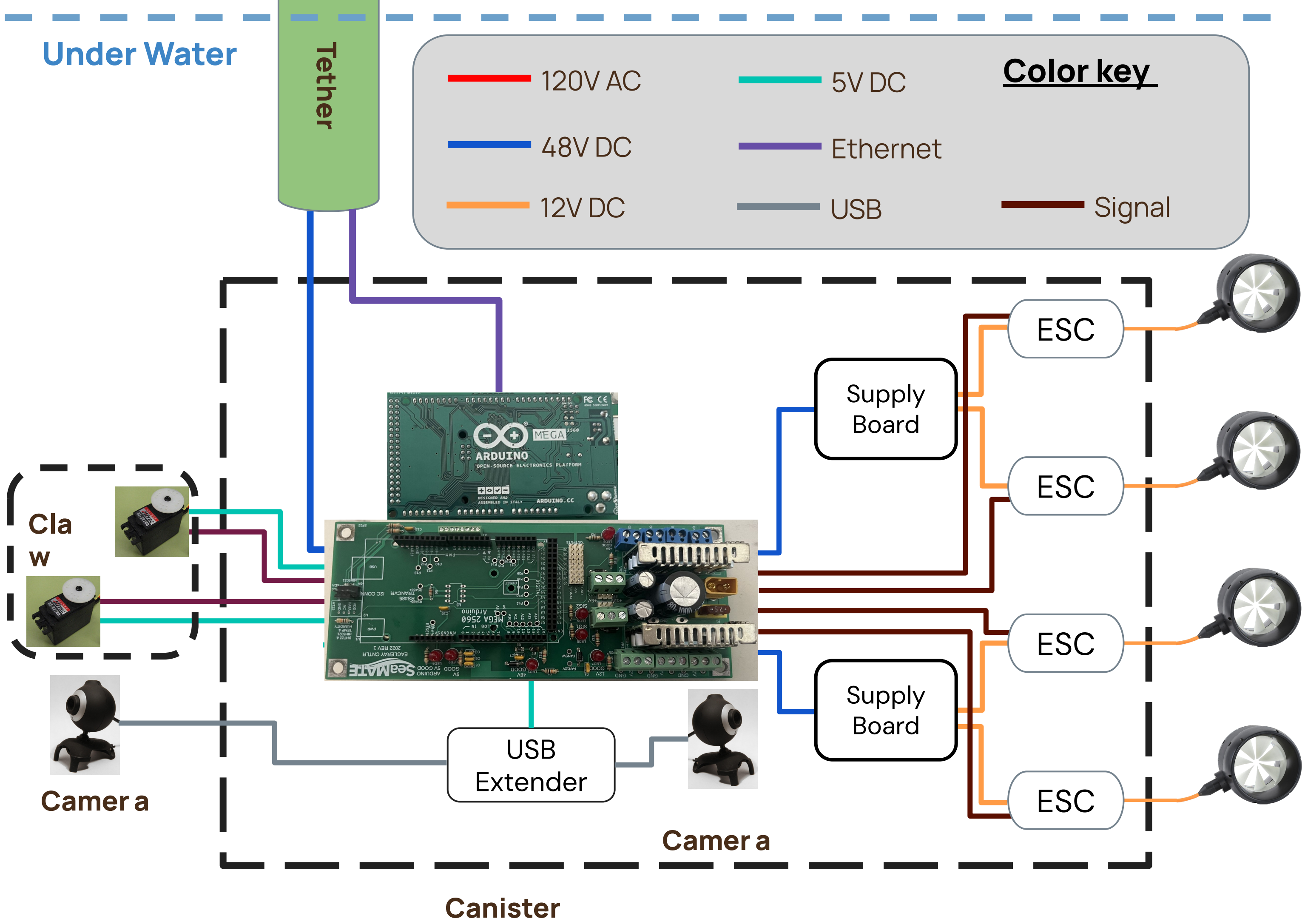
Construction Phase	
Category	**Checklist Item**
Workspace Safety	☐ Ensure workspace is clean, dry, and free from loose tools or materials
	☐ Store materials/equipment to prevent tripping or obstruction
	☐ Maintain clear access to exits, fire extinguishers, and first aid kits
Personal Protective Equipment	☐ Wear safety glasses when cutting, soldering, or grinding
	☐ Use heat-resistant gloves during hot tool or adhesive use
	☐ Wear lab coats or long sleeves during machining or chemical handling
Tool & Equipment Use	☐ Inspect tools/machinery for visible damage before use
	☐ Confirm guards and emergency shutoffs are present and functional
	☐ Disconnect power before tool adjustments or maintenance
	☐ Use ventilation/fume extraction for soldering or sealing
Electrical Safety	☐ Inspect cables for fraying or exposed wires
	☐ Ensure proper equipment grounding
	☐ Isolate and label any damaged or unsafe circuits
	☐ Keep all liquids away from electronics stations
Operation Phase	
Stages	**Checklist Item**
Pre-Deployment (Power Off)	☐ Confirm launch area is clear of obstructions and personnel
	☐ Tether is flaked out neatly and strain relief is attached to ROV
	☐ Electronics housing is sealed, and all screws are tight
	☐ Power supply and TCU are off before connection
	☐ Perform visual inspection of connectors and wires
Deployment (Power On)	☐ Conduct verbal checklist and confirm team is ready
	☐ Power on TCU and confirm system voltage is stable (48V nominal)
	☐ Verify ESC startup and thruster responsiveness
	☐ Confirm camera feeds and sensor data are active
	☐ Check for leaks or bubbles from frame and electronics housing
	☐ Confirm camera feeds and sensor data are active
	☐ Check for leaks or bubbles from frame and electronics housing
In-Water Operation	☐ Continuously monitor video feed and telemetry data
	☐ Observe tether to ensure it is free of snags or excessive tension
	☐ Stop operation if unusual movement or large air bubbles are observed
	☐ Record any unexpected behavior for post-mission diagnostics
Loss of Communication	☐ Attempt soft reset on TCU or surface controls
	☐ If no response, power down and recover ROV
	☐ Resume operation only after verifying all systems are stable
Post-Operation & Pit Maintenance	☐ Power off and fully disconnect ROV and TCU before handling
	☐ Inspect thrusters for debris, damage, or blockages
	☐ Dry electronics housing and inspect for signs of moisture
	☐ Re-lubricate O-rings and seals if housing was opened
	☐ Ensure tether and manipulators are secured and logged for next use

APPENDIX B: ELECTRICAL SID



Items	Max Power (W)
4 × T-200 Blue Robot Thrusters	792
2 × USB Cameras	12
2 × Servo Motors	12
MISC. Electronics	10
Total Power Consumed	826 W

Total Current Draw: 826 W / 48 V = 17.2 A
Overcurrent Protection: 150% of 17.2 A = 25.8 A
Fuse Used: 30 A



APPENDIX C: SOFTWARE SID