Whirlpool Robotics

Technical Documentation

2026

Hackley School, Tarrytown, NY, USA



Team Members:

Name	*MATE Status*	*Company Role*	*Hours*	*Grade Level*
Mateo Arencibia	Returning, 4th yr	CEO, Head Engineer	180	12th
Hilah Shklarski	Returning, 2nd yr	Programmer/ Engineer,	180	10th
Edmund Rose	Returning, 2nd yr	Lead 3D Designer	135	10th
Alberto “Ace” Perez	Returning, 2nd yr	Pilot	60	11th
Ethan Tseng	Returning, 3rd yr	Prop Building, CFO	60	12th
Patrick Flores	Returning, 2nd yr	Mechanical Engineer	80	10th
Kayla Reardon	Returning, 2nd yr	Lead AI Engineer	110	10th
Lucas Sosa	Returning, 2nd yr	Float Engineer	100	10th
Rohan Monday	1st yr	Programmer	110	9th
Emma Markowitz	1st yr	3D Designer	60	9th
Chizara Nnamdi	1st yr	Electrical Engineer	60	9th
Tyler Copeland	1st yr	Community Outreach	60	9th
Asher Dundas	1st yr	Float Engineer	80	9th
Melissa Boviero	Returning, 10 years	Mentor/Coach	140	—



The “OCTO”

Photo credit: Chizara Nnamdi

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 custom gripper, and a 25-meter tether for extended operational range. The electronics tube is housed within a flat acrylic frame that enhances hydrodynamic stability while reducing drag, with durable skids on the bottom for safe landings on the seafloor.

Second, the frame is composed of just two laser-cut acrylic sheets, making it low-complexity and easily replaceable in case of damage. This minimalist design also 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 and custom pieces, allowing for easy replication and replacement of parts. 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, our motors are within the frame, ensuring the protection of any nearby flora or fauna.

Together, these principles guide our company in designing the best ROV for every use: The OCTO: Eight Motors, One Mission, Zero Limits

Table of Contents

I. Team & Project.....4
Company Profile.....4
Schedule.....5
II. Engineering Design Rationale.....6
Engineering Design Rationale.....6
Problem Solving and Brainstorming.....7
Innovation.....8
Vehicle Structure and Systems.....9
Build Vs Buy, New Vs Used.....9
Gripper.....10
Propulsion.....12
Camera.....13
Buoyancy.....14
Float.....14
Payload and Tools.....14
III. Electronics Design & Rationale.....15
Electronics System Rationale.....15
Control System.....15
On-board Electronics.....16
Programming.....17
System Integrations Diagram (SID).....17
IV. Safety & Testing.....17
Safety in the Workplace.....17
Safety Features & Rationale.....18
Shroud.....18
Tether & Cable Management.....19
Safety Checklist.....19
Testing Summary.....20
V. Budget & Cost Management.....21
Main Engineering Budget.....21
VI. Acknowledgements & Funding.....22
Acknowledgements.....22
Funding.....22
VII. Gallery.....23
VIII. References.....24

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 and programming to 3D design and electrical work. Our company is composed of experienced members and members new to ROV. Our company CEO, Mateo Arencibia, has been with Whirlpool Robotics for four years, with CFO Ethan Tseng added from last year's scout team. Other returning members included sophomores Patrick Flores, Lucas Sosa, Hilah Shklarski, Kayla Reardon, Edmund Rose, and Junior Ace Perez. This year, Whirlpool Robotics grew to its largest size yet with the inclusion of freshmen Asher Dundas, Emma Markowitz, Chizara Nnamdi, and Tyler Copeland. We also outsourced help from Sophomore Steven Senger, making him a part-time member of the team.

Some members have taken on additional roles; for instance, Hilah and Mateo have worked on programming the ROV as well as the Float Profiler. Ace has returned as the pilot as well as a member of the frame team. Lastly, the return of our lead 3D designer, Edmund Rose, has helped the team create innovations on the ROV based on specific needs and designs. Edmund is also the reserve pilot in case of emergency. Whirlpool Robotics competed in the World Championship last year, showing steady growth in both talent and ability, as well as creating the right ROV for that year's missions and tasks. The team as a whole is adaptable, hardworking, and is able to use its collaborative skills and combined knowledge to determine the best ROV design and tools for the task at hand.

