2024-2025

TECHNICAL REPORT
THE RAYS

MEMBERS:

OWEN CROSS |27| - CTO | CFO

MICAH LARSON |28| - FLOAT CONTROL SOFTWARE

DANIEL MYRVOLD |29| - FLOAT ENGINEER

DALTON WALLACE |27| - CEO | MECHANICAL

DECLAN WALLACE |26| - LEAD WRITER

CRAIG BATTLES - MENTOR

HEIDI LENT - COACH

WARRENTON HIGH SCHOOL | WARRENTON, OR, USA

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ABSTRACT

The Rays are a division of Warrenton Aquatic Robotics. It is a leading provider of cutting-edge underwater solutions, based in Warrenton, Oregon, USA. Our mission is to design and develop innovative technologies that enhance the health and sustainability of our planet's oceans, waterways, and marshes.

Introducing the **BattleBot V2,** our latest advancement that builds on the success of its predecessor and expands its capabilities. The BattleBot V2 is engineered to address critical underwater challenges, featuring our proprietary machine learning program, MARV, designed to identify shipwrecks in the North American Great Lakes. With the addition of Photosphere Technology and renewable energy maintenance solutions, the BattleBot V2 is equipped to tackle a wide range of global environmental issues efficiently. Enhanced with state-of-the-art sensors and specialized tools, the BattleBot V2 is ready to drive impactful change in underwater exploration and conservation.





2025 Team (Left to right)

Dalton Wallace | Future Plans - Line man for Pacific Power

Owen Cross | Future Plans - Attending OSU for engineering

Daniel Myrvold | Future Plans - Attending OSU for engineering

Micah Larson | Future Plans - Getting a Software Engineering Degree

Declan Wallace | Future Plans - Getting a Degree in Environmental Science

TEAMWORK

COMPANY PROFILE

The Rays, of Warrenton Aquatic Robotics, are focused on bringing safe, reliable, and efficient solutions to our planet's ever-expanding natural resource and environmental issues. Our company's goal is heavily inspired by the United Nations Decade of Ocean Science and its “10 Challenges for Collective Impact”. The health and preservation of the North American Great Lakes is the primary target for this year's engineering goals. Each task was split up between three different departments; The ROV team, AUV team, and the writing and research team. Along with organization of tasks we designed a leadership structure with roles and responsibilities like CEO (Chief Executive Officer) and CFO (Chief Financial Officer) to help lead and organize work parties and manage budget responsibilities for the entire team. With safety in mind we also appointed a safety officer to oversee that all PPE, safety protocols, JSEA’s were all accounted for and in use.

The Rays secondary mission is striving to learn and grow not only as engineers but also as members of the global coastal community. Our company is composed of students in grade 8 through 11. Internal teaching within the company from older experienced leaders to younger members is key to sustaining our goal of developing the best solutions for any task. Educating internally is key for our personal success, however, as a company trying to solve these issues it is essential that we advocate and educate about these issues locally and globally. Bringing awareness of these problems is the biggest part of our responsibility as members of the global coastal community.

Figure 1. Team Members | The Rays

TEAM STRUCTURE

Our company consists of three primary teams: ROV, Float, and Writing. The ROV team includes Owen Cross, designer of the control and electrical systems as well as software, and Dalton Wallace, who designed the mechanical structures and tools for the ROV. The Float team consists of Daniel Myrvold, who is responsible for the design of mechanical and electrical subsystems, and Micah Larson, who designed, developed, and tested software for the Float. Declan Wallace was the head of the Research and Writing branch, responsible for theme research, technical document editing, and company image. Each team member wrote the sections of this document relating to their responsibilities. Clear lines of responsibility allow us to focus on the tasks at hand, while sharing reports allows us to efficiently share ideas and work to integrate our subsystems.

PROJECT SCHEDULING AND MANAGEMENT

We use **mind maps** to explore alternative approaches for each subsystem, analyzing options based on cost, technical difficulty, impact on other subsystems, and more (Figure 2). When information is lacking, we create a Work Breakdown Structure (WBS) to identify research or experimentation tasks, organizing them in logical order. For instance, motor mounts can't be designed before selecting the motors. Resources and time estimates are assigned to each task, working backward from final deadlines to improve outcomes. Our schedule (Figure 2) helps ensure timelines are feasible and highlights areas needing additional attention.

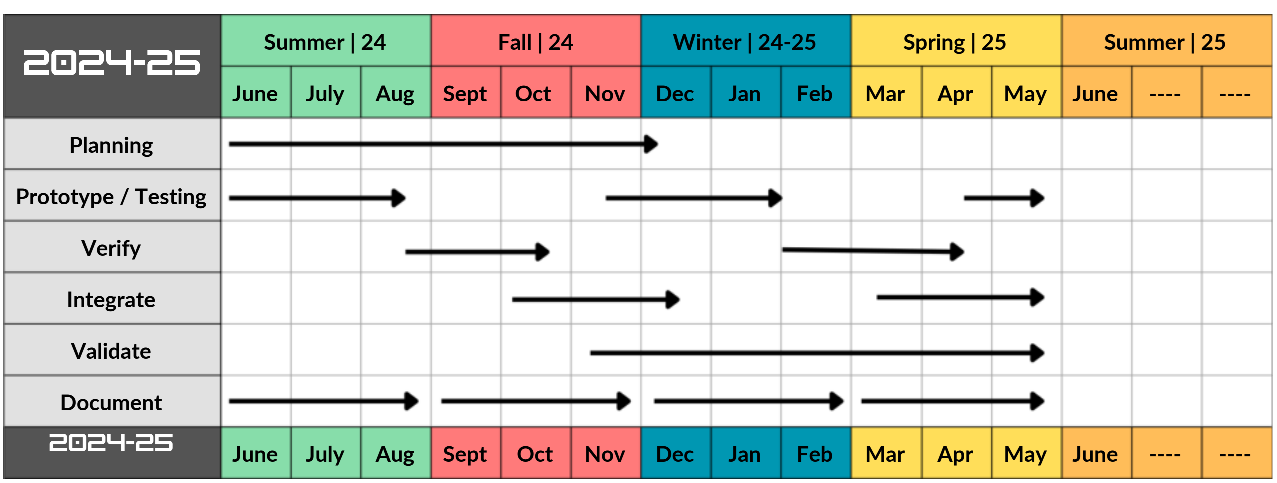

Figure 2. General Statement of Work | The Rays

DESIGN RATIONAL

DESIGN METHODOLOGY

When The Rays fabricate a new product, we start by making a list of design requirements. These requirements range from mandatory safety features to nonessential implementations that enhance the product's aesthetics and user-friendliness. Building off of last year's BattleBot, our design requirements focused on elevating our product to the next level while maintaining MATE guidelines, prioritizing safety, and ensuring machine functionality. Once we have our list of design requirements, we begin our concept development stage.

We start by using mind maps to sketch out our subsystems and possible solutions for each one. From the mind map, we create a schedule to follow, ensuring tasks are completed in a timely and structured manner. Using **Trade Studies** and weighted decision matrices based on our design requirements, we filter out some of the concepts we brainstormed. This helps prevent us from hitting a local maximum with our design and allows us to start on the right track. Some of these trade studies involved selecting sensors, microprocessors, and thrusters.

PROBLEM SOLVING

In our concept development stage, we aim to generate seven different concepts for each subsystem. We find that "seven ways" gives us a solid number of ideas to consider without taking too much time to evaluate each one. To come up with these ideas, we start by sketching out our subsystems on a mind map. Then, as a team, we share our mind maps for the projects we're working on so we can brainstorm ideas together. This is done in tandem with our weekly status and working meetings. By collaborating this way, we ensure that we explore every possible avenue and avoid overlooking potential solutions.

Once we have our seven concepts, we conduct a trade study for each subsystem. We take the design requirements for that subsystem and assign quantitative values to each requirement (Figure 3). These values might include how much thrust a thruster produces or how many amps a microprocessor draws. Once we've assigned values, we can identify the concept that best meets our design requirements. This process ensures that, going into the design stage, we are working with the strongest possible ideas.

