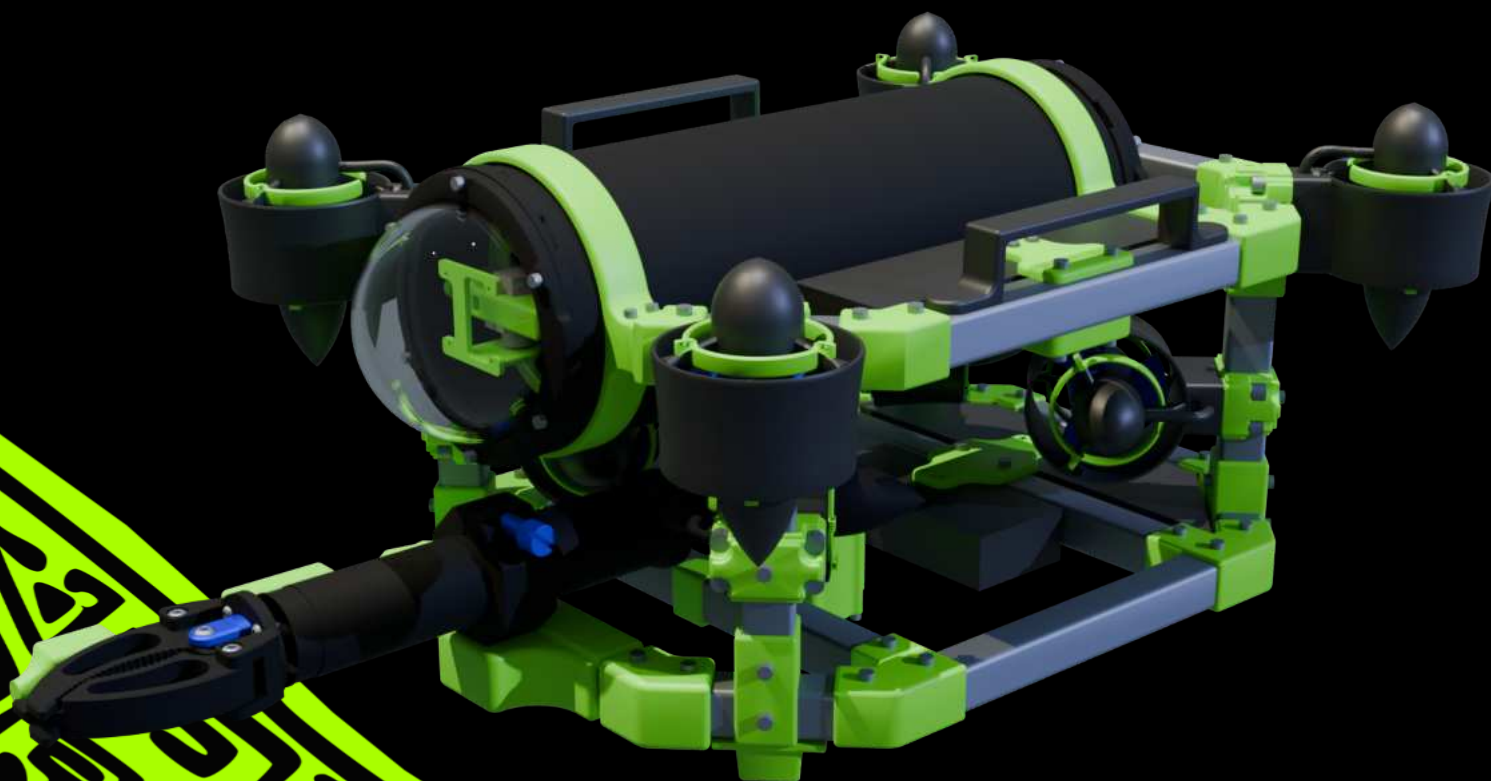


W.A.R. THE RAYS

Warrenton, Oregon, USA

TECHNICAL DOCUMENT

2025-2026



Team Member:

Dalton Wallace★	Chief Executive Officer	Pilot	Class o' '27
Daniel Myrvold★	Chief Technical Officer	Backup Pilot	Class o' '29
Micah Larson★	Chief Float Engineer	Scientist	Class o' '28
Addison Scull☆	Chief Marketing Officer	Float Specialist	Class o' '28
James Hallock☆	Associate Engineer	Tether	Class o' '27
Quinn Yuill☆	Associate Float Engineer	Co-Scientist	Class o' '27

Mentors: Heidi Lent, Craig Battles

☆ - New Members,

★ - Returning members

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Abstract

The Rays, a branch of Warrenton Aquatic Robotics, is an underwater solutions company comprised of Warrenton High School students based out of Warrenton, Oregon, USA. Our company's mission is to design and manufacture innovative technology to help improve the vitality of our planet's cryosphere, oceans, and waterways.

The BattleBot 2 is our newest innovation that builds upon the successes and addresses the flaws of our previous iteration. A dual camera system was developed to allow safe maneuvering as well as taking advanced 3D image scans of coral reefs; a float was designed that records temperature over depth to study ongoing climate change. We also reduced the size of our ROV significantly, making it lighter, faster, and more maneuverable. We are constantly evolving to aid in the preservation of our oceans and educate our communities about them.

Teamwork and Project Management

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 environment and its native species are the primary targets for this year's engineering goals. Each task was split up between three different departments: The ROV department, the AUV department, and the writing and research department. Along with the 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, and JSEAs were 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 grades 9 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 to 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.



