Whirlpool Robotics

Technical Documentation 2025

Hackley School, Tarrytown, NY, USA

Team Members:

Name	*MATE Status*	*Company Role*	*Hours*	*Grade Level*
Mateo Arencibia	Returning, 3rd yr	CEO, Head Engineer	180	11th
Hilah Shklarski	New	Lead Electrical Engineer and Tether Manager	135	9th
Edmund Rose	New	Lead Claw Designer, Lead 3D Designer, Mechanical Engineer	135	9th
Alberto “Ace” Perez	New	Lead Presentation, Documents, and Pilot	105	10th
Patrick Flores	New	Mechanical Engineer	100	9th
Kayla Reardon	New	Electrical Engineer	100	9th
Lucas Sosa	New	Float Engineer	100	9th
Ryan Carpenito	Returning, 3rd yr	Mechanical and Float Engineer	60	12th
Osiris Stand	Returning, 3rd yr	Float Engineer	60	12th
Melissa Boviero	Returning, 9 years	Mentor/ Coach	140	—

Abstract

Our ROV, the Omnidirectional Cable-Tethered Operative (“OCTO,” for short), is designed with four main principles in mind: (1) functionality, (2) modularity, (3) reproducibility, and (4) environmental consciousness.

> *First*, the OCTO is designed to handle a variety of tasks in any underwater setting. It is equipped with high-thrust propulsion, a durable gripper, and a 25-meter tether for extended operation and range. It is housed within a flat acrylic frame that enhances hydrodynamic stability while reducing drag.
>
> *Second*, the frame is composed of just two laser-cut acrylic sheets, making it simple and easily replaceable. This minimalist design allows quick access to the ROV’s internal components, with full disassembly possible in under five minutes.
>
> *Third*, our ROV is well-suited for large-scale production, utilizing a carefully selected combination of off-the-shelf components and 3D-designed and internally developed pieces. This approach ensures high reliability, ease of repair, and straightforward maintenance.
>
> *Fourth*, our ROV is particularly well-suited for environmental monitoring and underwater construction. For example, force sensors integrated into the gripper help prevent harm to marine life during handling, enabling delicate interaction with natural ecosystems.

By adhering to these design principles, we developed a robust, versatile, and user-friendly ROV capable of performing in demanding environments.

Table of Contents

I. Team & Project

Company Profile and Mission

Since 2016, we at Whirlpool Robotics have been working to design submersible ROVs that are both innovative and reliable. Each member of our team brings a unique set of skills to the table, from mechanical engineering, programming, and 3D design. Our company is composed of experienced members and members new to ROV. Our company CEO, Mateo Arencibia, has been with Whirlpool Robotics for three years, and two additional mechanical engineers, Osiris Stand and Ryan Carpenito, were added this year from last year's Scout team. This year, Whirlpool robotics grew to its largest size yet with the inclusion of additional mechanical engineers in Patrick Flores, Lucas Sosa, and Ace Perez, and additional electrical engineers in Kayla Reardon and Hilah Shklarski. Some members have taken on additional roles; for instance, Hilah and Mateo have worked on programming the ROV and the Float Profiler. Hilah has also been training to be the tether manager, too.

Meanwhile, Ace has taken on the piloting of the ROV. Lastly, the addition of our lead 3D designer, Edmund Rose, has helped the team create innovations on the ROV based on specific needs and designs. Edmund has also served as a substitute pilot. Whirlpool Robotics competed in the World Championship last year, showing steady growth in talent and ability and creating the right ROV for that year's missions and tasks. We are adaptable, hardworking, and will use our collaborative skills and combined knowledge to determine the best ROV design and tools for the job.

This year's theme is UN Decade of the Ocean, MATE year of the Great Lakes: Monitoring and Mitigating the Impacts of Climate Change on Our Water World. ROVs have been used to observe the effects of climate change for years, including tracking the effects of algae blooms, rising sea levels, and ocean warming. For instance, in 2018, an unmanned ROV was used to successfully track algal blooms in Lake Erie, providing real-time data to researchers and environmental scientists (Ball, 2018). Algae blooms can kill organisms and gravely damage ecosystems and underwater plant life by blocking the sun, stealing resources from photo-processing underwater plants, decreasing dissolved oxygen, and releasing harmful chemicals into the water (Centers for Disease Control and Prevention, n.d.).

Our team and company are dedicated to using technology to help mitigate factors that negatively affect water ecosystems. Not only can our ROV monitor and collect water samples through the use of its claw and gripper, but it can also navigate through small spaces without harming any organisms, due to its multiple motors, which create a precise driving system. Our company is also driven to sustainable practices through the choices made in reusing items, creating original items, and buying new items. For instance, we reused the majority of our parts from previous years, which has been cost-effective and is a less wasteful/more sustainable practice. When we do buy new parts, they are usually bought from BlueRobotics, a company that creates quality, long-lasting products.

Schedule

Throughout the year, we engaged with the community while designing, building, and testing our ROV. Our regular meetings were scheduled every eight days during school hours, but due to the limited time, we decided to add a meeting day outside of the school schedule. As the regional competition approached, we increased our efforts, holding extended sessions on Fridays and Saturdays from March to May.

The tasks were divided into trimesters as follows:

1. Trimester One – Redesign and Trial and Error (Sept. through Dec. 2024):
    a. Community outreach event with the Hudson Scholars Program
    b. Redesigning Frame
    c. Redesigning Electronics
2. Trimester Two – Final Construction (Dec. through Feb. 2025):
    a. Laser Cutting, 3D Printing, & ROV Assembly
    b. Programming & Wiring New Electronics
3. Trimester Three – Testing (Feb. through April 2025):
    a. Pool Testing & Pilot Practice
    b. Testing & Upgrading Electronics
    c. Documentation
4. Post-Regional Period – Testing (May thru June)
    a. Extensive Pool Testing & Pilot Practice

b. Rubric Review of Documentation
c. Tweaking the designs of tools (not using zip ties for camera position, finishing, and attaching a second claw)
d. Planning a Fly Route for Worlds, including the inclusion of more tasks based on the second claw.