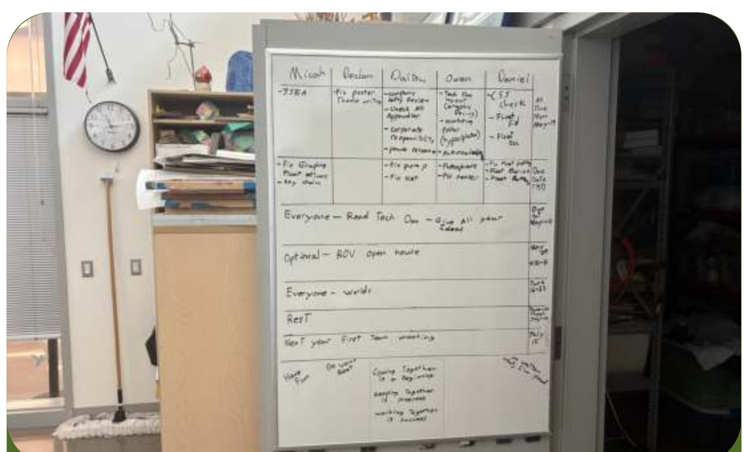

Figure 3. Team Plan Out | The Rays

VEHICALE STRUCTURE

The octagonal frame of our ROV was a deliberate design choice that offers both functionality and visual appeal. This shape provides eight flat surfaces, allowing for versatile mounting of vectored thrusters, cameras, tools, and canisters. Compared to square or rectangular frames, the octagon enhances maneuverability by offering more flexibility in thruster placement, which helps achieve stable and precise movement underwater. It also improves visibility from onboard cameras and makes the ROV easier to track from the surface—important during tight navigation or recovery.

From the start, our goal was to build a "Four-Year Frame"—a reusable and modular platform that could support multiple ROV iterations. We evaluated several materials, including PVC, HDPE, fiberglass, 3D-printed plastics, and X-Rail aluminum extrusion (Figure 4). X-Rail stood out due to its strength, low weight, and simple assembly using a single tool. Its modularity made it easy to attach components and adjust the design as needed.

However, midway through our build, ServoCity discontinued the X-Rail system. This unexpected challenge forced us to work with a limited supply, encouraging us to be more conservative and creative in how we used materials.

Figure 4. X-Rail Visuel | The Rays

To maximize mounting flexibility, we created custom motor mounts using 3D-printed PLA. These mounts were designed to rotate 180°, allowing us to reposition motors that were placed too closely together. PLA was chosen for its affordability, ease of printing, and the ability to print in bright colors—helpful for organizing parts and improving visibility underwater. We also printed corner covers to cap sharp metal edges. These serve a dual purpose: increasing safety during handling and making the ROV more visible underwater, which helps the deck crew prepare for quick tool changes during missions.

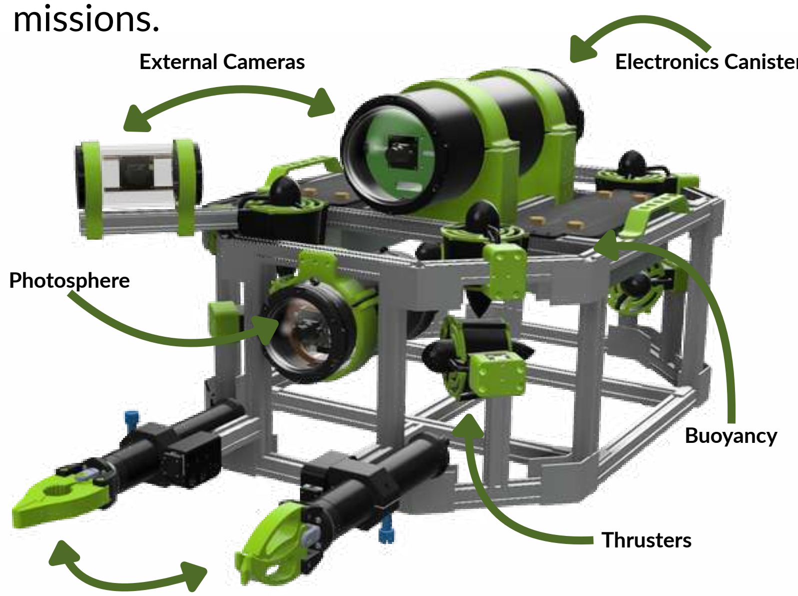

Figure 5. ROV Model | The Rays

Our electronics are housed in a sealed aluminum canister, chosen for its durability and ability to withstand underwater pressure. Placing electronics directly on the ROV reduces the number of wires in the tether, making the system simpler, lighter, and more reliable. This approach helps minimize drag in the water and keeps the electronics safe during extended missions.

ROV ELECTRONICS

This year's electronic system marks a major advancement with the shift from an Arduino-based setup to a Raspberry Pi system running BlueOS, an open-source platform developed by Blue Robotics. Unlike conventional ROV systems that use the Raspberry Pi as both the central computing and control unit, we use it exclusively for video processing and data handling. The processed data is transmitted topside via an Ethernet network connection, optimizing system efficiency.

To manage motor control and other peripherals—such as the gripper, lights, and auxiliary tools—we utilize a Pixhawk 4 running ArduSub, an open-source firmware designed for underwater vehicles. The Pixhawk communicates with the Raspberry Pi via USB, reducing the computational load on the Raspberry Pi. This setup ensures efficient system performance, enabling us to allocate more resources to advanced features such as AI-driven video enhancement and real-time object detection.

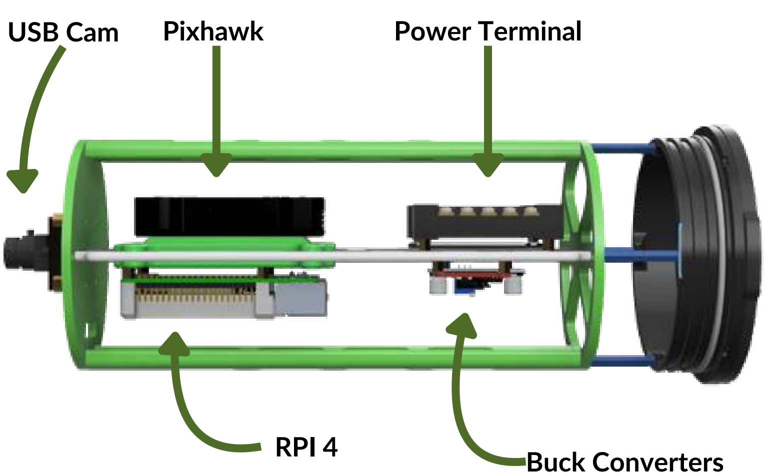

Figure 6. Electronics Tray | The Rays

TOP-SIDE SOFTWARE

The Ethernet cable from the ROV is directly connected to the topside laptop, creating a dedicated network interface with the Raspberry Pi onboard the vehicle. This wired connection ensures a stable, high-bandwidth link between the topside control station and the ROV, minimizing latency and avoiding the signal interference common with wireless setups. Through this network interface, we gain direct access to the Raspberry Pi's onboard system, allowing us to run and interact with QGroundControl, the control software integrated with BlueOS. QGroundControl serves as the primary user interface for operating the ROV, and we have customized it extensively to meet the unique demands of our system.

Figure 7. Conrol GUI | The Rays

This tailored interface consolidates control inputs, live video feeds, telemetry data, and system diagnostics into a single, intuitive dashboard. The software enables the pilot and support team to seamlessly command the ROV's thrusters, manipulate tools, and monitor sensor readings in real time.

Additionally, Cockpit's modular design allows us to add or adjust features as needed, ensuring that our control system remains flexible and scalable for future upgrades or mission-specific requirements. Overall, this Ethernet connection, combined with a customized Cockpit interface, provides a reliable, responsive, and user-friendly control environment that enhances operational efficiency and situational awareness during underwater missions.

BOTTOM-SIDE SOFTWARE

The ROV is powered by a Raspberry Pi running Blue Robotics' open-source software, BlueOS, which serves as the central hub for all topside and vehicle-side communications. We have carefully configured BlueOS to meet the specific requirements of our system, enabling it to handle not only basic control functions but also advanced features such as real-time telemetry, device management, and live video streaming. The intuitive web-based interface of BlueOS also allows for easy calibration, updates, and parameter tuning, making it a flexible platform for ongoing development.