Company Members L-R: Dalton, Micah, Daniel, James, Addison, Quinn. Photo credit: Maddison Hing

The Rays are made up of six people, each with their own tasks and responsibilities. Our team includes: Dalton Wallace, CEO, mechanical engineer, safety officer, and pilot; Daniel Myrvold, CTO, electrical engineer, treasurer, and backup pilot; Addison Scull, marketing officer, and float specialist; Micah Larson, float engineer, and scientist; James Hallock, associate mechanical engineer, and tether management; Quinn Yuill, associate float engineer, and co-scientist.

Project Management

Maintaining organization and time management are key to ensuring our company's success when showcasing our final products. The Rays started by creating a regular work schedule and weekly team meetings on Tuesdays. From there, we designed a statement of work, creating guides of dates for when certain aspects of our projects were supposed to be done. This helped our different departments work to achieve goals within the design process.

Department	Task	Start	End	Status
Mechanical	Design	Jul	Aug	Complete
Electrical	Design	Aug	Sep	In Progress
Software	Design	Sep	Oct	In Progress
Mechanical	Manufacture	Oct	Nov	In Progress
Electrical	Manufacture	Nov	Dec	In Progress
Software	Manufacture	Dec	Jan	In Progress
Mechanical	Test	Jan	Feb	In Progress
Electrical	Test	Feb	Mar	In Progress
Software	Test	Mar	Apr	In Progress
Mechanical	Assembly	Apr	May	In Progress
Electrical	Assembly	May	Jun	In Progress
Software	Assembly	Jun	Jul	In Progress

Design Rationale

Design Methodology

When The Rays fabricates a new product, we start by making a list of design requirements. These requirements range from mandatory safety features to nonessential implementations that make the product more aesthetically pleasing and user-friendly. Building off last year's BattleBotV2, our design

requirements were all about promoting our product to the next level while still maintaining MATE guidelines, safety priorities, and machine functionality. Once we have our list of design requirements, we can start our concept development stage.

The Rays start by using mind maps, sketching out our subsystems and possible solutions for each subsystem. From the mind map, we create a schedule to follow and ensure we get the task done in a timely, structured manner. Using trade studies and weighted decision matrices based on our design requirements, we can filter out some of the concepts we brainstormed. This prevents us from hitting a local maximum with our design and allows us to start on the right track. Some of these trade studies were about what sensors we should use, what microprocessors, or what thrusters to use. You can find our thruster trade study on page 8.

Innovation

Our company strives to design and build whatever we can from scratch. The BattleBot 2 has been modified from its previous version to be as efficient as possible. It has a gripper for picking things up, eight thrusters for all axes of movement,

and cameras so we can have a visual of what we're doing. We didn't create all of this overnight. The BattleBot 2 is a result of many years of work and research, finding new ways to do different tasks or better components to use for certain parts of the machine. Our most recent addition is a custom-designed 3D hook tool, perfect for carrying multiple props up to the surface and saving a lot of time. (More in-depth hook description on page 9)

Problem Solving

In our concept development stage, we try to come up with seven different concepts for each subsystem. We find that 'seven ways' gives us a good number of ideas to consider, while not taking up too much time to consider each idea. To come up with these ideas, we start by sketching out our subsystems on a mind map. Then, as a team, we talk and share our mind maps for the projects we are working on so we can brainstorm ideas together. We would complete this together with our weekly status and working meetings. By doing this, we can make sure that we shed light on every avenue and make sure we are not missing anything.

Once we have our seven concepts, we do a trade study for each subsystem. We take the design requirements for that subsystem, and we put quantitative values for each design requirement. These values could be how much thrust a thruster puts out or how many amps the microprocessor pulls. Once we have values, we can find the concept that fits our design requirements best. That way, we can make sure that when going into the design stage, we have the best ideas.

Systems Approach

One significant thing our company did this year was to contain all our electronics in one enclosure. This helps with our downsizing of the frame because less space needs to be taken up by having multiple enclosures throughout the machine. With our single aluminum tube, we had the space to shrink the frame and make our frame that much smaller and more efficient.

Vehicle Structure and Systems

Vehicle Structure and Frame

Octagonal Shape - The octagonal shape of our machine offers an ideal shape for mounting vectored motors, cameras, tools, and canisters. Building a reusable and modular frame was crucial because the shape offers more options for our vehicle's maneuverability, visibility, and aesthetics.

Material: Constructing a "Four Year Frame" was the fundamental design concept when initially designing the frame, so we had to narrow down our options for frame materials. The considerations included PVC, HDPE, goRail, fiberglass, and 3D printing. From these options, we decided that goRail was the perfect choice to construct the BattleBot. This is because of the affordable cost, modular capabilities, and ease of construction and fixing, as it only needs one tool to put together. These features ensured that our frame could be expanded upon for the next four years of BattleBot iterations. At least that is what we had thought until the company ServoCity discontinued the goRail system. From here, we have had to

learn to adapt to the limitations of resources that we now have by keeping our design choices prudent and conservative.

This year, the team decided to make the frame smaller, which would improve our ability to get from one place to another, ease of transport, and ability to do some tasks. The overall volume of the ROV is smaller by 54%. The improved frame also has custom-cut goRail ends that fit together without gaps; this reduces the chance of cutting anything and is much easier to fit into the custom 3D printed brackets. By doing this, we reduced the number of brackets and screws, the cost, and the weight as well.

The new motor mounts and corner brackets are printed out of PETG, saving the number of screws needed and lessening the overall weight of the machine by eliminating metal corner brackets. The weight decreased by roughly 7.7 kg. Another advantage of using PETG is that it does not absorb water as much as PLA; therefore, it won't affect the buoyancy of the machine during



The Battle Bot's Tube
Photo Credit: Micah Larson

flight. The mount design was also integrated into the frame structure, which places the motors precisely where we want them for maximum thrust, movement, and speed.