II. Engineering Design Rationale

Engineering Design Rationale

The OCTO was engineered to be robust, stable, and multipurpose. Its signature flat profile, achieved using a layered design with acrylic sheets, provides exceptional stability within the water. This stability, combined with a dual-camera system, makes it well-suited for doing a multitude of tasks in water environments where many other ROVs would struggle. Importantly, this stability is achieved without sacrificing maneuverability or increasing weight. The acrylic frame and its composite steel support bars keep the ROV lightweight (6.8 kg), while its open structural design minimizes fluid resistance across key surfaces. Although the ROV has a relatively wide footprint, this design choice was intentional, offering an improved lateral stability that outweighs any potential drawbacks.

Taking into consideration our ROV last year, which had 8 motors externally mounted at 45 degrees and 45 degrees, this year we chose a motor configuration aimed towards stability. Eventually, we decided to separate horizontal and vertical motors. We chose to have 4 horizontal motors to allow for leaning in all four directions with stability. The horizontal motors are at 30-degree angles, a decision made to reduce wasted power output and increase speed and efficiency. In choosing this configuration, the driving challenges we encountered last year have been eliminated.

Internally, onboard electronics are optimized for compactness and reliability. While the risk of water entering is always a factor in underwater robotics, our layout enhances maneuverability and facilitates future modular upgrades. Together, these design decisions enable the OCTO ROV to support complex system deployments, operate a range of modular sensors (including a deployable float), and navigate diverse aquatic environments with precision, gathering data effectively and safely driving through aquatic ecosystems.

The OCTO is controlled by an XBOX controller, with controls that are programmed to control multiple motors at a time. Using the same hand-eye coordination of video games, the OCTO can be driven in multiple directions by the ROV driver intuitively.

Problem Solving and Brainstorming

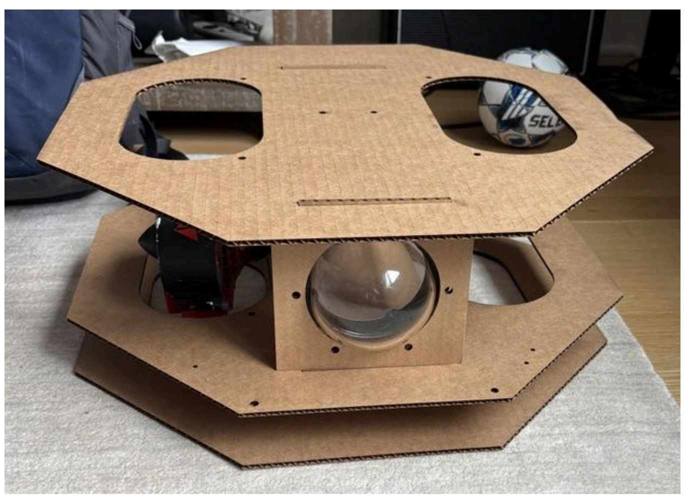
New design ideas were inspired by past ROVs developed by other teams and our goal to introduce a novel structural approach. Whirlpool Robotics studied the designs of previous Whirlpool teams, along with information they gathered at the World Championship on ROVs that were more successful than ours, and explored different designs and tested various materials and construction methods. Although the final design incorporated 3D printing and laser-cut components, multiple alternatives were thoroughly evaluated before reaching a consensus. Throughout the last three years, Whirlpool Robotics teams have favored the acrylic sheet design. Due to its affordability, light weight, and its ability to be laser cut easily, we found it to be an optimal material for our frame, and one which we have been using in different ROV iterations for years. For the onboard electronics, we have also favored using the BlueRobotics acrylic canisters, which are designed with the wetlink penetrators to create a watertight seal around these components, and which can be tested with the vacuum hand pump for leaks in that seal. Although we did decide to keep these components from previous years, through discussions and reflections, we decided to change the layout of the motors to include tilting of the horizontal motors. According to Serway and Jewett (2018), changing the horizontal motor mounting can affect the rotation efficiency. This research is included below.

Motor Configuration Research			
	30° Mounting	45° Mounting	90° Mounting
Power Forward	66%	50%	50%
Back Backward	66%	50%	50%
Power Sideways	33%	100%	N/A
Rotation Efficiency	Moderate	High	High

Innovation

Our ROV's design represents improvements from previous iterations, most notably in how we have used the acrylic frame and also in our thoughtful thruster placement. In past years, our frame was in a box-like or cuboid shape, with each component mounted on one of its faces. While still using the extruded composite aluminum on the frame as structural beams, we have decided on an overall larger frame size, and one that provides space for each thruster to be nested around the acrylic canister, which is sandwiched between each acrylic sheet in the frame. This layout holds the horizontal motors at a 30-degree tilt, which is an added feature to the ROV this year. These eight motors allow the ROV to drive quickly and purposefully through the water, leading to our company tagline for this ROV product, "OCTO the ROV: Eight Motors, Zero Limits."

Beyond enabling a more advanced propulsion layout, the acrylic design offers greater stability, reduced weight, and substantially lower material costs compared to aluminum or other past materials used by Whirlpool Robotics. To maximize resource efficiency, leftover sections from the laser-cut acrylic sheets were repurposed to reinforce identified weak points in the frame, such as supporting the acrylic canister dome. This use of scrap materials is an effective and economical alternative to using thicker, more expensive material.