This year's theme is "UN Decade of Action for Cryospheric Sciences." ROVs have become an essential tool in this effort, as they allow researchers to access environments that are too dangerous or remote for human divers, such as beneath Arctic and Antarctic ice shelves. For instance, ROVs have been deployed under ice sheets to measure meltwater flow, document ice shelf thinning, and collect water samples at varying depths to track changes in temperature and salinity (Moore, Bohm, & Jensen, 2010). The data gathered by ROVs in these environments directly informs climate models and helps scientists understand feedback loops between cryosphere loss and rising sea levels. As glaciers and sea ice retreat, freshwater input into the

ocean disrupts circulation patterns that regulate global climate, making continuous underwater monitoring more critical than ever (NSIDC, 2024). By designing ROVs that are modular, environmentally conscious, and capable of precise navigation, teams like Whirlpool Robotics are contributing to the broader scientific mission of understanding and responding to cryospheric change.

Our team and company are dedicated to using technology to help mitigate factors that negatively affect water ecosystems, particularly in the context of this year's theme, the UN Decade of Action for Cryospheric Sciences. As ice sheets and glaciers continue to melt, monitoring the downstream effects on ocean temperature, salinity, and marine life has become increasingly urgent. The OCTO is well-suited for this mission; it can navigate tight spaces without harming organisms thanks to its eight enclosed motors, and can monitor and collect water samples using its new custom-built rotating claw. Our commitment to sustainability also extends to how we build: we reused the vast majority of our parts from previous years, repurposed leftover aluminum scraps to reinforce the frame, and when purchasing new components, we prioritize BlueRobotics for their high-quality, long-lasting products.

Schedule

Throughout the year, our regular meetings were scheduled every eight days during school hours, but due to the limited time, we decided to add extra meeting days outside of the school schedule on the weekend, as well as work sessions during free periods. We kept a logbook in our engineering lab to record our extra work hours so that we could hold one another accountable and keep the workload equitable.

The tasks were divided into trimesters as follows:

1. Trimester One – Brainstorming and Redesign (Sept. through Dec. 2025):
    a. Redesigning Frame
    b. Redesigning Electronics
    c. Redesigning Float
2. Trimester Two – Construction (Dec. through Feb. 2025):
    a. Laser Cutting, 3D Printing, & ROV Assembly
    b. Programming & Wiring New Electronics

    c. Building float prototypes
3. Trimester Three – Testing (Feb. through May 2025):
    a. Pool Testing & Pilot Practice
    b. Troubleshooting motors, claws, and float
    c. Finalizing Documentation

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 while submerged. 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 (7.2 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 improved lateral stability that outweighs any potential drawbacks.

Internally, onboard electronics are optimized for compactness and reliability, sitting on a designed component holder that keeps the electronics and wiring in place and organized. While the risk of water penetration 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 cameras and sensors, 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 intuitive hand-eye coordination as video games, the OCTO can be driven in multiple directions by the ROV driver easily.

Problem Solving and Brainstorming

New design ideas were inspired by our team's past ROVs and those developed by other teams, with a 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 from our participation in previous years, and looked at designs that were more successful than ours. We 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.

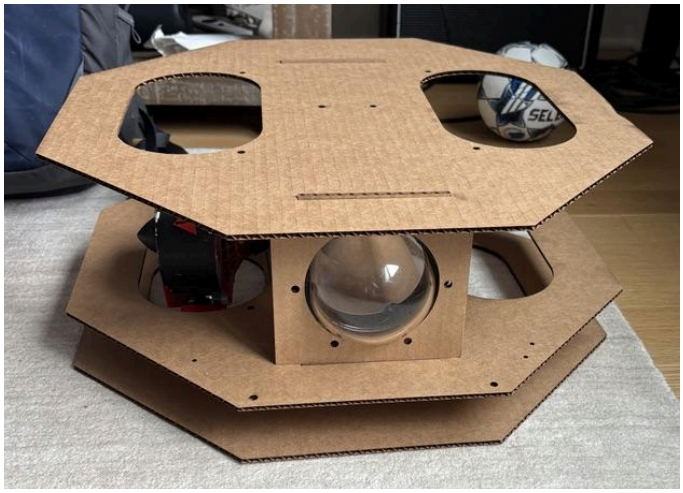
Motor Configuration Research			
	30° Mounting	45° Mounting	90° Mounting
Power Forward	66%	50%	50%
Back Backward	66%	50%	50%
Power Sideways	33%	100%	N/A
Rotation Efficiency	Moderate	High	High

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. Another addition this year is that each of these thrusters is completely protected by the acrylic frame, further protecting the ROV's surroundings. This layout holds the horizontal motors at a 30-degree tilt, which we added to the ROV last 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 materials.