This canister is Blue Robotics 100mm x 300mm aluminum. Since it's made of a composite metal, it can withstand high pressures. With this in mind, we decided to put all our electronics in it for a safe place to keep them under the water. Having the electronics under the water allows for fewer wires in the tether. The metal canister also helps cool the electronics housed inside the tube by acting as a heat sink.

Electrical and Control Systems

Electronics

This year's electronic system utilizes 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 like the

gripper, lights, and auxiliary tools, we utilize a Pixhawk 4 running ArduSub, an open-source firmware designed for underwater vehicles, and made to pair with blue OS. 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 for advanced features such as AI-driven video enhancement and real-time object detection. See Appendix B.

Software

The Ethernet cable from the ROV is directly connected to the topside laptop, establishing a network interface with the Raspberry Pi onboard the ROV. Through this connection, we access the Pi's network, enabling the operation of Cockpit, a control software integrated with BlueOS. This system features a customized user interface that can be tailored specifically for our ROV, providing seamless control and



The BattleBot's Control system
Photo Credit: Micah Larson



The BattleBot's Control system
Photo Credit: Micah Larson

real-time monitoring of all functionalities.

The ROV is powered by a Raspberry Pi running Blue Robotics open-source software, BlueOS. Connected to the Raspberry Pi is a Pixhawk 2.4.8 flight controller, loaded with the latest version of ArduSub. This combination enables precise control and seamless integration with our custom features, ensuring optimal performance and adaptability for complex underwater operations.

Control System

To control the ROV, we utilize an Xbox controller connected to the topside laptop via Bluetooth. Through CockPit, we are able to assign personalized key bindings and control configurations. The integration with the topside laptop is facilitated through the Bluetooth connection, enabling seamless communication between the controller and the ROV's control systems. With two monitors - with the bottom camera view on one and the main navigation and claw view on the other - with the main one having all the telemetry data showing,



A green Xbox controller used to pilot the BattleBot
Photo credit: Heidi Lent

like the depth, temp, and accelerometer data. This helps with piloting to allow the pilot to see all the data that is needed to pilot

Electrical Setup

Our electrical setup this year is simple: only one half of the tube is used for our major control boards, and the other half is used for wiring. This makes the inside of our tube really easy to use and add more stuff if needed. Up at the top, we just have a small box that houses our fuse, emergency off switch, and volt amp meter, along with our computer.



The BattleBot's Tube (inside)
Photo Credit: Daniel Myrvold

Image Recognition Software - Invasive Species ID

Our invasive species detection software uses OpenCV and RoboFlow Inference to efficiently and accurately identify invasive species. The detection UI is written in Python and uses asynchronous flow control to keep graphics real-time, as well as process inferences in the background.

Propulsion

The Rays designed and ran an extensive Motor Thrust Test to compare three different motors that we had to choose from. The Diamond Dynamic Thruster performed very similarly to the M100 thruster. With this data, the team decided that the cost of the Diamond Dynamic thrusters vs. the M100's was significantly cheaper and therefore an easy decision to choose the Diamond Dynamic thrusters.



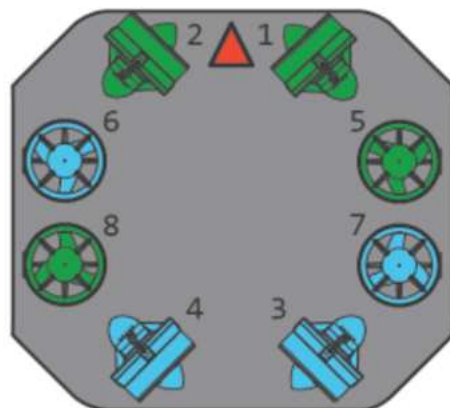
Having eight Diamond Dynamic thrusters instead of six provides significantly more efficient thrust distribution, ensuring balanced and consistent performance. The additional two motors enable a vectored thrust configuration. They are positioned at 45° angles at each corner of the frame. This arrangement, combined with motor mixing software, allows for precise and controlled movement through the water.

The four vertical motors, positioned at each corner of the

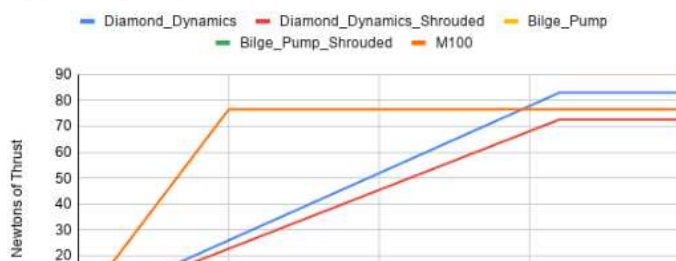
ROV's frame, work with the IMU to enable automatic leveling and maintain proper orientation. This setup also allows manual angle adjustments, providing flexibility for navigating tight spaces and completing complex tasks.

We realized that an octagon was the perfect shape to mount all eight motors. This saved costs by reducing the number of 3D parts needed for the corners.

We designed and built custom, 3D printed shrouds because the shrouds we had previously on our thrusters did not meet MATE safety requirements. The desire was for shrouds that met requirements, are easily maintained, and are aesthetically pleasing. They also must not reduce the effectiveness of the thrusters. Our testing last year provided guidance to reduce the frontal area and improve the free area on either side of the thruster propellers. We tested the safety



Motor Thrust Test



coverage with our little fingers (not while the thruster was running). The resulting shrouds provide safety, performance, and a professional appearance for our product. The shrouds are also cost-effective and easy to replace.