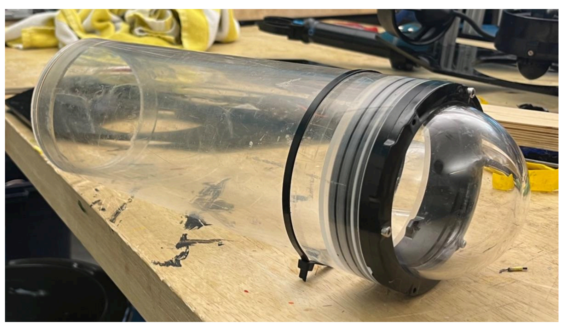


Initial Cardboard Prototype

Photo credit: Mateo Arencibia

Vehicle Structure and Systems

To maintain stability, the ROV was designed with a wide, flat profile that helps keep the vehicle level during operation. While this increased the overall footprint of the ROV, potentially affecting mobility and weight, these challenges were effectively addressed by adopting an open-frame structure that minimizes drag and makes driving easily maneuverable. As already mentioned, maneuverability is further enhanced by the inclusion of four thrusters mounted at 30-degree angles, providing full control along the X-axis and compensating for any drawbacks of the wider design. Besides the affordability and flexibility of using acrylic sheets, which have already been discussed, each acrylic panel can be replaced individually with just six screws, simplifying field repairs. Furthermore, all onboard electronics are housed within a pressurized acrylic tube, which includes a pressure release valve for safety.



Acrylic Tube

Photo credit: Mateo Arencibia

Originally, we planned to use a four-motor design, but after evaluating the precision required for marine renewable energy maintenance and the tasks involved, we decided to upgrade to an eight-motor system. Notably, all of these motors, along with the claw and aluminum mounts, were salvaged or reused from previous ROV models- an approach detailed in the following section.

New Vs. Used, Build vs Buy,

As a team competing in MATE competitions since 2016, we have built up a substantial inventory of spare parts and equipment over the years. This extensive collection allowed us to incorporate used components wherever possible. For instance, we salvaged large quantities of extruded aluminum from previous frame designs, repurposing them to reinforce the new laser-cut acrylic frame. We also reused all of our motors from previous years, and only replaced two ESCs because of their wires falling apart. These practices of reusing materials align with the mission's emphasis on sustainability, integrating eco-friendly solutions into our model whenever feasible.

For our gripper/claw, we currently have a Newton Subsea Gripper, purchased in 2020 from BlueRobotics. This was purchased because, in developing our own designed grippers throughout the last several years, we found that we struggled to find the right combination of materials to have a reliable gripper. Previous members struggled with creating a gripper that made proper gripper motion or creating a gripper that was sensitive to not over-gripping. Plus, waterproofing all these mechanisms within the gripper for long-term use was also a consistent challenge. This is why past members of Whirlpool robotics decided to look into what options were available and came upon the Subsea grippers. However, new to our company this year, our lead 3D designer has been studying the Newton grippers for its flaws, most notably that it does not rotate to provide horizontal and vertical grip, which has meant that in the past, it's been the ROV pilot that has had to rotate the ROV itself to have this multidirectional gripping. Our lead 3D designer, along with our CEO, has developed a prototype for a gripper that will be a new addition to the OCTO this spring.

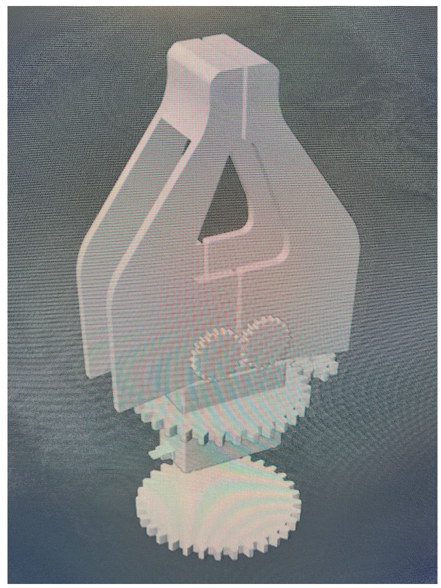
While key items have been purchased as component pieces from vendors, mostly Blue Robotics, we have purchased these items to increase their longevity of use. Having been a school that has been participating in ROV for almost a decade, many of these items were purchased years ago or have been incorporated into the ROV over the years. Being able to reuse items by purchasing quality items that are properly waterproofed has both benefited our budget in the long run and is more sustainable.

Gripper/ Claw

In previous years, we relied on the BlueRobotics Newton Subsea Gripper for our claw, but its limitations became increasingly apparent. During the 2024 MATE competition, the Newton Gripper failed to pick up both rocks and certain configurations of PVC pipes, prompting us to face a long-standing realization: if you want something done right, you have to do it yourself.

As a result, we decided to design and build our claw from the ground up. This new design addressed several shortcomings of the Newton Gripper, most notably incorporating the ability to rotate along its axis. Edmund Rose was tasked with leading the claw design, beginning work on a basic prototype in December. “I had never designed a claw before,” said Rose, “and it showed in my first draft, which was a significant learning experience.” With our new 3D printer, we were able to rapidly iterate on the prototype, though early testing revealed that the first version did not meet our performance standards.