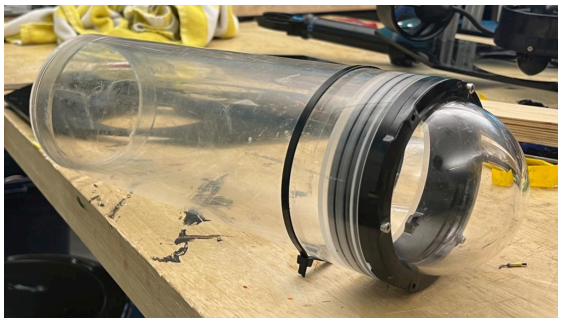


Initial Cardboard Prototype

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 easy and efficient. 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 precise driving in fragile coral systems and the tasks involved, we decided to continue the upgrade to an eight-motor system. Notably, all of these motors, along with the 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 wiring to the ESCs and Raspi's. 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 previously had 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. However, there are major limitations we have struggled with the gripper, including changing the direction of grip to suit different missions. In response to tackling this as a priority this year, our lead 3D designer has been studying the Newton grippers for their flaws. He noted that it does not rotate to provide horizontal and vertical grip, which has meant that in the past, it's been the ROV pilot who 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.

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

In previous years, we relied on the BlueRobotics Newton Subsea Gripper for our claw, but its limitations have become 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.

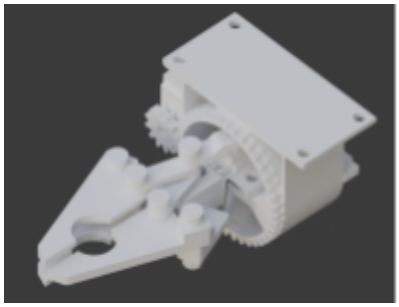


New gripper mounted on the robot

Photo credit: Edmund Rose

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, assisting in things like lifting delicate corals and turning equipment.

In the 2025 season, we first attempted to design a custom claw, but due to its unreliability, it wasn't integrated into the robot. This year, we are focusing on having a rugged and consistent design, able to flexibly handle any obstacle. A major step of this process is the integration of nuts and bolts into the design, acting as strong rotation points that hold the claw together. It largely removes the need for unreliable 3D-printed gears and rotation mechanisms, making it possible to have only 1 set of 3D-printed gears on the gripper. This set is part of the claw's most important feature: axial rotation. This allows it to grip PVC pipes in both the vertical and horizontal orientations, which was something we were unable to do last year. It also means we have the ability to continuously rotate the claw, opening up the ability to complete tasks we were unable to accomplish last year.



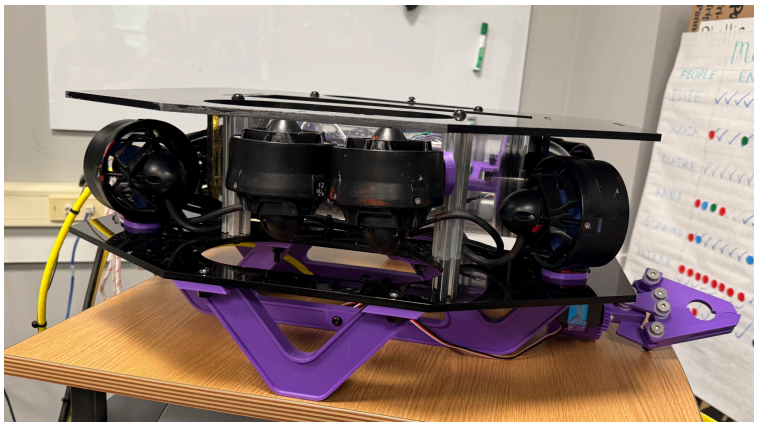
Rendering of the new gripper

Photo credit: Edmund Rose

via Blender

Propulsion

For the thrusters, our company decided to use the BlueRobotics T200 thrusters. These thrusters provided excellent 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 over 4 years ago, 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.