Buoyancy and Ballast

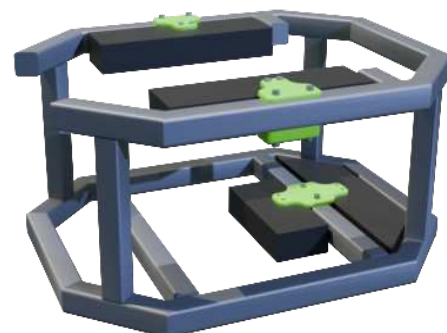
For our buoyancy this year, we wanted an option that wouldn't compress under pressure, supply good buoyancy, and would be cheap. With these requirements, we did some looking at potential options: PU foam, pool noodles, and buoyancy tubes.

During testing, we found that the pool noodles tend to compress at greater pressure and lose their buoyancy capabilities. Due to that problem, we decided that we wouldn't use pool noodles. Our next option is the buoyancy tubes. These tubes fit all of the requirements perfectly. The only problem is that they are way too hard to work with and to get consistent. Another problem with this option is making the proper-sized tube to give the ROV just the right amount of buoyancy.

Since those two options were eliminated, we were hoping that PU foam would work. We tested how much pressure the foam could handle. We tested this by standing on it; the

foam was so strong that it was able to withstand our body weight (145-160lb). We decided that the foam passed that test with flying colors. We also found out that it's very cheap at about \$0.01-\$0.05 per cubic inch of foam. With it being very cheap and not as compressible, we just had to see how buoyant it is. We did a little testing with an 8 lb weight. This new foam was much more buoyant than the pool noodles. With the PU foam fitting within all three of the requirements, we decided that the PU foam would be the best option for our machine this year.

For the ballast, our company ran into an issue. The main problem we ran into was the fact that our machine was way too positively buoyant in the front. We counteracted this by removing all of the buoyancy in the front. We thought that no buoyancy in the front of the ROV would bring the nose down, so we could drive. We couldn't have been more wrong. The nose of our ROV was still way too buoyant. We then looked at ways that we could attach weight to the front. We looked and thought



The BattleBot's Buoyancy
Photo Credit: Micah Larson

of ways, and decided that there was no way that we would be capable of adding weight to the frame. As one of our team members was working on the float, we came to the realization that the ballast doesn't have to be on the outside; it can also be on the inside. We then took a small bag of BB's and placed it into the front of our enclosure. Adding this small bag increased the density of the enclosure, making the ROV perfectly buoyant.

Payload and Tools

For our tools, we looked at what extras were needed for the mission tasks and how our machine could complete these tasks. The tasks this year required very few tools. The first tool we made this year was a lift bag. Now this lift bag is made out of a 2L soda bottle. We wanted to use a soda bottle instead of the normal balloon because it is a lot harder to pop a soda bottle than it is a balloon. In order to fill this bottle, we ran a tube down to it that is connected to its cap. To actually fill the bottle with air, we attached a bike innertube fill valve to the other end of this tube.

For the buoy container, we had to make a spool of wire that would connect to it. Our Company decided to accomplish this by making a spool system that would be rigid and work.

We 3D printed a spool, so then we didn't have a problem with the wire catching onto anything on the ROV. With this spool, we have a paracord wound up in it. At the very end of the cord, we have our in-house-made carabiner.

To attach these tools to the mission. We needed a carabiner system that wouldn't fail. We thought about buying and modifying a carabiner from Home Depot. We made our own carabiner out of PETG. We decided that we needed to make one because ours takes less force to open. With us being able to make ours in-house, it allows us to make it with very little cost. With it being so cheap, we can sell it to many people.

This year, we also decided that we should have a hook. This is because the eDNA and the oil platform port cover have a string to pick them up from, and if we can pick those up with a hook, we can take them both up at once and have our claws open. Our hook is designed to be both removable and to keep the string on, so they don't fall off when moving. So we have a hook on both the back and the front, making sure the string can only be easily taken off by hand and not by moving. It is also designed to have a magnet at the end for picking up small metal pins or anything like that.

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.

- Primary Camera: Mounted inside the main tube on a gimbal made in-house to provide a comprehensive view of the ROV for navigation.
- Secondary Camera: Positioned at the bottom, pointed down, allowing us to see the ocean floor and take easy pictures to analyze.

This digital system minimizes latency, reduces power consumption, and decreases tether bulk, significantly improving reliability, maneuverability, and reaction time.



Gripper

This year, for a gripper, we were going to make our own in-house for these reasons:

- The gripper is made out of PETG, which makes it very light and cheap. The gripper being light means we don't have to put a counterweight in the back of the ROV. This new gripper should be lighter than two Blue Robotics claws. This gripper will have 6 axes of movement. This much movement allows the ROV to grab a variety of things from many different angles.
- The gripper is based on a Gradual excavator. We decided to go with this design because it has a higher amount of stress tolerance.

In the end, we didn't end up finishing our in-house gripper due to time constraints. Because of this, we decided to stick with the same claw we have used for the past few years; this claw is Blue Robotics' Newton Subsea Gripper.



Tether

The goal for this year's tether design was simplicity. To achieve this goal, we minimized the number of cables required to operate the machine from six to two. We also improved buoyancy systems by including a foam buoyancy line to give our cable neutral buoyancy, thus improving ROV maneuverability in the water. An industry-standard yellow hi-vis sheath was implemented for on-deck safety for machine operators. This year, we also added multiple floats on the tether to assist in keeping the tether more upright and on top of the surface. This would keep the tether from interacting with the environment in a negative way. Another major improvement to our tether this year is the incorporation of a waterproof quick connect to make transportation easier.