First claw iteration
Photo credit: Made in Blender by Edmund



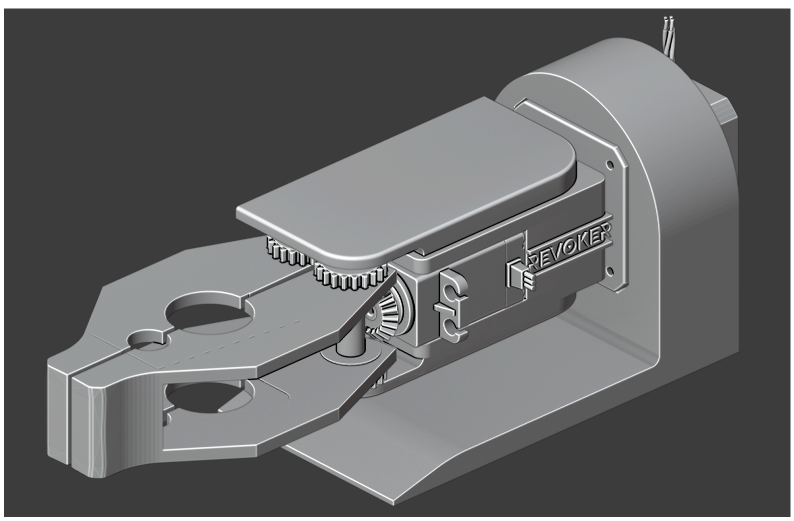
A later claw iteration without supports
Photo credit: Made in Blender by Edmund

Rose decided to redesign the claw from scratch to incorporate lessons learned from the first prototype. “I came up with a new claw design that would be mounted to a central ‘bus’ gear, which would then be rotated around by a separate motor.” We designed various gears and 3D-printed them to make sure they functioned correctly. After a month or so of designing, Rose was ready to test the new prototype. However, the claw would not slice properly, and this became a large setback. We eventually found a workaround, but this cost us valuable time. The good news was that the claw worked. All that was left to do was the rotary bus system. However, I realized that this entire system was completely over-engineered, and we could instead simply mount the system directly on the motor.

About a week later, we were ready to print our first fully functioning prototype. However, as it was being produced, our 3D printer began refusing to extrude filament, putting a hold on operations. Yet in attempting to fix it, we only broke it more. A critical part of the extruder had been accidentally ripped out, and a replacement piece was sold out on every site we could find, meaning this was likely a common issue.

We were able to use our older 3D printer to build a prototype, which worked wonderfully. Aside from some minor mechanical issues, the claw was working. “This was a huge victory as the finished laser-cut frame had just been made, allowing us to seamlessly integrate the two systems, “ remarked Rose.

Rose did a final iteration, redesigning the gripping part of the claw to allow easy grabbing of standard PVC pipes and more. For Worlds, he then decided to redesign the gripping apparatus to be able to interlock, as well as allowing the mount to slide onto the frame of the robot.

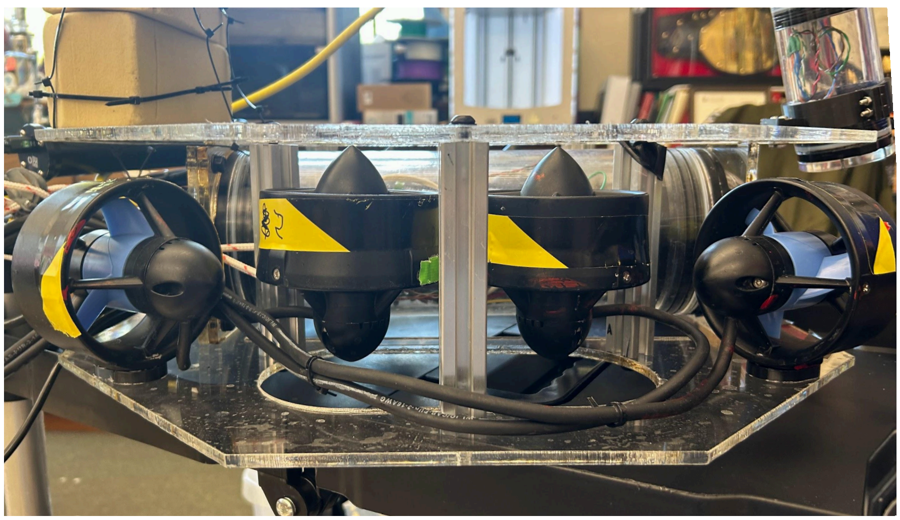


An older claw version assembled in a 3D model, models of the servo and motor included

Photo credit: Made in Blender by Edmund Rose

Propulsion

For the thrusters, our company decided to use the BlueRobotics T200 thrusters. These thrusters provided the ultimate power to our ROV while maintaining a relatively affordable price point. That being said, they are expensive pieces of equipment on the ROV, however, our team decided that we should place significant resources into the thrusters as they are one of the most essential parts of the vehicle. All of these motors are reused from our previous ROV and were purchased after our repeated efforts to assemble our motors through parts bought separately failed. We used an eight-motor design because we believe in the stability of an Octo design. An octagon is more stable than a square or rectangle due to having more sides to spread out the force. This stability would also help there be less wobble. Furthermore, this design would allow for very exact control on the X-axis when placed at a 30-degree offset. To conserve price, we reused spare T200s for our four upwards motors, which was an increase from the two used last year.



ROV shroudless side view of motors

Photo credit: Hilah Shklarski

Camera

The ROV is equipped with two 1080p cameras. One camera is positioned at the front, facing forward to give the pilot a clear view of the claw and the path ahead. Along with general camera use, this camera will also be used to gather photos in the shipwreck task of the 2025 MATE Challenge mission. The second camera is mounted directly above the first, angled downward, providing a view of the claw. This configuration provides the pilot with both visibility of the area in front of the ROV and below it, improving obstacle detection and avoidance. The 1080p resolution was selected for its high image quality.