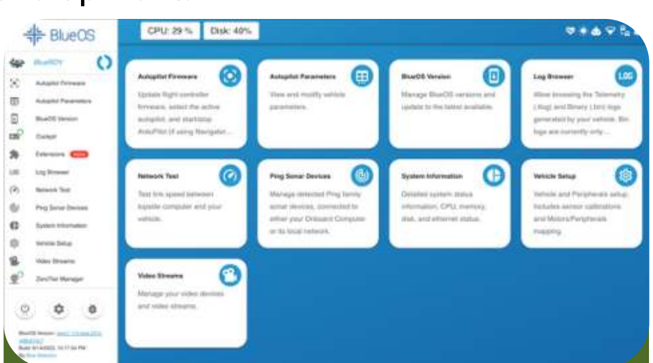

Figure 8. GUI Config | The Rays

Connected to the Raspberry Pi is a Pixhawk 1 flight controller, which runs the latest version of ArduSub, a control firmware specifically designed for underwater vehicles. ArduSub provides precise motor control, sensor integration, and autonomous behavior options such as depth hold and heading lock.

Figure 9. Depth Sensor | The Rays

It translates the commands received from the topside controller into real-time responses from the ROV's thrusters and sensors, ensuring smooth and accurate movement. This combination of BlueOS and ArduSub creates a highly adaptable system architecture. It allows us to easily integrate custom features, such as auxiliary sensors, motor configurations, or even future autonomy modules. The modular design also ensures that if we need to scale up the ROV or change components in future seasons, we can do so without rewriting core software. Together, the Raspberry Pi and Pixhawk form a reliable and responsive control backbone that supports both manual piloting and potential future mission automation.

VISION SYSTEM

This year, a significant improvement is the adoption of a digital camera system, replacing the low-quality, power-intensive analog setup used in previous years. This new system includes two 1080p high-resolution, 170-degree ultra-wide, H.265 USB cameras (Figure 10):

- Primary Camera: Mounted inside the main tube to provide a comprehensive view of the ROV for navigation.
- Secondary Camera: Positioned near the claw for precise monitoring of tool operations.

Figure 10. Low light USB Cam | The Rays

To further enhance video quality, we've integrated DWE.ai, an open-source AI that works harmoniously with BlueOS. This system applies real-time video enhancements, such as color correction, delivering a clear and optimized view of the ROV's environment. Additionally, the digital system minimizes latency, reduces power consumption, and decreases tether bulk, significantly improving reliability, maneuverability, and reaction time.

TETHER DESIGN

The goal for this year's tether design was simplicity. To achieve this, we minimized the number of cables required to operate the machine from six to three. We also improved buoyancy by including a foam buoyancy line to give our cable neutral buoyancy (Figure _), thus enhancing ROV maneuverability in the water. An industry-standard yellow hi-vis sheath was implemented for on-deck safety for machine operators.

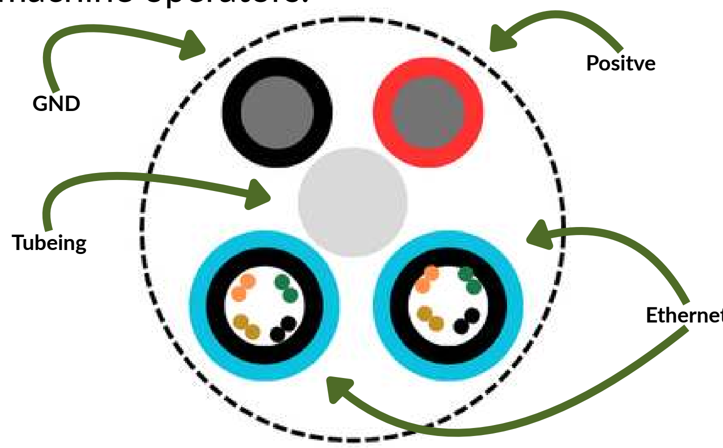

Figure 11. Tether Layout | The Rays

PROPULSION

Having eight motors instead of six allows for more efficient thrust distribution and balanced performance. Four of these motors are mounted at 45-degree angles on the corners of our octagonal frame, enabling a vectored thrust setup. Combined with motor-mixing software, this provides precise and smooth movement in all directions. The four vertical motors, also placed at the corners, work with the IMU to keep the ROV level and properly oriented.

This system supports automatic stabilization as well as manual angle adjustments, which are useful for navigating tight spaces and complex tasks. We chose the octagonal shape because it perfectly fits all eight motors, reducing the number of custom 3D-printed mounts and saving on costs. Cutting off the front corners helps the ROV safely access smaller spaces while maintaining a clean, functional design that allows flexible mounting of tools and cameras.

Before deciding on these motors, we conducted a trade study comparing power, efficiency, size, and cost. We selected motors that offered the best power-to-price performance, ensuring strong thrust without exceeding our budget. This balance of power and cost makes our ROV both effective and economical for this season and future upgrades.

Thrusters	Thrust (N) 12v/Amp	Total Thrust (N)	Cost	Score ((Thrust/Amp)/Cos
T200	6.178N/a	36.387 N @ 17.0a	$236.00	0.026
T500	7.747N/a	39.227 N @ 16.9a	$726.00	0.011
tate bilgepump (No Shrouds)	3.375N/a	13.500 N @ 4.0a	$75.00	0.045
Diamond Dynamics	2.354N/a	24.517 N @ 13.0a	$64.00	0.037
CUIFATI	1.471N/a	11.768 N @ 8.0a	$75.71	0.019
Hawk Hobby	1.739N/a	26.086 N @ 15.0a	$69.98	0.025

Figure 12. Trade Study | The Rays

BUOYANCY AND BALLAST

The addition of more watertight enclosures for our electrical systems allowed us to significantly reduce the amount of buoyancy required.

Instead of using bulky PVC pontoons, we opted for dense foam, which offers a cleaner, more professional appearance and greater flexibility. This foam can be custom-cut to match the exact shape and contour of our ROV, making the overall profile more streamlined. To further improve aesthetics and durability, we designed and 3D-printed a custom cover that fits over the foam, creating a seamless integration with the rest of the frame.

For ballast, our team engineered a unique, adjustable weight system located in the four lower corners of the ROV.

Figure 13. Ballast | The Rays

This configuration not only provides stable ballasting but also allows for easy trim adjustments. By spreading the ballast system across multiple points, we can fine-tune the balance and orientation of the ROV on the fly, without needing extra tools or preparation. This setup gives us greater control over the vehicle’s neutral buoyancy and trim, both of which are critical for smooth operation and precision during mission tasks.

PAY-LOAD & TOOLS

NET-TOOL

We have created a custom, handmade net designed specifically for collecting surface samples. The net is constructed from a combination of materials, including PVC pipe for the frame, copper wire for structural reinforcement, and mesh netting for capturing the samples. This tool allows us to collect floating objects such as fish, debris, or surface-level organisms like Medusa jellyfish. By using this net, we can safely gather and retrieve samples for further observation and study, all while maintaining control from the ROV without requiring surface interference.

Figure 14. Net | The Rays

WATER SAMPLE DEVICE

We custom-built a high-speed water pump (1,000 mL/sec) with an integrated pH sensor to collect water samples and real-time chemical data simultaneously.

Designed to operate independently from the ROV, it reduces vehicle weight and system complexity while enabling multitasking. A reinforced paracord tether adds durability, making the tool efficient, flexible, and mission-ready.

Figure 15. Pump | The Rays

GRIPPER

At the start of the year, we began developing a fully articulated claw. However, with limited team members, we only made it halfway before needing to shift focus to the ROV. Since the custom claw wasn't completed, we planned to use a single Blue Robotics claw. It performed well, but we then discovered a broken one in storage. After repairing it with spare parts, we had two functional Blue Robotics claws. With both ready, we mounted them on the ROV to allow dual claw orientations and enable handling multiple objects at once. This saves time underwater by eliminating the need to surface and reposition the claw.

M.A.R.V

This year, we developed and deployed M.A.R.V. (Machine-learning for Autonomous Recognition and Visualization), a compact AI system built for advanced underwater tasks. Compatible with any ROV and powered by 12V, M.A.R.V. performs real-time object detection, photogrammetry, and accurate pixel-based measurements using onboard cameras.

One highlight is its photosphere capability. As the ROV moves, M.A.R.V. captures over 500 high-resolution images, which are stitched into a 360° view of the environment. This output is displayed through our custom software, offering an interactive experience similar to Google Maps.