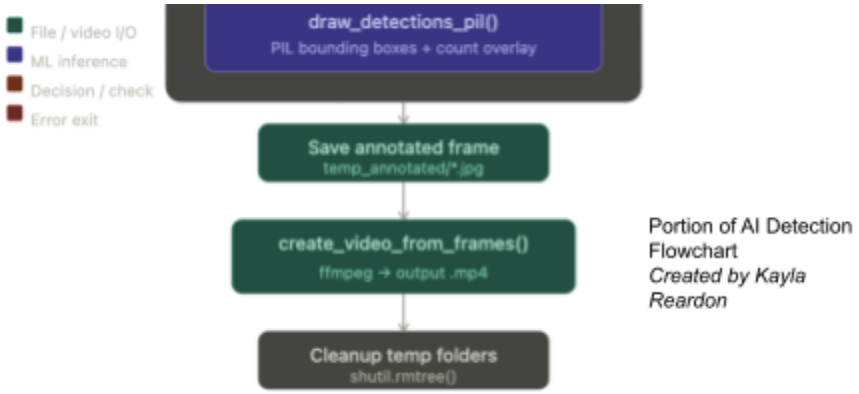
ROV side view of motors

Photo credit: Hilah Shklarski

Camera

The ROV is equipped with two cameras. One camera is a 1080p camera, positioned at the front, facing forward to give the pilot a clear view of the claw and the path ahead. The second camera is a fishing camera, 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, and the fishing camera was picked for ease of use and an

external monitor. The camera interface is structured with a live feed for the pilot, and a video and photo button will allow us to funnel pictures into other systems. Our camera's photos will be imported into Meshlab to generate 3D imagery. Our cameras also use Roboflow to train an AI to detect crabs. We take the video, send it to the Python code, have it analyze and create a new video, and then the crabs will be detected with that. This will be used during this year's mission to distinguish crab species. By incorporating AI, the pilot will be able to gather that data in autonomous ways.



Portion of AI Detection Flowchart
Created by Kayla Reardon

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. 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. We troubleshoot the foam placement until we have neutral buoyancy and was correctly horizontal in the water.

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. Our float is designed with a buoyancy engine, we have two ESP-32 that each have wifi capabilities. One of the ESP-32's is untethered and inside the float with a buoyancy engine and sensor. For the ESP-32 outside of the pool, it is connected to a laptop, which communicates with the float. This float works by manipulating the water inside an 800 ml syringe, being controlled via a linear actuator that has been programmed by an ESP-32 to push water in and out of the syringe, causing the Float to rise and fall. This is all powered by a NiMH battery pack. The float is called the ABYSS (Autonomous Buoyancy-controlled Yielding Sensor System).

Payload and Tools

This year, we have incorporated an ultrasonic distance measuring sensor that will be used both for obstacle avoidance and to measure data in the water. This tool will specifically assist in the measurement of the coral environment, providing height and length, which could then be used for digital drawings of the habitat.

A second tool is for carrying the coral payload. It is a simple design PVC tray that can be manipulated by the gripper to gently scoop up corals.



Coral Scooper *Photo Credit: Melissa Boviero*



Ultrasonic Distance Measuring Probe

III. Electronics Design & Rationale

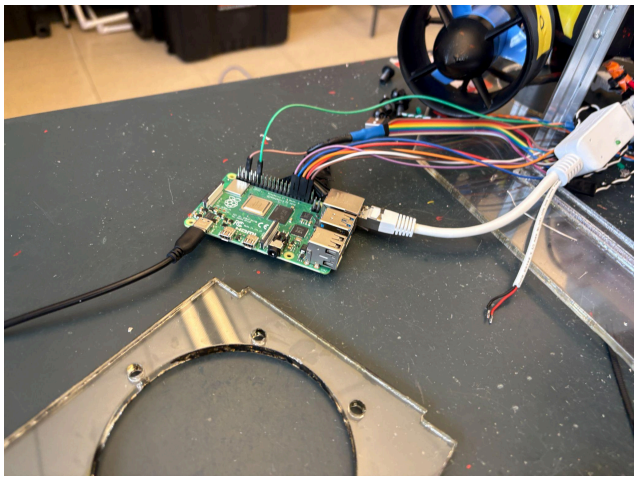
Electronics System Rationale

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 4B
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 Raspberry Pi to connect to a wifi router, which gives us secure communication and a stable connection between the Raspberry Pi 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:

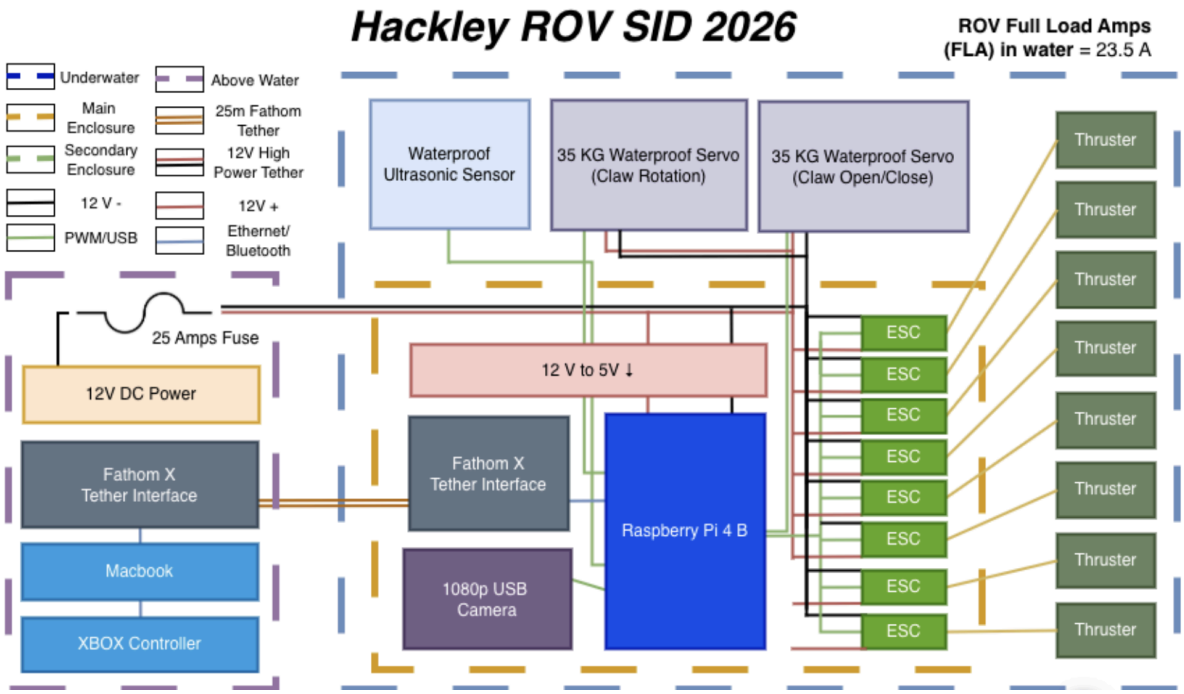
1. Raspberry Pi 4B
2. Fathom-X Tether Interface
3. USB Camera
4. Voltage Regulator (12V–5V)
5. Ethernet Switch
6. Eight ESCs
7. The claw

A high-power wire from the surface delivers the 12V 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 it. 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

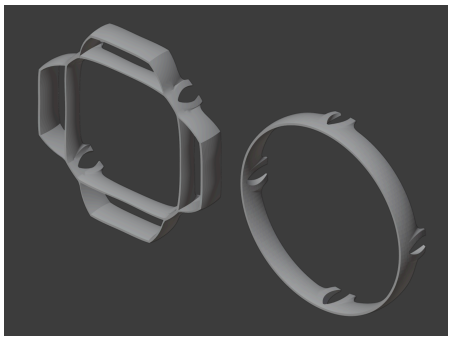
Workplace safety was a top priority while we were working on the OCTO. When using dangerous machinery, we made sure that a qualified adult was supervising at all times and that the entire team had sufficient training in the operation of each tool. PPE, such as goggles, gloves, and face masks, was also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

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 does not exert force on the electronic components themselves. 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 in a previous 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 cylinder to make sure 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.

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 weeks rigorously testing our ROV on land and 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 the negative buoyancy due to the claw and camera, 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, 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 went towards frame alterations, electronic upgrades, cameras, sensors, and our float. The key items of our ROV were resued from previous years, including thrusters, ESCs, the acrylic container, and our tethers. No parts for the ROV were donated; thus, each part was either purchased new or reused from previous years.