Buoyancy

Our ROV frame is naturally buoyant due to the size of the electronics enclosure, with small amounts of additional heavy-machined buoyancy foam added to ensure balance and eliminate any extra negative buoyancy caused by the gripper or claw. We chose this type of foam since it provides high buoyancy in small quantities. The open frame design of the OCTO creates many spaces to add floats or weights, allowing buoyancy to be altered on the fly to guarantee that neutral buoyancy and balance are maintained regardless of payload or additional equipment added to the ROV. During our first run of pool testing, we noticed that it was more negatively buoyant on the back end of the ROV. For that, we added several pieces of foam to counteract that force successfully. However, once it started to drive forward, we noticed that the OCTO would pitch forward (on its nose) when driving forward and straight. While we tried decreasing the foam on the back initially, we eventually saw that adding a piece of a pool noodle to the top of the OCTO gave it perfect neutral buoyancy both when still and moving in all directions.

Float

The float has a simple design and is highly cost-effective, allowing many of them to be constructed and deployed. Once deployed, it begins to relay information seamlessly, including depth data using a pressure sensor. The float aims to provide information gathered in open water and the water column to a monitoring station. We have two versions of the float that we built. One of these designs uses a buoyancy engine, and the other one uses a T200 thruster. For both floats, we have two Arduinos that each have antennas connected to them. One of the Arduinos is untethered and inside the float with a thruster or buoyancy engine and antenna. For the Arduino outside of the pool, it is connected to a laptop with an antenna, and those communicate and send values. At the time of writing this document, we have not successfully run the buoyancy engine float. This float theoretically would work by manipulating the water inside three syringes, all being controlled via servo motors that have been programmed by an Arduino to push water in and out of the syringes, causing the Float to rise and fall. We have not managed to have this be successful yet, and will likely move to focusing on the Thruster-powered Float Profiler. For all the efforts and multiple team members we have had working on the float, the name of our float profiler is “Hopes and Dreams.”

III. Electronics Design & Rationale

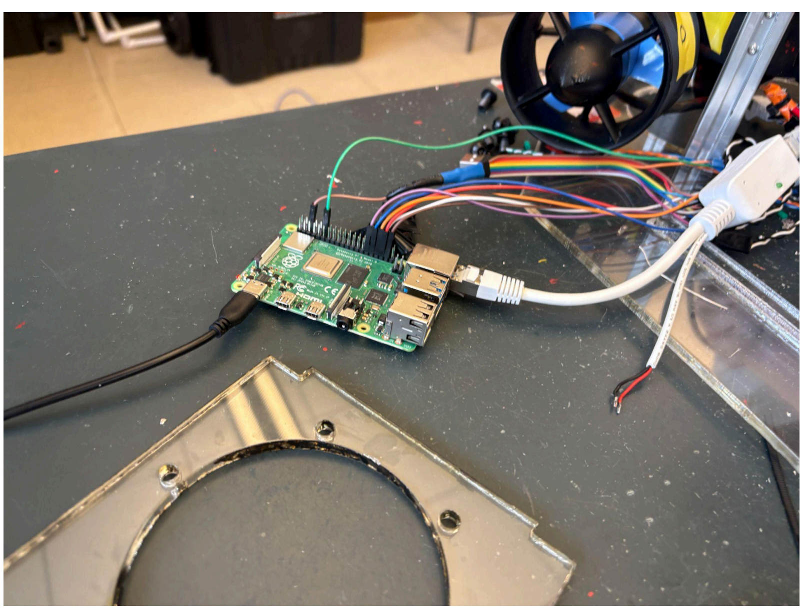
Electronics System Rationale

In previous years, our electronics system was based on Serial communication between the ROV and the control system at the surface. Unfortunately, this limited the possible electronic components and sensors we could use on the ROV because our setup allowed for a small number of ports. In addition, adding more ports would have been costly and taken much time; the previous design was not scalable. To solve this challenge, we decided to employ Ethernet communication between the surface-level electronics and the ROV, which allows for an essentially unlimited amount of data to pass through our tether. Because of this, we were able to improve the operation of individual components such as the camera, gripper, and most importantly, the motors. Finally, the use of Ethernet communication allows for multidirectional transfer of information: in other words, we can send control commands to the ROV, but also receive information (from cameras, sensors, etc.) from it.

Control System

The control system (i.e., the electronics at the surface placed in the control box) consists of the following components:

1. Raspberry Pi $B
2. Fathom-X Tether Interface
3. USB Xbox Controller
4. Voltage Regulator (12V–5V)



Raspberry Pi during the first full 8-motor test
Photo Credit: Mateo Arencibia

Piloting an ROV is no game, but with our streamlined controller design, it's just as intuitive.

The Xbox controller is connected via Bluetooth to a computer, which is then connected to the Raspberry Pi via SSH. SSH is a way for the Raspi to connect to a wifi router, which gives us a secure communication and stable connection between the Raspi and the computer. The Voltage Regulator is used to step down the 12V supplied at the competition to 5V, so that it can be used by the Raspberry Pi, the tether interface, and the Ethernet switch. The Raspberry Pi receives commands from the Xbox controller and sends them to the Ethernet switch. The signal, in turn, is sent to the tether interface for communication with the ROV. All of these components are neatly housed within a control box at the surface. Any information being received from the ROV, most crucially the feed from the camera, is sent back through the tether interface, then the Ethernet switch, and finally gets to the Raspberry Pi. From here, it can either be viewed directly from the Pi on a portable touchscreen or over the internet with a computer.