The system can identify both static and moving targets—such as cargo, fish, people, and underwater structures—enhancing navigation and safety. It also measures objects using pixel analysis combined with quick calibration, providing real-time dimensional data in challenging conditions. All features run through a single Python script on a secondary laptop. Using an ultrawide camera, multiple video streams are merged into one view. The software employs YOLOv8 for detection, OpenCV for image processing, and PyGame for the interface—all managed in VS Code.

M.A.R.V. is housed in a 3-inch Blue Robotics watertight tube with a dome for the ultrawide lens. Mounted just below the main electronics tube, its placement ensures a wide field of view while maintaining a low profile and optimal ROV integration.

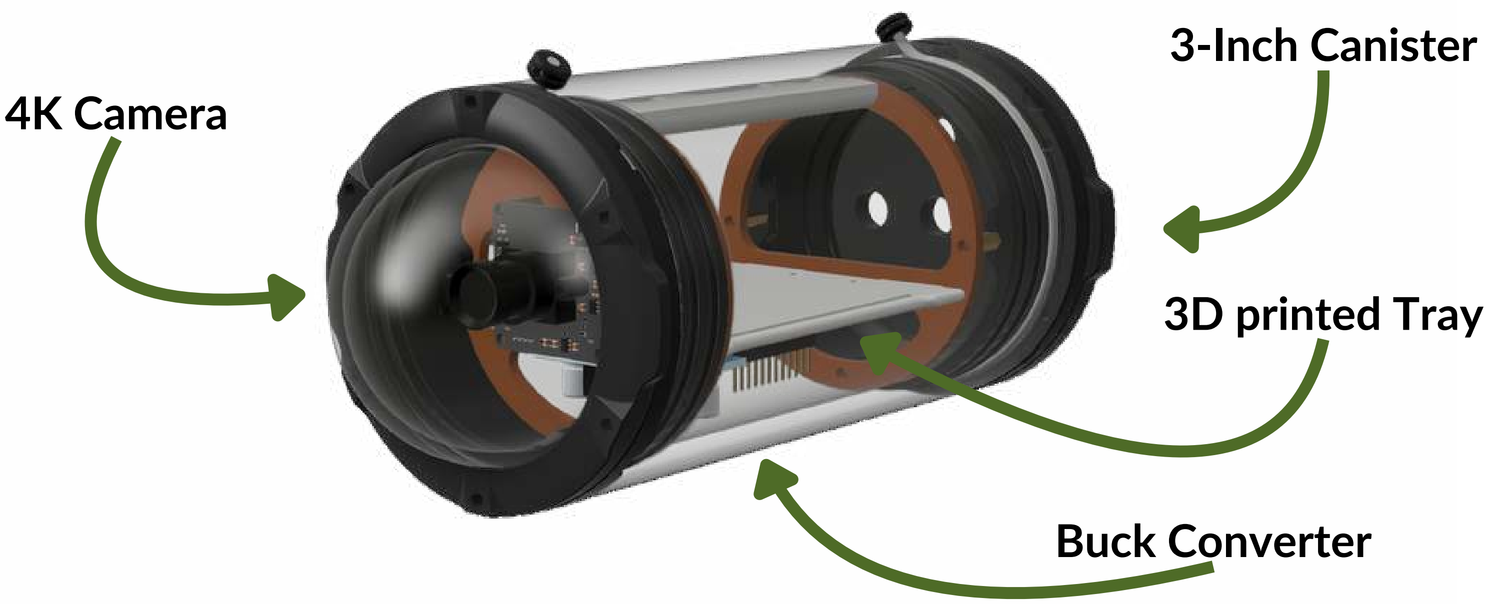

Figure 16. M.A.R.V | The Rays

NON-ROV DEVICE

FLOAT DESIGN

Our float, Torpedo Ray, was built for simplicity, reliability, and efficiency. We use XBee radios for wireless data transfer and a compact single-unit design that improves on last year's split system. The float's C-based software uses a **State Machine** to handle diving, data collection, and surfacing. It collects pressure data at 2.5 meters for 50 seconds, then returns to the surface and uploads the data via pySerial to our Python-based topside software, which graphs it automatically. Safety and reliability are ensured through features like LED visibility strips, a battery monitor, and protective legs.

Mechanically, we focused on modularity and improved performance. A smaller linear actuator and larger syringe provide faster, more precise vertical movement. Inside, a custom PCB simplifies wiring and allows quick component replacement. All electronics are neatly housed in a larger, clear canister with added space for future upgrades. Custom end caps and organized penetrators make access and repairs easier. These design choices helped us spend more time refining software while keeping the float stable, efficient, and competition-ready.

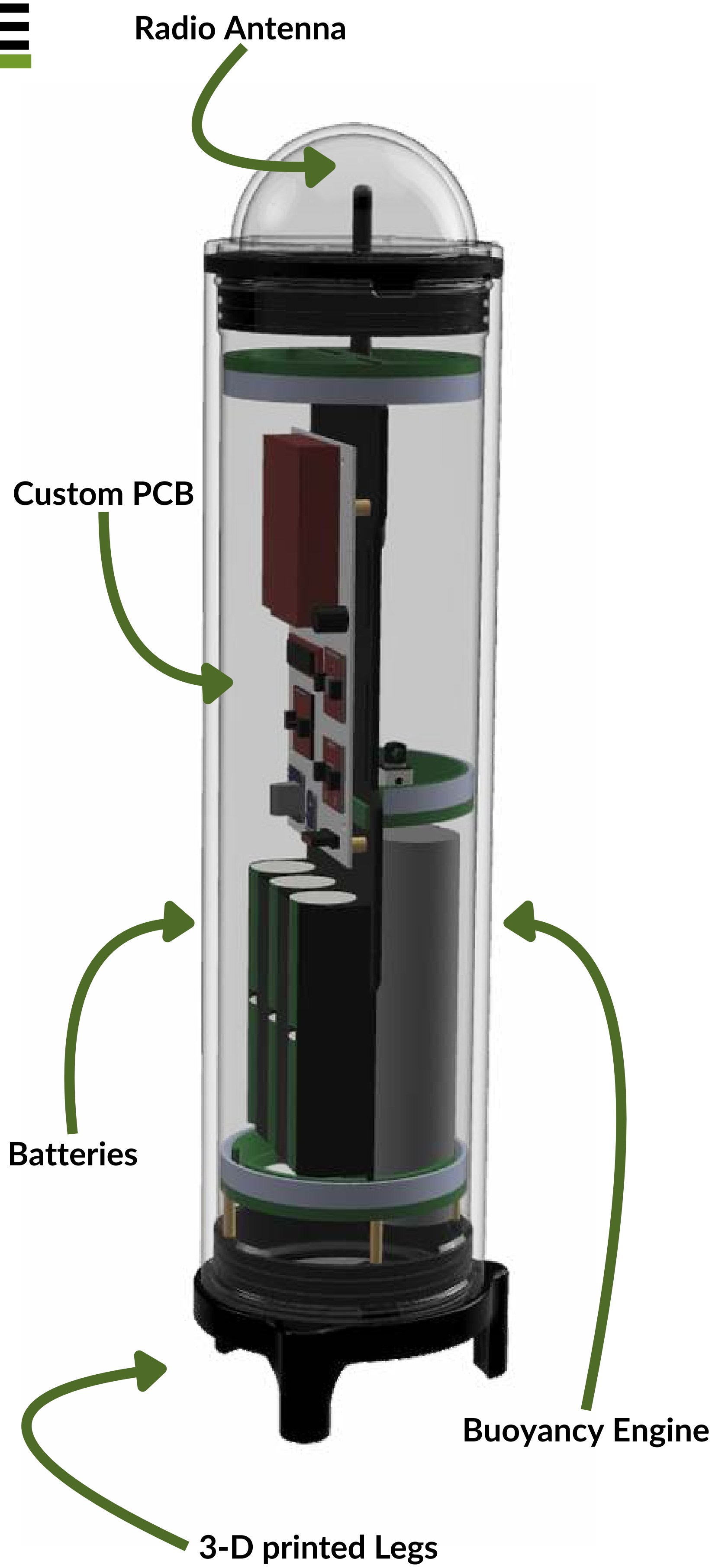

Figure 17. Full Float | The Rays

STATE MACHINE

The custom-designed software program employs a state machine with five states: Initialize, Ready, Dive, Ascend, and Upload. It starts in Initialize, preparing everything. Once in the water, it sends a signal to move to Ready. In Ready, it collects the surface pressure and awaits the dive command. After receiving the dive command, it transitions to the Dive state. The float then dives to a depth of 2.5 meters in the pool and stays there for 50 seconds, collecting a pressure measurement every 5 seconds. Once the 50 seconds have passed, it moves to the Ascend state, and upon reaching the surface, it transitions to the Upload state, sending all collected data to automated graphing software.