Float Design - Torpedo Ray V2

Our float, *Torpedo Ray*, was designed for simplicity, reliability, and functionality. Communication between the float and our topside software is handled via a RYLR LoRa radio over USB serial using pySerial. Our topside interface, built in Python using Raylib and Matplotlib, allows for

responsive user input and real-time data visualization. The float's onboard software is written in C and uses a state machine to guide it through Waiting, Descend, Ascend, and Relay states. This logic allows the float to collect pressure data during each profile and wirelessly upload data to our automated graphing system. A pressure sensor and RTC allow precise control and timed actions, while a Teensy and Arduino Nano run the system and store data on an SD card via OpenLog. Safety features such as LED strips for visibility, a battery monitor, pop-off end caps, and protective legs were added to ensure operational security and easy recovery. See Appendix C.



The Torpedo Ray
Photo Credit: Micah Larson

Mechanically, we improved efficiency and modularity. We integrated a smaller, faster linear actuator into a reused buoyancy engine mount to control depth accurately with fewer delays. A larger syringe allows quicker vertical

movement, and a custom-designed acrylic tray keeps components neatly organized with two-sided mounting for space-saving. Our new, larger, clear canister houses a custom PCB, NiMH batteries, and extra room for future sensors, with 3D-printed BB containers providing ballast. The custom PCB reduces wiring by connecting components via onboard routes and connectors, and if it breaks, everything is easily unplugged and swapped. Penetrators were grouped into a new custom end cap for quick access to the on/off switch, temperature sensor, pressure sensor, pump, and buoyancy engine. Altogether, these design decisions allowed us to focus more time on refining software and electronics while ensuring the float is adaptable, stable, and competition-ready.

Top Side Software

Our topside software interface (TSI) is built upon Python's binding for the Raylib graphics library, which allows for performant, real-time, and effective graphical interfacing. The TSI also uses Matplotlib to produce and display runtime-generated graphs. Our TSI makes use of PySerial to send and receive the AT commands that our RYLR two-way radios use, as well as regex to parse and extract necessary data from incoming AT responses.

On-board Software

We programmed our float with C, making sure to include all the necessary libraries, such as libraries for transmitting through the RYLR, the PID controller, and libraries for all the sensors. We are using what's called a State Machine, which just makes the float transition between different states and makes it easier to edit different parts of the software. The custom-designed software program employs a state machine with four states: Waiting, Descend, Ascend, and Upload. It starts in waiting while it collects the surface pressure and awaits the dive command. After receiving the dive command, it moves into the Descend state. It then dives to a depth of 2.5 meters in the pool and stays there for 30 seconds, collecting a pressure measure every 5 seconds. Once its time is up, it moves to the Ascend state, in which it hovers for 30 seconds, then repeats the vertical profile before uploading the data.

Float Mechanical

This year we bought a new, clear, & bigger tube so we have more space for a larger PCB, c-cell batteries, and more sensors. Having more space also leaves room to improve and make changes that might be necessary next year and the

years after that. Inside the canister, we've custom-designed and 3D printed containers for BB's to add four pounds of weight to ensure the float will sink when it needs to. We designed a custom end cap to hold all the penetrators that we need, including: an on/off switch, the temperature sensor, a bike pump, the pressure sensor, and one for the buoyancy engine.

We designed a custom laser-cut acrylic tray with mounts for the PCB, the batteries, the buoyancy engine, and more. Doing this helps make it look neater and has the ability to change if necessary. This also makes it so we can mount components on two sides to conserve space.

Electrical System

We designed and sourced two custom PCBs, allowing minimal wiring. These PCBs connect every component via routes on the boards. We also included pin sockets and JST connectors, so each part just needs to be plugged in. This modular system allows us a greater degree of serviceability.

We added a pressure sensor for the needed data and to tell the PID controller what depth we are at, so the float knows when to go down, stay in one place, and then go up. We added a temperature sensor for

future use when we might need it. On the PCB, the float uses a Teensy 4.1 with an integrated transflash card reader and RTC, making a more compact system by using fewer components. There is also a battery reader that reads how much voltage and amps are left in the batteries, so we don't send it into the water with a low battery. We are using a separate processor to control our individually addressable LED strips, which allows for the heavy GPIO load but low computational load of our lights to be outsourced to a less sophisticated microcontroller to be run in parallel. We also added LED light strips inside the tube to add a cool factor and to make it more visible for our ROV machine and the diver who might be near it.



The Torpedo Ray's batteries
Photo Credit: Micah Larson

Similar to last year, our company is using 6 NiMH (Nickel Metal Hydride) batteries. With NiMH

batteries, we get 7.2 volts and 5 amps no matter what. We need at least 5.5 volts and 2 amps to run our system. Batteries are placed at the bottom of the float - this acts as ballast to keep the float upright. Our buoyancy engine utilizes the same linear actuator as last year due to its quick response and large capacity. These features allowed us to complete last year's stabilization-based tasks. Our buoyancy engine also allows us to hover at our two new designated depths.

Build vs. Buy and New vs. Reused

Build vs. Buy

Compared to last year, we built more things. To start, we built custom corner brackets for all of our goRail; this cuts a lot of cost from the metal store-bought brackets. We also made our entire inner tray for our tube. This allows us to organize things how we want with very little cost. Everything green on our machine is custom-designed and 3D printed in-house. Our company also spent time building a gimbal for our main drive camera. We bought all of our control boards, our tube, and our claws. We did this to save time designing all the complex parts, while

still maintaining very high-quality parts.

New vs. Reused

This year, we reused just about everything, such as our goRail, enclosures, claw, tether, motors, and control system. We did this because we spent a lot of money on these parts and want to make the most out of them. They also work perfectly for what we need. Something new this year is our gimbal for the camera, and the tether quick connect. These are some great parts that help improve the ROV's ability to do tasks, along with our ability to transport the ROV.