On-board Electronics

The electronics system on board the ROV consists of the following main components:

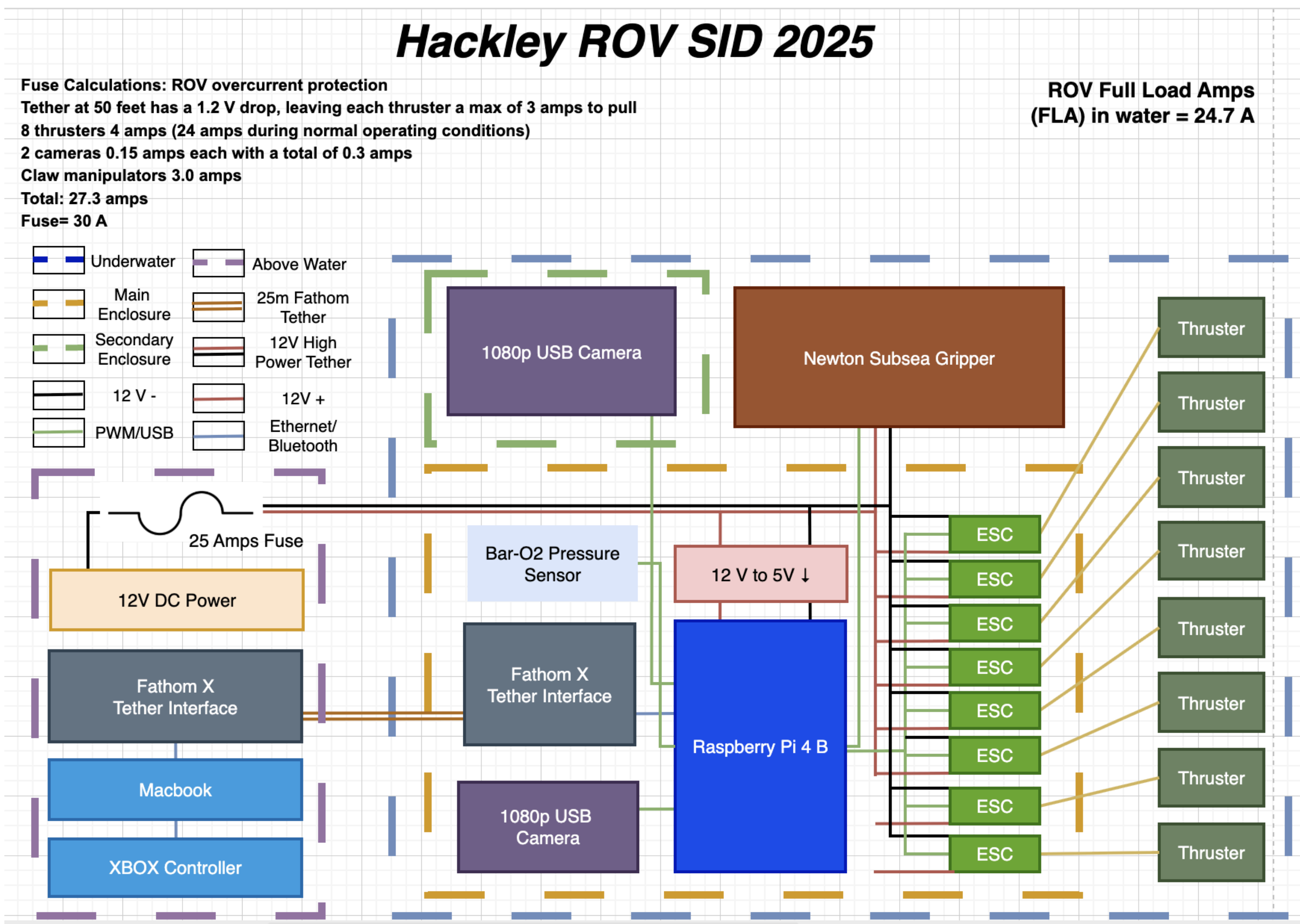
1. Raspberry Pi 3B
2. Fathom-X Tether Interface
3. USB Camera
4. Voltage Regulator (12V–5V)
5. Ethernet Switch
6. Eight ESCs
7. Newton Subsea Gripper
8. Edmunds claw/the revoker

A high-power wire from the surface delivers the 12V from there via the tether bundle to the ROV. The first portion of the system works analogously to the electronics on the surface: commands to be received from the control system will be sent through the tether and received by the tether interface. Then, they get sent to the Ethernet switch, from which the Raspberry Pi interprets these signals and sends them to the relevant component. Motor commands get sent to the ESCs, which then are relayed to the proper T200 thruster. Commands for the claw go directly to the Newton Subsea Gripper. Finally, the information received from the camera goes directly to the Raspberry Pi (on-board), which is then sent back through the communication system to the surface-level Pi (explained above).

Programming

Programming for this project was done on two MacBook terminals. One terminal transmitted PMW values calculated from Xbox controller inputs. The other terminal was connected to the onboard Raspberry Pi 4 B via SSH. All code was written in Python.

System Integrations Diagram (SID)



IV. Safety & Testing

Safety in the Workplace

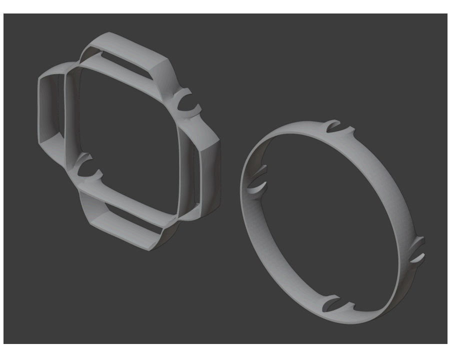
Workplace safety was a top priority while we were working on the OCTO. When using dangerous machinery, we made sure that a qualified adult was supervising at all times and that the entire team had sufficient training in the operation of each tool. PPE, such as goggles, gloves, and face masks, was also worn whenever it was deemed necessary for the safety of the team.

Safety Features & Rationale

Our commitment to safety extends to the design of the OCTO as well. Shrouds cover all eight of the motors, which are also embedded in the frame to further prevent any injury to operators and marine organisms. Furthermore, an extensively tested watertight seal on the acrylic tube greatly mitigates any possibility of electronics shorting. This has been tested repeatedly using a vacuum hand pump. The acrylic canister also has a pressure release valve, ensuring that dangerous pressure does not create an implosion. On the ROV, a tether relief point is attached to the back housing, which ensures that the tether is not pulled away from the electronic components. OCTO's connection to the power source is also secured using both Anderson Power poles to provide a secure connection from our ROV to its power source (without the risk of exposed wire seen in Alligator clips), as well as a proper fuse.