	Type	Catergory	Expense	Description	Sources/Notes	Quantity	Initial Price	Price After Quantity
6/5/2025	Purchased	Hardware	Silicone Sealant	Gorilla Waterproof Caulk and Seal Silicone Sealant	Home Depot	1	$6.34	$6.34
10/9/2025	Purchased	Electronics	USB-C Power Supply	27W USB-C Power Supply	Amazon	1	$22.49	$22.49
1/12/2026	Purchased	Hardware	Acrylic Plastic Sheet	2 Pieces of 36 x 48 Inch, 1/4 Inch, Acrylic Plastic Sheet	Amazon	1	$137.99	$137.99
2/9/2026	Purchased	Electronics	USB-C Hub	USB-C Hub for MacBook	Amazon	1	$16.96	$16.96
2/10/2026	Purchased	Electronics	Development Board	3 Pack ESP32 ESP-WROOM-32 Development Board WiFi + Bluetooth CP2102 Dual Core Microcontroller	Amazon	2	$14.25	$28.50
2/10/2026	Purchased	Hardware	PVC End Cap	6" PVC Pipe End Cap	Home Depot	1	$15.19	$15.19
2/10/2026	Purchased	Hardware	PVC Cap with Steel Clamps	6" Flexible PVC Cap with Stainless Steel Clamps	Home Depot	1	$14.29	$14.29
2/10/2026	Purchased	Hardware	PVC	17" 6 Inch PVC Pipe	Home Depot	1	$25.99	$25.99
2/10/2026	Purchased	Hardware	Hex Head Lag Screws	50 Pcs 1/4" x 1-1/4" Hex Head Lag Screws	Amazon	1	$16.14	$16.14
2/10/2026	Purchased	Hardware	Floral Foam Blocks	3 Pack of Floral Foam Blocks	Amazon	1	$5.99	$5.99
2/10/2026	Purchased	Electronics	SD Card	2 Pack of 32GB Micro SD Card	Amazon	1	$15.19	$15.19
2/11/2026	Purchased	Hardware	3D Printer Filament	Purple 3D Printer Filament	3D Universe	2	$17.27	$34.54
2/11/2026	Purchased	Hardware	3D Printer Filament	Black 3D Printer Filament	3D Universe	1	$13.29	$13.29
3/17/2026	Purchased	Hardware	Infant Toys	OBall Infant Toys	Amazon	2	$4.99	$9.98
3/17/2026	Purchased	Hardware	PVC Tee Pipe Adapter	10 Pack of PVC Tee Pipe Fitting Adapters	Home Depot	1	$13.99	$13.99
3/23/2026	Purchased	Hardware	Test Cap	Knockout Test Cap	Home Depot	1	$3.04	$3.04
4/2/2026	Purchased	Electronics	Metal Servo	IP68 Waterproof 40KG Metal Servo	Amazon	1	$24.99	$24.99
4/2/2026	Purchased	Electronics	Jumper Wires	Breadboard Jumper Wires	Amazon	1	$6.63	$6.63
4/2/2026	Purchased	Hardware	Ankle Weights	20-Pound Pair Adjustable Ankle Weights	Amazon	1	$19.99	$19.99
4/14/2026	Purchased	Hardware	PVC	1/2" Size PVC Pipes	Amazon	1	$24.99	$24.99
4/26/2026	Purchased	Electronics	RC Reciever Battery Pack	4.8V 2000mAh AA NiMH Receiver RX Batteries with Hitec and JR Connectors	Amazon	1	$22.55	$22.55
4/26/2026	Purchased	Hardware	Rubber Bands	Rubber Bands	Home Depot	1	$8.50	$8.50
4/26/2026	Purchased	Hardware	Screw Assortment	159 Pcs M6 Screw Assortment	Home Depot	1	$14.24	$14.24
4/26/2026	Purchased	Hardware	Screw Assortment	800 Pcs M2 Metric Screw Assortment	Home Depot	1	$9.49	$9.49
4/28/2026	Purchased	Sensors	Measuring Sensor	Ultrasonic Distance Measuring Sensor	Amazon	1	$35.69	$35.69
4/29/2026	Purchased	Electronics	Raspberry Pi	Raspberry Pi 4 Model B 2019	Amazon	1	$125.99	$125.99
5/6/2026	Purchased	Sensors	Fishing Camera	Underwater Fishing Camera with Temp Depth Sensor	Amazon	1	$118.16	$118.16
6/5/2026	Purchased	Sensors	Camera	Arducam 4K 8MP Autofocus USB Camera Module	Amazon	1	$34.99	$34.99
	Used	Electronics	Thursters	Eight T200 thursters	Past ROV	1		
	Used	Electronics	ESCs	8 ESCS from Blue Robotics	Past ROV	1		
	Used	Frame	Acrylic Container	Container, Caps, and Wetlinks	Past ROV	1		
	Used	Electronics	Tether and Power	Eight braided neutrally bouyant tether and high power cord	Past ROV			
	Used	Bouyancy	Foam	High Density Foam	Past ROV			
							Total Spent	$797.29