Safety

Safety Philosophy - "Life and Limb Before Mission"

The Rays value all living things and will make sure that no person or other living thing will be harmed prior to deploying their machine. *If we can't do the mission safely, we won't do it.*

Our company values safety as the number one priority. We have set procedures for everything we do in our Job Safety Environment Analysis manual. This manual lists the hazards

we might run into, such as airborne particles when sanding or hot metals when soldering. Our manual states the safety precautions and the proper PPE required for every task. This may include wearing a respirator and safety glasses when sanding or soldering in a ventilated area with safety glasses. On top of the JSEA manual, we have checklists set in place for the operation of the ROV. These checklists follow the JSEA manual and list what we need to do for the safe operation of the ROV. When we design our ROVs, safety is a must-have design requirement. We want our machines to operate safely and pose no danger to our global ecosystem. To do this, we have included: thruster shrouds that meet an IP-20 standard, tools to protect the ROV when maintenance is being done, handles to aid in the transportation of the ROV, warning labels to communicate hazards, and many fail checks in the code to prevent any loss of control. You can see our safety checklist in Appendix E.

When working with any equipment, we make sure that these key things are happening:

- Safety goggles when working with anything that could fly.

- Soldering w/fan (to keep lungs healthy).
- Two people minimum in the practice pool area.
- Turn off EVERYTHING before leaving the lab.
- Closed-toed shoes.
- No electrical boards on the tables (they're stainless steel).
- Always have a clean/safe work area(s).
- Long hair tied back.
- Proper power regulation.
- No running.
- Safety guards on cutting machine(s).

If all of those are being followed, then we don't have to worry about a hospital bill.

ROV Vehicle Safety Features - Tether Connector, Pressure Release Valve, etc.

Safety in the pool/ocean is just as important to us as safety in the work area. So we have incorporated all of these safety features into our machines.

- Three feet on the machine (To eliminate wobbling).
- Handles (Safe spot to grab).
- Shrouds (No loss in fingers)

- Tether strain relief - on both ends (Just in case it gets caught).
- Pressure valve (Don't want to make a bomb).
- Rubber grommet penetrators (To waterproof the internals).
- Hi-Visibility sheath (So no diver gets tangled).
- Emergency shut off (In case of fire).

Operations and Safety

Checklist - on deck JSEA

When on deck or at our desk, we always make sure that safety is on our mind. We have made a JSEA for when we're out on deck. We have this so the whole team knows what the other is doing. This is very important for our company so that no one gets hurt. When we are at our work desks, we have a different set of safety protocols that we follow. Our company makes sure that when a worker is working with any equipment, they have to wear proper PPE. See Appendix A for the JSEA.

Float Safety

The float may be a minor part of what we do, but we still have safety measures that we follow.

- Pop off the end cap (for pressure release).

- Pressure valve (for pressure release).
- 3 feet on float (no wobble and protect penetrators).
- PWR monitor (so we don't send it to dive on low battery).
- PCB (to eliminate messy wiring).
- Lights (for status indication).

All this makes sure that when the float is being used, whether it works or fails, everything around it is safe.

Testing and Troubleshooting

Philosophy

Because our company creates unique ROV solutions for our clients, we need to have a reliable testing strategy/process. Every new technology solution goes through rigorous testing to make sure it is safe. To start, we always make a 3D model or SID, depending on which it is, then we make a prototype using 3D printing or breadboards. Finally, once the prototype works, we can make the final product.

Testing

The ROV never works perfectly on the first try. We ran into some problems with our motor placement.

Four of our eight motors had stuff under them, which hindered their full performance. We fixed this by putting them on the outside of the frame. This improved the speed of the ROV a lot. Another issue we ran into was the fact that our claw mount was way too weak and broke easily when picking up heavy things, but this was an easy fix in our 3D modeling to make it stronger. One of the biggest issues we had this year was downsizing. Our ROV is 54% smaller than last year. This was hard because we are still using the same system, so we have to spend hours testing frame ideas on our table and in CAD, but in the end, we did it, and the results are far better than last year.

Due to the high resolution of the cameras, we initially overlooked the fact that the standard maximum cable length for a USB camera is typically 3.5 feet. However, given the cameras' 1080p quality, the signal was unable to reliably reach the Raspberry Pi using the original 6-foot cable setup. To address this, we systematically troubleshooted the issue by testing the cable length inch by inch until we got to 1.5 feet and achieved a stable connection that maintained both the image quality and the cameras' refresh rate without compromise.

This year, we were given 8 blue robotics M100 thrusters from our local

community college, so naturally, we wanted to use them. Before we could, we had to test them to make sure they were better than ours. The test showed us that our motors produced the same amount of thrust as the M100s, so we had to see how many amps they would draw. We found that our motors were more efficient with fewer amps, at only 1.2A at full trust, while the m100s drew close to 5.4A at full trust. This was an easy decision for us to make. With all the data, we decided to go with our Td1.2 motors. You can see the thrust results on page 8.

Budget and Cost

We start with setting a budget, how much money do we have to build or modify our ROV? This value will be put in as one of our design requirements. We will design around this value, making sure we are on budget. To aid in this, we create a budget spreadsheet where we estimate how much funding each subsystem needs, and we can divide up our total budget accordingly.