Shrouds

Due to some difficulties with our shroud safety certification last year (we used UW ROV models), we decided to modify the old shroud models to have two rings, instead of one. We tested them with a 12.5 mm virtual cylinder, and they passed IP20 standards. We have different versions for the front and back shrouds, and they are located on all 8 motors, in visible colors.



Our new rear shroud (left) vs our old rear shroud (right)
Photo Credit: Edmund Rose in Blender

Tether & Cable Management

We used the BlueRobotics Fathom X tether, securely bundled via zip-ties with a high-power wire (both 25m), to connect the ROV with the control system on the surface. Zip-ties are used to connect the two cables; these ensure that both the wires are easily accessible if they need to be swapped out, but also that they are firm and do not jostle around to one another. This tether is both neutrally buoyant and properly insulated to protect from electrical currents affecting the water.

To manage the tether for the pool missions, we had a main member practice being on the pool deck as the pilot practiced their fly route. The tether manager practiced understanding how much tether slack to give, watching the movement of the ROV while controlling the tether, learning how to leave enough slack so the tether does not snag or catch on any of the pool items related to the mission, but can still fly around freely. When asked how she learned to figure out the correct amount of slack, Hilah's response was, "It takes practice."

Safety Checklist

We have also created and submitted a safety checklist to ensure complete and total ROV safety during both construction and operation. We have submitted a separate Job Safety Environment and Analysis document addressing specific safety steps in greater detail; however, the information below was used as a checklist as we tested our ROV and prepared the OCTO for competition:

- ☐ ROV — Physical Aspects
  - ☐ All items attached to the ROV are secure.
  - ☐ Hazardous items are identified, and protection is provided
  - ☐ All propellers are completely shrouded to IP-20 standards.
  - ☐ Mesh size is less than 12.5 mm.
  - ☐ No sharp edges or elements of the ROV design could cause injury to personnel or damage the pool surface.
- ☐ ROV — Electrical Aspects

- ☐ Tether has proper strain relief at the ROV.
- ☐ There are no exposed motors.
- ☐ There is no exposed copper or bare wire.
- ☐ All wiring is securely fastened and properly sealed.
- ☐ Any splices in the tether are properly sealed.
- ☐ Single attachment point to the power source.
- ☐ Anderson power pole attachment to the power source.

☐ Surface Controls — Electrical & Physical

- ☐ Properly sized inline fuse within 30 cm of the power supply attachment point.
- ☐ All wires entering and leaving the power pole control station have adequate strain relief and wire abrasion protection as the wires pass through the enclosure.
- ☐ The surface control station is built in a neat external waterproof case. There are no loose components or unsecured wires. All electrical components are covered inside this enclosure.
- ☐ All connectors utilized are properly rated for their application.

Testing Summary

We spent multiple weeks rigorously testing our ROV in the pool before the competition to verify optimal performance. During these tests, we focused on three main aspects:

First, we worked on achieving neutral buoyancy of the ROV through the use of foam. Because of our light design and canister use, neutral buoyancy was surprisingly easy to achieve, as it was already close to neutral buoyancy without any modification. To make slight adjustments to negative buoyancy due to the claw, we attached small foams to the OCTO.

Second, we focused on the navigation & ease of control. Through pool testing, we realized we had to adjust the speed of the ROV thrusters, along with a programmed delay, to make piloting the ROV easier for the driver. While we initially were using the motors at maximum thrust to check on our programming and connections when the OCTO was on land, once it was in the water, the power made the ROV difficult to manage and drive. However, through multiple testing and trial and error, adjusting the proper speed and delay, these challenges were overcome.

With these in place, we were able to move on to our third area of focus- the ability to complete the missions. Through a study of the handbook and the MATE provided flythrough, we decided upon which missions the OCTO was best suited for and created mock-ups using leftover PVC and other materials, and tested them in a pool environment.

V. Budget & Cost Management

Main Engineering Budget

Our main engineering budget for the ROV consists of the large building blocks/essential ROV components. No parts for the ROV were donated, and thus, each part was either purchased as new or reused from previous years.

Item Description	Reused	Cost	Source
8 T200s & ESCs	X	$1652	BlueRobotics
Extra ESCs		$152	BlueRobotics
1 Raspberry Pi 4B		$70	PiShop.us
2 1080p USB Cameras	X	$30	Amazon
4” Watertight Tube	X	$212	BlueRobotics
2” Watertight Tube	X	$46	BlueRobotics
Fathom ROV Tether	X	$150	BlueRobotics
Fathom X Tether Interface	X	$240	BlueRobotics
Xbox One Controller	X	$60	Team Donation
Netgear Router	X	$200	Recycling
Acrylic Sheets		~$100	Amazon

12V to 5V Converter	X	$15	Amazon
Newton Subsea Gripper	X	$250	BlueRobotics
Cost of Bought Items	–	**$322**	–
Total Cost	–	***$3177***	–

Miscellaneous Budget

Our miscellaneous budget for the ROV, consisting of the smaller products, is listed below. No parts for the ROV were donated, and so each part was either purchased as new or reused from previous years.