BUOYANCY ENGINE

Our company purchased a new linear actuator that is smaller and faster. Its compact size allows it to fit better inside the float, reducing the amount of modeling required. Being faster helps the float make quick adjustments to maintain a constant 2.5-meter depth in the pool. A larger syringe is utilized so Torpedo Ray can submerge and surface promptly. Reusing the buoyancy engine mount from last year helped speed the design process and reduce production costs. This gave us more time to improve software and address electrical issues.

CANISTER

This year, we bought a new, clear, and larger tube, giving us more space for a bigger PCB, C-cell batteries, and additional sensors. Having more space also allows room for improvements and changes that might be necessary next year and beyond. Inside the canister, we have custom-designed and 3D-printed containers for BBs to add four pounds of weight, ensuring the float will sink when needed.

Figure 18. Float Canistor| The Rays

3D PRINTED TRAY

We designed a custom laser-cut acrylic tray with mounts for the PCB, batteries, buoyancy engine, and more. This helps create a neater appearance and provides flexibility for future modifications. Additionally, it allows us to mount components on both sides,

ELECTRICAL SYSTEM

We designed and purchased a custom PCB to minimize wiring. The PCB connects everything through routes on the board. We also included pin sockets and JST connectors so that all components simply plug in.

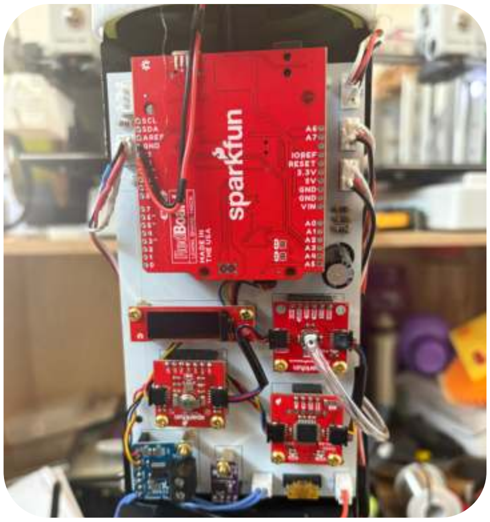

Figure 19. Float PCB | The Rays

ONBOARD SOFTWARE

We coded our float in C, making sure to include all the necessary libraries, such as those for transmitting through the XBee, PID parameters, and all the sensors. We use a state machine, which allows the float to transition through different states and makes it easier to edit specific parts of the code.

PENETRATORS

We designed a custom end cap to hold all the penetrators we need, including an on/off switch, a temperature sensor, a bike pump, a pressure sensor, and one for the buoyancy engine.

Figure 20. Penetrators | The Rays

BATTERIES

We are using NiMH (Nickel Metal Hydride) batteries instead of alkaline batteries. With alkaline batteries, we either get 9 volts and 1 amp or 1.5 volts and 5 amps, according to the rules. With NiMH batteries, we get 7.2 volts and 5 amps consistently. We need at least 5.5 volts and 2 amps to run our system, so the alkaline batteries wouldn't work, but the NiMH batteries do. The batteries are placed at the bottom of the tray, which acts as ballast to keep the float upright.

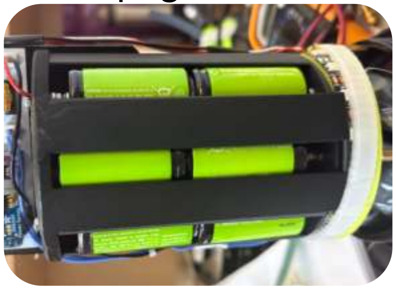

Figure 21. Float Batteries | The Rays

FLOAT TOPSIDE SOFTWARE

Our float, Torpedo Ray, communicates with our topside software, which allows the user to activate the float and visualize incoming data through graphs. The topside software is written in Python and uses Pyxel, a pixel-based graphics library, along with PyxelUniversalFont (PUF) to enable custom fonts and scalable text for improved readability. Pyxel offers fine control over the display, making the interface interactive yet straightforward. Communication with the float occurs via an XBee radio connected over USB serial using pySerial, a Python library for direct serial communication. This single-unit radio design is a significant improvement over last year's split system, requiring less hardware, reducing potential failure points, and simplifying debugging and code updates.

PRESSURE SENSOR

We added a pressure sensor to provide essential depth data to the system. This sensor feeds real-time information to the PID controller, allowing the float to respond accurately by descending, holding position, or ascending as needed. This automation helps maintain depth stability during tasks and improves overall system performance. Additionally, we installed a temperature sensor to prepare for future missions that may require environmental monitoring. While it isn't in active use yet, having it in place ensures we're ready for expanded data collection when needed.

FLOAT SAFTEY

We added LED lights for improved visibility so that divers, other ROVs, and our own ROV can easily see it. Protective feet are installed on the bottom to shield the penetrators when the float is not in use. A power monitor ensures we never deploy the float with a low battery. Additionally, we designed pop-off end caps that release pressure safely, preventing catastrophic failure.

Figure 22. Float with Lights on | The Rays

LAB PROTOCOLS

In our lab, safety is a top priority, and we follow strict protocols whenever working with tools, machinery, or electrical systems. Safety goggles are always worn when using equipment that could generate flying debris. During soldering, a ventilation fan is used to protect team members from harmful fumes. At least two people must be present when operating in or around the practice pool to ensure accountability and quick response in case of emergency. All systems and equipment must be powered down before leaving the lab to prevent electrical hazards. Closed-toe shoes are mandatory to protect feet from falling objects or sharp tools. To avoid short circuits, electrical components especially "electrical birds" are never placed on stainless steel tables. Keeping workspaces clean and organized is essential to avoid clutter-related accidents. Team members with long hair must tie it back to prevent it from getting caught in equipment. Fire extinguishers are kept nearby and accessible at all times. We ensure proper power regulation by avoiding overloaded circuits and using equipment according to specifications. Running is strictly prohibited in both the lab and pool area to minimize the risk of slipping or collisions. Additionally, all cutting machines must have their safety guards in place during use. These safety standards help maintain a secure and productive working environment for everyone involved.

BUDGET & ACCOUNTING

Our team begins each season by creating a detailed budget (see Appendix D), which includes estimated expenses based on both previous years' data and current project plans. This year, we incorporated cost estimates from each subsystem's bill of materials (BOM) and compared them with actual expenses from last season's ROV to improve the accuracy of our budget projections. Since our design follows a standard ROV platform, the budget primarily focuses on enhancements, new tools, and component upgrades. Additional expenses, such as transportation to competitions and meals, are estimated separately and typically covered individually by team members.

Our projected income includes funding from the Warrenton Hammond School District, community donations, and team members personal purchases. To ensure responsible financial management, all purchases require approval through a request system supervised by our mentor or coach. Receipts are tracked in a project costing spreadsheet, which is regularly reviewed to maintain budget compliance. The detailed cost report for this season is provided in Appendix D.

CRITICAL ANALYSIS

TESTING

Our testing philosophy centers around the principles of safety, effectiveness, and reliability. Because our company designs and builds custom ROVs for unique client missions, we rely on a structured and rigorous testing process to ensure that every system performs exactly as intended under real-world conditions. This process begins with verification making sure each component meets design specifications and progresses toward validation, where we confirm that our complete system satisfies client needs in the field. Testing begins early in the design process: mechanical systems go through simulation, surface testing, and in-water trials to confirm strength, buoyancy, and functionality; electrical systems are validated through simulation, power-on checks, and integrated bench testing; and software is refined from virtual simulations to physical test benches before being deployed. These parallel streams come together during full-scale ROV trials, where the complete vehicle is tested in mission-like environments, followed by dedicated mission practice runs. This continuous and layered approach to testing allows us to identify problems early, iterate rapidly, and ensure our final product is not only operational but also optimized for real mission performance. Our philosophy ensures that safety is never compromised, reliability is always achieved, and the final solution is truly mission-ready.