Then we have an ROV Cost Accounting spreadsheet that tracks our spending. This serves as a running total for the project. You can see this document in Appendix H. We spent the majority of our

funding on the new thrusters and the new WetLink penetrators, which led to an innovative and cost-effective ROV, but our predictions needed to be corrected. See Appendix D

Conclusion

Acknowledgements

Donations or Grant Money received		Travel Expenses
AAUW	iLab @ OSU Hatfield Marine Science Center	MTS
Carruthers	Pacific Power	Sexton
Connie Gerth	The Silver Salmon Grille	AUVSI
Fast Lube and Oil	Kids Love Bounce House	The Schmidt Ocean Coalition
French's Gutters	Oceancrest Motors	John & Frances von Schlegell
Gearhart Condos	WHSD	Mary Taylor
Hammond Kennel	Teacher & Mentor	RG Carter Trust
Janet Hargis	Heidi Lent	Oregon Sea Grant
Pups & Suds	Craig Battles	

The Warrenton Aquatic Robotics Company - and in particular - The Rays- would like to thank all of the generous sponsors that have supported us all year. Thank you also to our parents, who have been so willing to transport us to all work days and nights throughout the year. To those who also provided lunch and or dinners, we are forever grateful.

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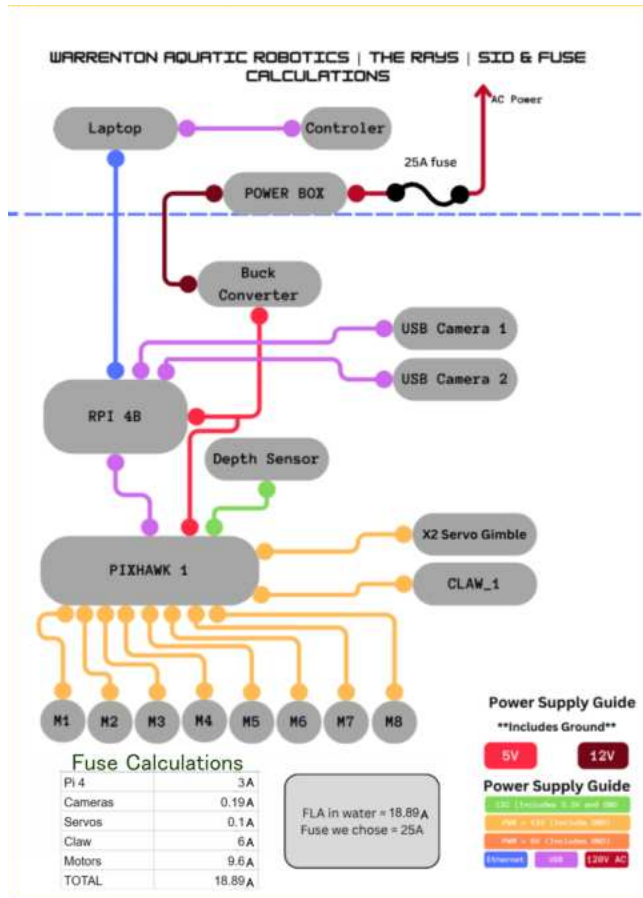
Appendices

Appendix A - JSEA

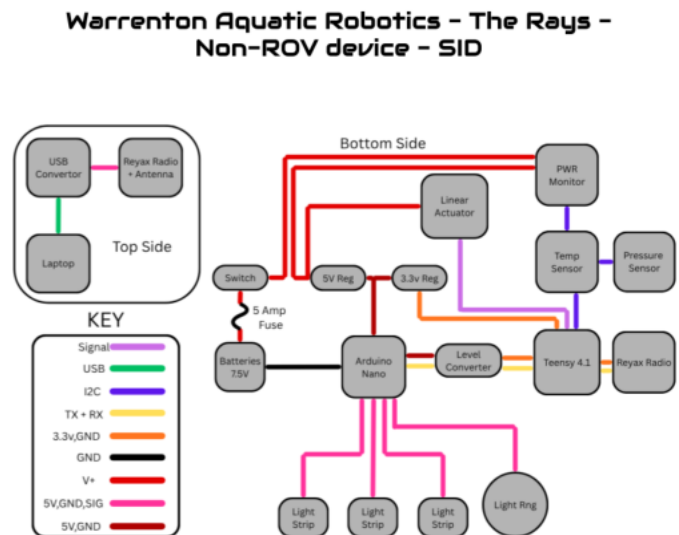


TASK	HAZARDS	CONTROLS	RESPONSIBLE PARTY
1.Lifting moving ROV, tether and control	a. Lift injuries	1a Proper lifting techniques for ROV, tether and control 2a Share load	The lifter
	b. Trip/Fall hazards	1b Clear pool area of obstacles 2b, c1 Sturdy, closed toe shoes	Those who fall
	c. Foot injuries (dropped ROV)	2c PPE (hard hat, safety glasses and high visibility clothing)	The dropper
	d. Equipment damage	1d Movement procedures	
	e. Electrical shock hazards near water	1e Ensure GFCI/fuses on power	Our Safety officer
System Set Up			
TASK	HAZARDS	CONTROLS	RESPONSIBLE PARTY
1.Prepare ROV	a. Open pressure release floods electrical b. Loose connections	1a Ensure the pressure release valve is closed. 1b Connections verified before power up	Our Mechanical engineer Our Electrical engineer
2.Deploy tether	a. Trip hazard	1a Tether and props laid out per plan	Our Tether Manager
3.Connect Controller	a. Electrical shock/flash hazards	1a Power supply and controller OFF 2a Safety glasses	Our Electrical engineer
Pool Side Operations			
TASK	HAZARDS	CONTROLS	RESPONSIBLE PARTY
1.Launch/Recover	a. Lifting	1a Design < 1g 2a Lift training	Our Safety officer
	b. Rotating/Moving equipment	1b Danger areas marked	Everyone
		2b Procedures defined 3b Communication training tether manager, pilot and assistants	
System Breakdown			
TASK	HAZARDS	CONTROLS	RESPONSIBLE PARTY
51. Power Off	a. Electrical shock	1a Dry hands 2a Control power/Supply power off	Our Electrical engineer
	a. Lifting strain	1a Components designed < 1g	Our Mechanical engineer
2. Lifting ROV, controller and tether	b. Foot injuries (dropped components)	2a, 1b, 1c Proper lifting techniques for ROV, controller and tether 2b PPE - sturdy closed toe shoes	Our Safety officer
Power Up Checks			
TASK	HAZARDS	CONTROLS	RESPONSIBLE PARTY
1.Power up	a. Electrical short/shock	1a Stand clear procedure	Everyone
	b. Rotating/moving equipment	1b No loose clothing/hair tied back	Everyone
2.Motor Test	a. Rotating equipment	1a Communication pilot to tether manager per procedure	Everyone