Item Description	Reused	Cost	Source
Foam Poster Board		$125	Staples Custom Foam Posters
M3 Screws		$100	*(various sources used)*
Wires		$50	*(various sources used)*
WetLink Penetrator: Motors	X	$100	BlueRobotics
WetLink Penetrator: Claw	X	$12	BlueRobotics
WetLink Penetrator: data cable	X	$12	BlueRobotics
Cost of Flight (per student)		300	Parent
Cost of Transportation to Alpena (per student)	x	250	Parent
Cost of Housing (per student)	x	250	Parent
Total Cost of Bought Items	–	$325	–
Total Cost of ROV related items	–	***$449***	–
Total expected cost of student travel to World's		***$800***	

VI. Acknowledgements & Funding

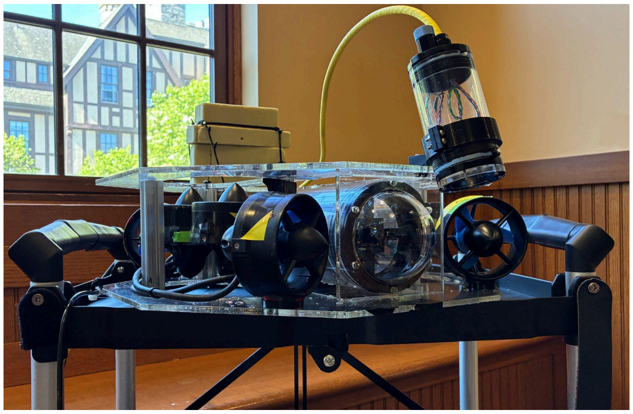
Acknowledgements

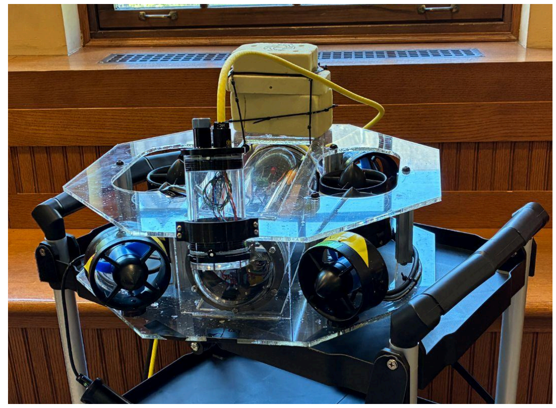
We would like to thank the MATE organization for all the work they put into creating this amazing opportunity to compete. We are grateful for all the time and effort put forth by the coordinators, judges, and volunteers. We would like to thank our team mentor, Ms. Melissa "The Boxer" Boviero, for all of her help and advice in designing, building, and testing our ROV, as well as for her support over the years in helping build Hackley School's ROV program. We would like to thank Hackley School for its continued and future support for our underwater robotics and engineering program. Lastly, we would like to thank our friends and family for their encouragement and continued support as we have embarked on building the OCTO and getting ready for competition.

Funding

We would like to thank the Hackley Upper School Science Department for funding our ROV, both this year but also in past years, since we are using parts from several years back. We would like to thank past members of the ROV team, who have donated to the program as alumni. We would also like to thank our family for providing additional financial support for building supplies and for their financial support for our travel to the MATE World Championship.

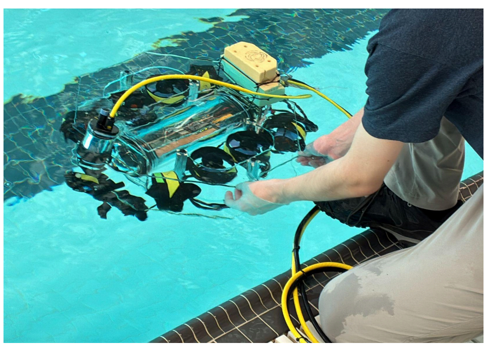
VII. Gallery

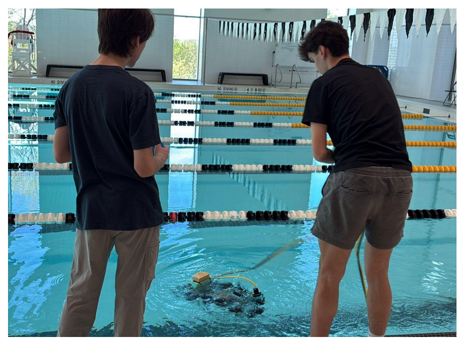




OCTO side view
Photo credit: Lucas Sosa

OCTO top/front view
Photo credit: Ace Perez





OCTO in the pool
Photo credit: Mateo Arencibia

OCTO pool testing
Photo credit: Patrick Flores

Team Whirlpool Robotics at the PA Regional
Photo credit: Erica Sosa

VIII. References and Resources

1. Ball, M. (2018, August 30). *NOAA to trial algal bloom detection with unmanned underwater vehicles*. Unmanned Systems Technology. https://www.unmannedsystemstechnology.com/2018/08/noaa-to-trial-algal-bloom-detection-with-unmanned-underwater-vehicle/
2. Centers for Disease Control and Prevention. (n.d.). *Harmful algal blooms: Contributing factors and impacts*. U.S. Department of Health & Human Services. https://www.cdc.gov/harmful-algal-blooms/about/harmful-algal-blooms-contributing-factors-and-impacts.html
3. Deep Trekker Inc. (n.d.). *Underwater ROVs: What Are They Used For?* Deep Trekker. Retrieved May 2, 2025, from https://www.deeptrekker.com/resources/underwater-rovs
4. Marine Advanced Technology Education (MATE) Center. (2024). *2025 MATE ROV Competition: UN Decade of the Ocean, MATE Year of the Great Lakes: Monitoring and Mitigating the Impacts of Climate Change on Our Water World – RANGER Class Competition Manual*.
5. Moore, S. W., Bohm, H., & Jensen, V. (2010). *Underwater robotics: Science, design & fabrication* (Rev. ed.). Marine Advanced Technology Education (MATE) Center.
6. Serway, R. A., & Jewett, J. W. (2018). *Physics for scientists and engineers* (10th ed.). Cengage Learning.