VI. Acknowledgements & Funding

Acknowledgements

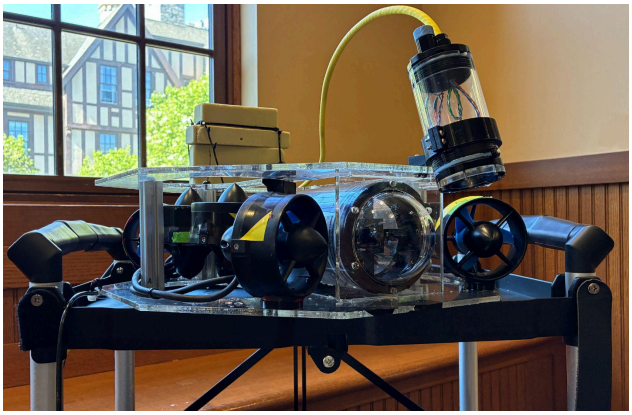
We would like to thank the MATE organization for all the work they put into creating this amazing opportunity to compete. We are grateful for all the time and effort put forth by the

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.

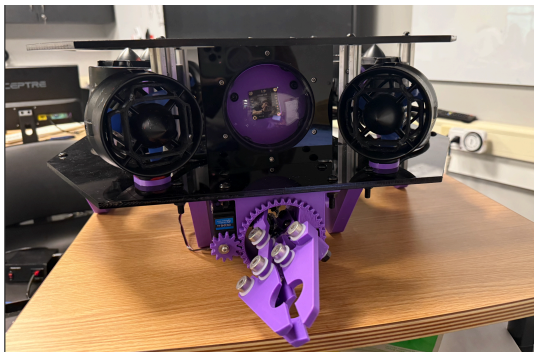
Funding

We would like to thank the Hackley Upper School Science Department for funding our ROV, both this year and 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 support with long hours and weekend sessions

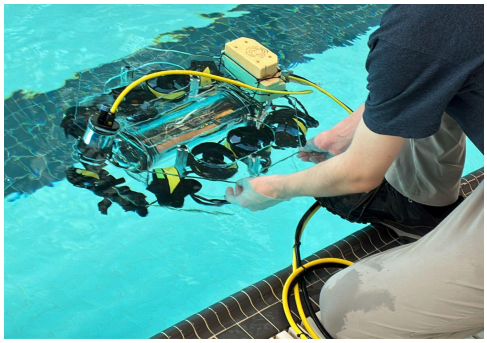
VII. Gallery



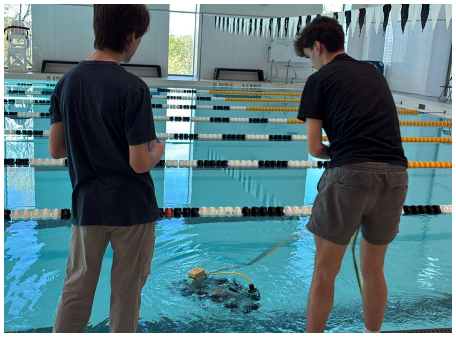
OCTO side view
Photo credit: Hilah Shklarski



OCTO top/front view
Photo credit: Hilah Shklarski



OCTO in the pool
Photo credit: Mateo Arencibia



OCTO pool testing
Photo credit: Patrick Flores



Team Whirlpool Robotics
Photo credit: Melissa Boviero

VIII. References and Resources

1. National Snow and Ice Data Center (NSIDC). (2024). Cryosphere. https://nsidc.org/cryosphere
2. UNESCO. (2023). UN Decade of Action for Cryospheric Sciences 2025–2034. https://www.unesco.org/en/decades/cryospheric-sciences
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. Moore, S. W., Bohm, H., & Jensen, V. (2010). *Underwater robotics: Science, design & fabrication* (Rev. ed.). Marine Advanced Technology Education (MATE) Center.
5. Serway, R. A., & Jewett, J. W. (2018). *Physics for scientists and engineers* (10th ed.). Cengage Learning.