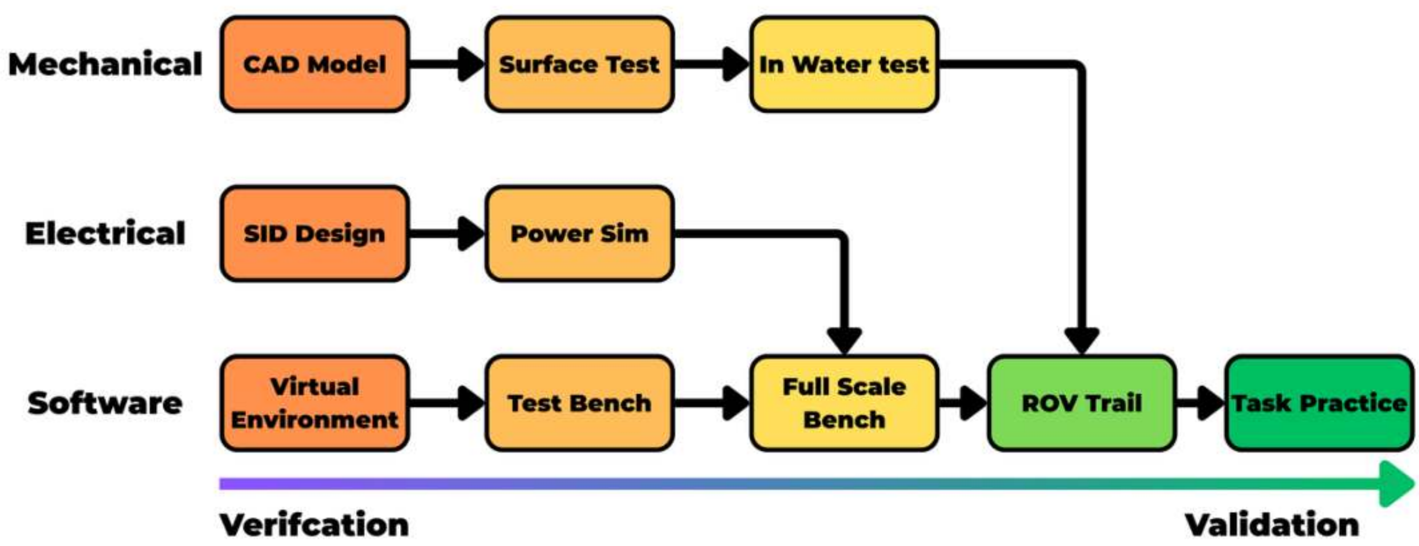

Figure 23. Testing Flow Chart | The Rays

TROUBLE SHOOTING

Troubleshooting was a critical part of our ROV development process, helping us identify and solve unexpected issues during real-world testing. One early problem involved the camera cable length. Although USB standards allow up to 9 feet, our 1080p cameras lost signal quality even at 6 feet. We systematically tested shorter lengths until we found one that maintained both image quality and refresh rate.

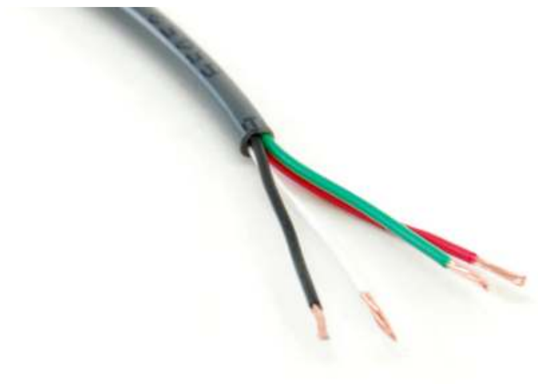

Figure 24. USB Camera Cable| The Rays

For the water pumping system, we chose to pump water directly to the surface to reduce onboard weight. We discovered the motor only worked in one direction, requiring a redesign of the claw mount. More importantly, we found that increasing the voltage from 9 to 12 volts cut the water transfer time in half—from 2 seconds to 1 second for 50 ml. Our initial plan to use dual 3D-printed claws with different grippers ran into issues with poor tolerances and the water-absorbing nature of PLA.

To ensure reliability, we switched to factory-made grippers. We also encountered performance issues with motor placement—four of the eight motors were blocked by internal parts, reducing thrust. Moving them to the outside of the frame significantly improved speed. However, drag from flat buoyancy mounts was still slowing the ROV. To fix this, we designed curved “speed plates” that reduced drag while preserving buoyancy.

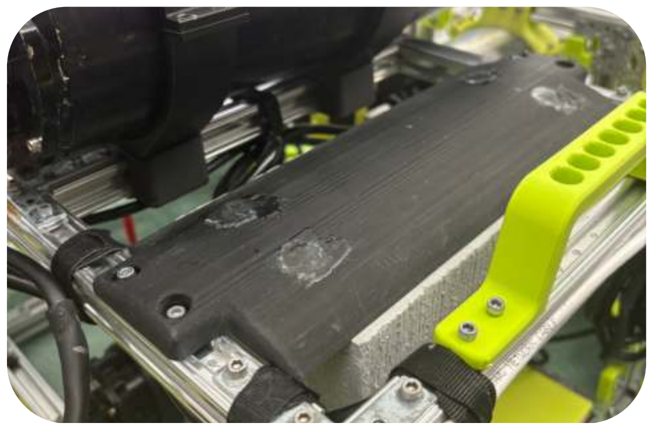

Figure 25. Speed Plates | The Rays

Finally, our photosphere imaging system had trouble stitching images cleanly. After adjusting the software and running multiple tests, we achieved a smooth and functional image output. These challenges helped us refine the design and improve the ROV’s overall performance and reliability.

SAFETY

Safety is a core value. Our motto, “Life and Limb before Mission,” means no task is worth risking harm to people, wildlife, or the environment. If it’s unsafe, we don’t proceed.

We use a Job Safety Environment Analysis (JSEA) listed as Appendix C Manual to identify hazards and enforce safety measures. Proper PPE is always worn, and every ROV deployment follows a detailed Safety Checklist to ensure readiness and risk awareness.

In the lab, strict protocols include wearing goggles, using fume fans when soldering, having at least two team members present, and powering down equipment before leaving.

Clean workspaces and safe practices prevent accidents.

Safety is built into our ROVs with thruster guards, corner covers, emergency shutoffs, and visible tethers. The float system includes pressure valves, stable feet, and power monitors to avoid failures.

Our commitment to safety protects our team, technology, and environment—always putting people before the mission.

ACKNOWLEDGEMENTS

- **MATE Center and Marine Technology Society – Donations of money**
- **National Science Foundation – For funding MATE**
- **Warrenton High School / Middle School – For providing us a place to work**
- **Our Coach and Mentor – For giving us the resources we need**
- **Sexton Corporation – Donation of money for winning regionals**
- **Our Families – For always being there for us and feeding us**
- **Hatfield Marine Center – For running the regional competition**
- **Sea Grant – For funding the Oregon MATE regional competition**
- **Ocean Schmidt – For their support of MATE**
- **Blue Robotics – For reduced rates on canisters**
- **Addie Earl - For being an associate of the poster**