Appendix B - ROV SID



Appendix C - Float SID and Fuse Calculations



Item	Max Current [A]
Teensy 4.1	0.
Arduino Nano Every	0.0
Temp & Pressure Sensor	0.0
Level Converter	0.00
REYAX RYL890	0.1
Actuonix L12-R Servo	0.6
NeoPixels 66 LEDs	3.9
TOTAL MAX	4.90
Fuse we chose	5

Fuse calculations

Appendix D - Budget & ROV & Float Cost Accounting

Beginning Balance	\$1,500
ROV Budget	\$2,000
Float Budget	\$500
Travel to Worlds	\$15,000
Fundraising Needs	\$16,000

Item	Quantity	Cost	New vs. Reused
Frame		\$69.10	
X-rail - \$0.45" - 99.25"	1	\$44.66	Reused
Nuts - \$0.13 per - 94 count	94	\$12.22	Reused
Screws - \$0.13 per - 94 count	94	\$12.22	Reused
PETG		\$25	
One roll - 1	1	\$25	New
Motors		\$584	
Dymond namics - 8	8	\$73	Reused
Blue Robotics		\$1,434	
Main tube - 1	1	\$564	Reused
Gripper - 1	1	\$720	Reused
Penetrators - 10	10	\$15	Reused
Electronics		\$323.68	
Pixhawk - 1	1	\$50	Reused
Buck reg - 1	1	\$7.70	Reused
Step down voltage board - 1	1	\$5.99	Reused
Ethernet - 1	1	\$20	Reused
Misc wire - 1	1	\$18	Reused
Foam in tether - 1	1	\$25	Reused
Sheath - 1	1	\$10	Reused
PI 4 - 1	1	\$60	Reused
PI 4 radiator - 1	1	\$16.99	Reused
Camera - 2	2	\$55	Reused
TOTAL		\$2435.78	

Float Cost Accounting			
Item	Amount	Cost	New/Reused
PCB	5	\$20	New
Linear Actuator	1	\$70	New
Syringe	1	\$4	Reused
Teensy 4.1	1	\$37	New
Arduino Nano	1	\$20	Reused
Pressure Sensor	1	\$90	New
Temp Sensor	1	\$76	New
Logic Converter	1	\$12	Reused
3.3v Regulator	1	\$7	Reused
5v Regulator	1	\$7	New
Fuse	1	\$10	Reused
Battery Charger	4	\$20	New
Batteries	12	\$51	New
Radios	2	\$17	New
Enclosure	1	\$300	New
End Caps	2	\$90	New
Dome	1	\$40	New
usb Converter	1	\$11	New
Qwiic Connects	1	\$2	Reused
Battery Reader	1	\$10	New
On/Off Switch	1	\$25	New
LED's	1	\$14	New
Ballast	1	\$4	Reused
Total	42	\$937	

Appendix E - On Deck Safety Check List

Checklist

Enter/Exit Pool Deck

- ☐ Team is ready
 - ☐ Members are wearing their head protection, safety glasses, closed-toe shoes, and safety vests
 - ☐ Hair back
 - ☐ No loose clothing
- ☐ Machine is ready
 - ☐ ROV components Secured
 - ☐ Tether coiled and stowed
 - ☐ Controller secured
- ☐ Pool Deck is Ready
 - ☐ Area clear of obstacles
 - ☐ Table in position
 - ☐ Power is available and includes Ground Fault Circuit Interrupter (GFCI)

System Setup

- ☐ ROV Ready
 - ☐ Gripper in position
 - ☐ CHECK PRESSURE RELEASE VALVE
 - ☐ Connections secure
- ☐ Tether Ready
 - ☐ Unstowed and ready to deploy
- ☐ Controller Ready
 - ☐ Power supply off
 - ☐ Controller connected
- ☐ Team Ready
 - ☐ Pilot ready
 - ☐ Tether manager ready
 - ☐ Navigation/Gripper manager ready

Power Up Checks

- ☐ Tether manager clear of moving parts
- ☐ Power on
- ☐ OLED displays joystick and gripper zero'ed positions (boot up complete)
- ☐ Pilot communicates "motor testing" to tether manager
- ☐ Tether manager communicates "clear for motor test" to pilot
- ☐ Camera images displayed for 3 cameras
- ☐ Reboot required?

Pool Side Operations

- ☐ Pilot zeros joystick for launch/recover
- ☐ Pilot communicates "clear to launch/recover" to tether manager
- ☐ Tether manager ensures lift/launch safety
- ☐ Tether manager communicates "open/close" to gripper control to grasp/ungrasp props
- ☐ Tether manager communicates "ROV clear" to pilot when joysticks can command motors

System Breakdown

- ☐ Machine is ready
 - ☐ Power is off
 - ☐ ROV components Secured
 - ☐ Tether coiled and stowed
 - ☐ Controller secured
- ☐ Pool Deck is Ready
 - ☐ Area clear of obstacles
 - ☐ The table returned to the original position if moved