Oregon State University

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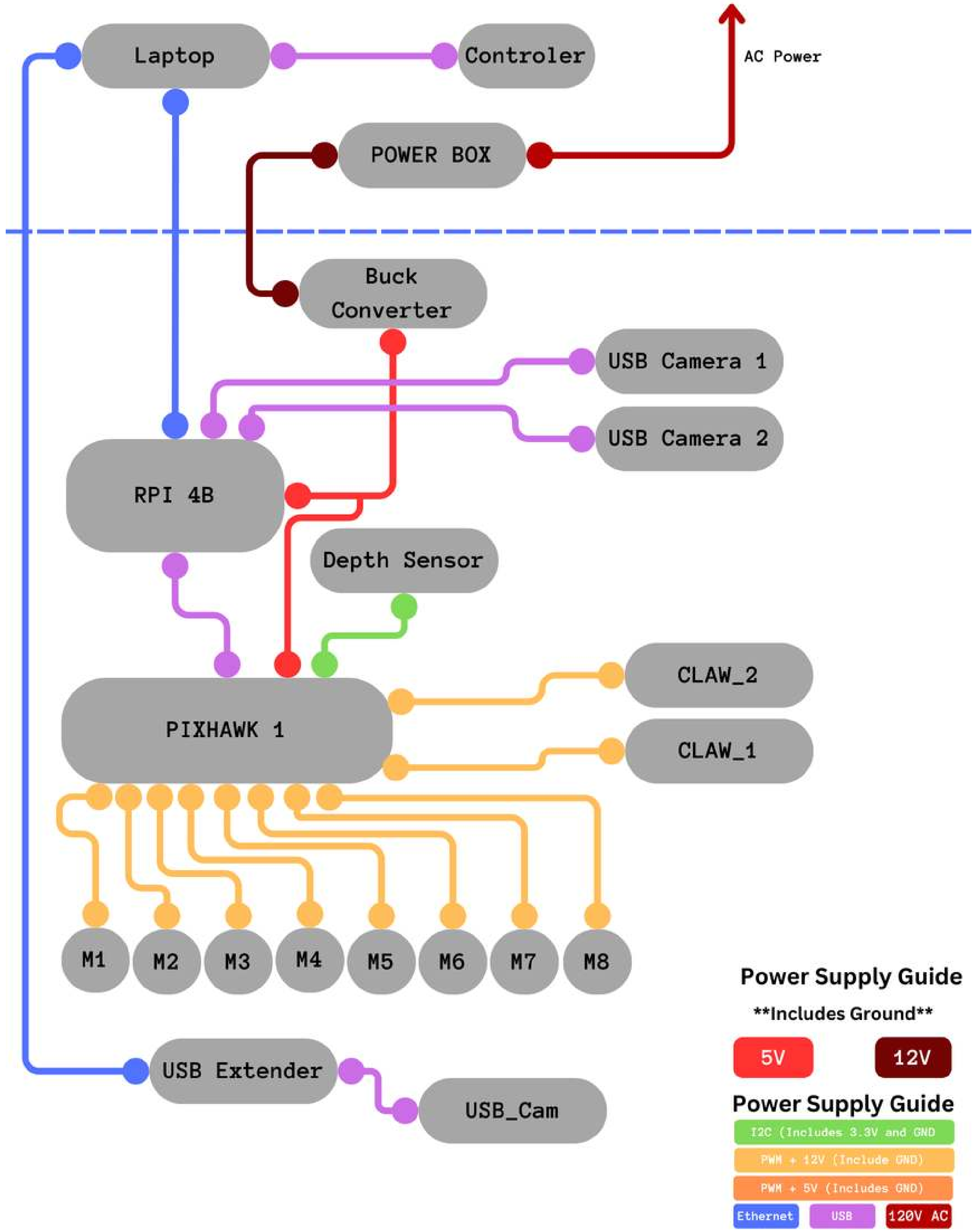
MATE ROV COMPETITION OREGON

NSF

Sea Grant OREGON

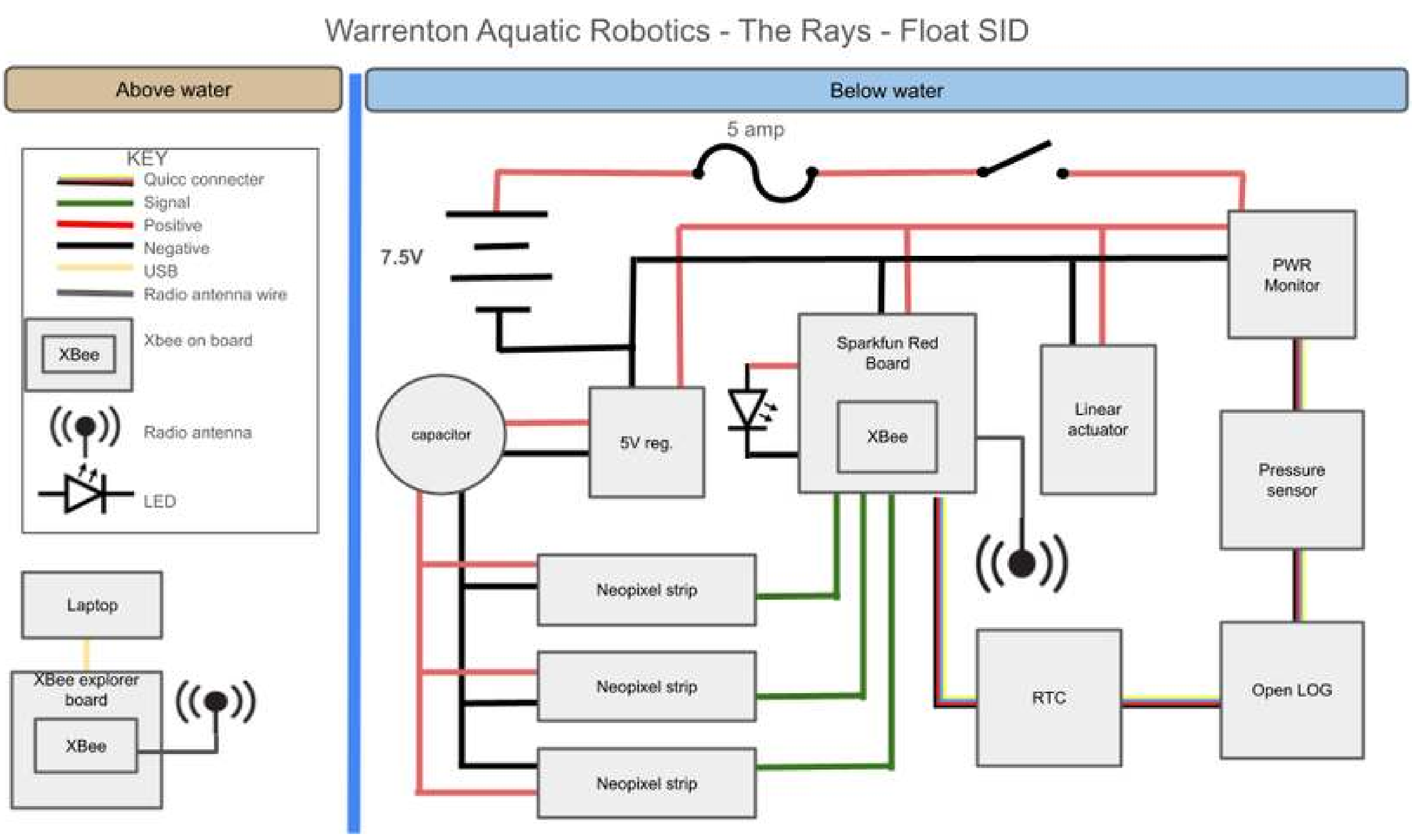
APPENDIX A: ROV SID & FUSE CALCULATIONS

Warrenton Aquatic Robotics | The Rays | ROV SID



ITEM	Amount	AMPS_per_ITEM	Total Amps
Motors	8	1.2 Amps	9.6 Amps
RPI 4	1	3 Amps	3 Amps
Claws	2	6 Amps	12 Amps
Cameras	2	.5 Amps	1 Amps
M.A.R.V	1	2 Amps	2 Amps
PixalHawk	1	.5 Amps	.5 Amps
		TOTAL =	28.1 Amps
(PSA THIS IS IF EVERY THING IS AT FULL RUN)			

APPENDIX B: FLOAT SID & FUSE CALCULATIONS



Item RED board with	Max amp taken (mA)
Xbee Pressure sensor	245
Real Time Clock PWR	0.002
reader Open LOG	0.022
Small Screen Linear	15
actuator Neo pixels	23
Total amps Fuse we	20
chose	450
	2050
	2803mA
	2.803A 5amp

APPENDIX C: NON-ROV DEVICE AND ROV JSA

Warrenton Aquatic Robotics

THE RAYS

JSEA

Entering/Exiting the Deck Area

TASK	HAZARDS	CONTROLS
1.Lifting moving ROV, tether and control	1a. Lift injuries	1a.1 Proper lifting techniques for ROV, tether and control 1a.2 Share load
		1b.1 Clear pool area of obstacles
	1b. Trip/Fall hazards	
		1b.2, 1c1 Sturdy, closed toe shoes
	1c. Foot injuries (dropped ROV)	1c.2 PPE (hard hat, safety glasses and high visibility clothing)
	1d. Equipment damage	1d.1 Movement procedures
	1e. Electrical shock hazards near water	1e.1 Ensure GFCI/fuses on power

System Set Up

TASK	HAZARDS	CONTROLS
1.Prepare ROV	1a. Open pressure release floods electrical 1b. Loose connections	1a.1 Ensure the pres\sure release valve is closed.
		1b.1 Connections verified before power up
2.Deploy tether	1a. Trip hazard	1a.1 Tether and props laid out per plan
3.Connect Controller	1a. Electrical shock/flash hazards	1a.1 Power supply and controller OFF
		1a.2 Safety glasses

Pool Side Operations

TASK	HAZARDS	CONTROLS
1.Launch/Recover	1a. Lifting	1a.1 Design < 15kg
		1a.2 Lift training
	1b. Rotating/Moving equipment	1b.1 Danger areas marked
		1b.2 Procedures defined
		1b.3 Communication training tether manager, pilot and assistants

System Breakdown

TASK	HAZARDS	CONTROLS
1. Power Off	1a. Electrical shock	1.a.1 Dry hands
		1a.2 Control power/Supply power off 1a.1 Components designed < 15kg
	1a. Lifting strain	
2. Lifting ROV, controller and tether	1b. Foot injuries (dropped components)	1a.2, 1b.1,1c.1 Proper lifting techniques for ROV, controller and tether
		1b.2 PPE - sturdy closed toe shoes

Power Up Checks

TASK	HAZARDS	CONTROLS
1.Power up	1a. Electrical shock 1b. Rotating/moving equipment 1a. Rotating equipment pilot to tether	1a.1 Standard procedure 1a.1 Communication
		1b.1 No loose clothing/hair tied back
2.Motor Test		manager per procedure

Float operations: Daniel Myrvold and Micah Larson, Pilot: Dalton Wallace, Scientist: Owen Cross, Tether management: Declan Wallace.
Created: May/2025

APPENDIX D: ROV/FLOAT BUDGET AND COST ACCOUNING

		Item	Unit Price	Amount Used	Total Price	New Or Used
Mechanical	Frame	336mm X-rail	$9	8	$72	Used
		120mm X-rail	$5	8	$40	Used
		192mm X-rail	$6	12	$72	Used
		96mm X-rail	$5	4	$20	Used
		45 degree Bracket	$3	16	$48	Used
		Flat Bracket	$1	38	$38	Used
		Nuts	$0.40	250	$100	Used
		Screws	$0.50	250	$125	Used
		Summary			Total = $515.00	
	Ballest	Hex Screw	$0.19	4	$0.76	Used
		90 Degree Corner Bracket	$2.50	8	$20	Used
		Butterfly Nut	$1.38	4	$5.52	Used
		Washers	$0.23	38	$8.74	Used
		Summary			Total = $35.02	
	Buoency	High Dence Foam	$2	1	$2	New
		Summary			Total = $2.00	
	Gripper	Newton Subsea Gripper	$640	2	$1,280	Used
		Summary			Total = $1,280.00	
	Enclosure	4in Water Tight Enclosure	$330	1	$330	Used
		2in Water Tight Enclosure	$52	2	$104	Used
		4in O-ring Flange	$45	2	$90	Used
		4in 14 Hole End Cap	$32	1	$32	Used
		4in Blank End Cap	$30	1	$30	Used
		2in 4 Hole End Cap	$34	2	$68	Used
		2in Blank End Cap	$30	2	$60	Used
		3in Water Tight Enclosure	$150	1	$150	New
		3in Penetrater End Cap	$16	1	$16	New
		3in Dome	$32	1	$32	New
		3in O-ring Flange	$35	2	$70	New
		Pressure Relief Valve	$28	4	$112	Used
		6.5mm Penetrator	$12	2	$24	Used
		7.5mm Penetrator	$12	2	$24	Used
		5.5mm Penetrator	$12	2	$24	Used
		Summary			Total = $1,166.00	
	Propulshon	Diamond Dynamic Thrusters	$64	8	$512	Used
		Summary			Total = $512.00	
	Misc	Filament	$25	3	$75	New
		Summary			Total = $75.00	
		Summary Of All			Max Total = $3,585.02	

		Item	Link	Unit Price	Amount needed	Total Price	Do we have it
Electronics	Visual System	Ultra wide Rasberry pi Cam	Link	$36.99	$1.00	$36.99	No
		Usb Breakout board	Link	$6.49	1	$6.49	Yes
		Usb Camera	Link	$18.99	4	$56.97	No
		4K Pi cam	Link	$86.00	1	$86.00	No
		Summary		Total = [illegible]			
	Proccers	Rasberry pi 4 B	Link	$35.00	1	$35.00	Yes
		Pixahawk 4	Link	$159.99	1	$159.99	Yes
		Arduino Uno	Link	$21.50	1	$21.50	Yes
		Summary		Total = [illegible]			
	Sensors	Temp Sensor	Link	$14.95	1	$14.95	No
		Depth Sensor	Link	$17.99	1	$17.99	Yes
		Summary		Total = [illegible]			
	Power	5 postion power rail	Link	$6.50	1	$6.50	Yes
		Buck Convter	Link	$7.99	1	$7.99	Yes
		3.3V buck Conveter	Link	$5.95	1	$5.95	No
		5V buck Conveter	Link	$6.95	1	$6.95	No
		Summary		Total = [illegible]			
	Extra	Logic Converter	Link	$3.50	1	$3.50	No
		Qwic hub	Link	$2.50	1	$2.50	No
		Pico Buck	link	$17.50	1	$17.50	Yes
		USB C Breakout	Link	$7.99	1	$7.99	Yes
		Micro USB Breakout	Link	$7.99	1	$7.99	No
		USB Booster	Link	$42.99	1	$42.99	Yes
		Summary		Total = [illegible]			
	Connectors	Power Connector	Link	$49.90	1	$49.90	No
		Ethernet Connector	Link	$28.99	2	$57.98	No
		16 pin quick connect	Link	$22.00	1	$22.00	No
		2 pin power connector	Link	$15.99	1	$15.99	No
		XT60 H connector	Link	$7.99	1	$7.99	Yes
		Jumper Connectors	Link	$12.99	1	$12.99	Yes
		Ferrule crimmpling kit	Link	$17.99	1	$17.99	Yes
		Summary		Total = [illegible]			
	Wire	100 foot ethernet cable	Link	$14.95	2	$29.90	No
		14 gauge cable	Link	$74.99	1	$74.99	No
		Servo Wire	Link	$14.80	2	$29.60	No
		14 gauge wire	Link	$16.99	1	$16.99	No
		Summary		Total = [illegible]			
	Motor	Water proof motor	Link	$64.00	8	$512	Yes
		Servo Motor		$48.00	2	$96	No
		Summary		Total = [illegible]			
	Hardware	M3 Stainless stell	Link	$9.98	2	$19.96	Yes
		M3 Stainless Black	Link	$7.99	2	$15.98	Yes
		M3 Brass Standoffs	Link	$10.99	2	$21.98	Yes
		Summary		Total = [illegible]			
	Summary (All new)			Total = [illegible]			
	Summary (With Have/Don't have)			Total = [illegible]			

		Amount	Cost	New/Reused
Float	PCB	5	$20	new
	liniar acuator	1	$70	new
	syringe	1	$4	reused
	Arduino	1	$23	reused
	RTC	1	$19	reused
	Xbee	1	$22	new
	Xbee board	1	$12	new
	openlog	1	$19	reused
	presure sensor	1	$27	reused
	5v regulator	1	$7	new
	fuse	1	$10	reused
	battery charger	4	$20	new
	batteries	12	$51	new
	entena	1	$7	reused
	enclosure	1	$300	new
	end caps	2	$90	new
	dome	1	$40	new
	Temp sensor	1	$20	reused
	Qwiic	1	$2	reused
	Battery reader	1	$10	new
	on off switch	1	$25	new
	LEDs	1	$14	new
	battery holder	4	$20	new
	ballest	1	$4	
	Total	45	$836	

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