Technical Documentation
Representing Aquatic Futures in Technology
R.A.F.T Robotics Company

Alcona Community Schools
51 N Barlow Rd
Harrisville, MI 48740

RAFT Personnel

Emma Schroeder (11th Grade) - Co-CEO, Project Specialist, Float and Software Engineer

Emily Atkinson (11th Grade) - Co-CEO, Lead Pilot, Software Engineer, Safety Officer

Juliet Mann (9th Grade) - Software Engineer, Co-Pilot

Myra Armstrong (9th Grade) - Mechanical Engineer, Tether Manager

Brandon Stanley (10th Grade) - Mechanical Engineer

Elizabeth Thomson - Mentor
Jodi Mann - Mentor
Kyle Smith - Mentor

RAFT Robotics Company

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RAFT Robotics Company

Company Abstract

The Alcona RAFT Company is composed of five passionate students, ranging from junior to freshman. We started back in June and have worked relentlessly to push ourselves towards advancing our robot from previous years. We have prepared the robot and ourselves to be ready to face whatever task is given.

Our robot has many features and adaptations that have been developed with consideration for both previously encountered problems and future issues that will need to be addressed. We have included a claw for a multitude of various tasks that include, but are not limited to, deploying and recovering floats, installing underwater cables, and implementing management systems. In addition, we have also included important tools such as a camera for visual aid to the driver, strong thrusters for efficient movement, and braces in the frame for structural soundness. This robot is strong, durable, maneuverable, and, with the help of our capable pilot, able to take on any challenge that is thrown its way.

Our company excels in the most important aspects of teamwork. We believe that communication, cooperation, and collaboration are the building blocks of successful teamwork and are crucial for any team to be able to function effectively. By fulfilling these principles, we are able to produce a robot that is fully equipped to handle a huge variety of tasks. That is why we work hard every day to live up to those ideals.

Signed,
The Alcona RAFT Company

Photo Credit:
Jodi Mann

RAFT Robotics Company Project Management

Team Participation

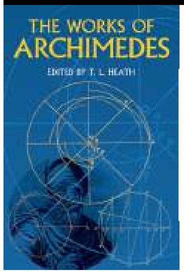
This year, our team members have worked especially hard to build, wire, and prepare our robot for competition day. At the start of the season, we all collaborated in designing and building our robot. However, once our design had been finalized and tested, we each had time to focus completely on a designated area of expertise. Our pilot worked at perfecting their driving skills, our project specialist worked to prepare and finalize our documents and presentations, and our engineer was always on standby to fix any technical issues that presented themselves.

Acknowledgements

While our school's Underwater Robotics program is new, it is fast-growing. We would like to thank Alcona Community Schools for letting us meet there after school, and the Michigan Department of Education for their funds provided by 99h funds. It is these donations that are essential to our team's functionality. In addition, we have several amazing and hardworking mentors who are always there to lend suggestions and advise us from time to time as the need arises. A special thank you to Mrs. Jodi Mann for helping us learn an Arduino system and coding skills, and Mr. Kyle Smith for our frame design assistance and teaching us CAD skills. Finally, thank you to our team mentor, Ms. Liz Thomson, for working with us every day.

It is important to note that while we had mentors help, we also had lots of new content to learn this year. Specifically, we would like to reference the following websites and books:

1. **Arduino Starter Kit Project Book**
   i. Scot Fitzgerald and Michael Shiloh
2. **PhET Lab Simulations**
   i. University of Colorado Boulder
3. **Blue Robotics**
   i. Rusty Jehangir
4. **The Work of Archimedes**
   i. Archimedes



RAFT Robotics Company
Project Management

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Project Management

Timeline Overview

September – Design Phase

- We met a few times in late September to start developing frame designs and concepts for float designs. It was important for our team to work together on these ideas and be decisive about what ideas we would use and what ideas we would save for later.

October to November – Frame Building

- Prototyping began with basic frame construction and buoyancy testing. We were unable to meet regularly as we have many team members in various other groups. We spent most of our meeting time making our frame out of aluminum, and this was quite challenging since this was the first time we used this material and the applications to reinforce our design.

December to January – Component Development

- This phase included testing motor configurations and refining the tether design. We spent most of our work time making sure our motors and payload tools were placed effectively within our system.

February to March – Assembly and Integration

- Mechanical and electrical systems were assembled. We integrated thrusters, sensors, and control boards by using our enclosure as our primary connection power for all components on the ROV. The software team began the initial code deployment and diagnostics testing.

April – Testing and Refinement

- We conducted pool tests to evaluate ROV maneuverability, camera visibility, and task performance. Based on the test results, we refined control algorithms, adjusted the ballast, and made minor mechanical tweaks. We also competed in the SquareOne contest on April 3rd.

May – Final Preparations and Documentation

- With the ROV fully operational, we finalized this technical report, filmed our marketing video, and ran full mission simulations to prepare for competition. We will compete at the MATE Great Lakes Regional contest on May 17th.

Project Management

Effective communication is essential to our team's success. In addition to our regular in-person meetings, we maintain consistent contact through a team group chat and a shared Google Drive. These tools allow us to collaborate outside of scheduled practices, organize key documents, and ensure that everyone remains informed and engaged.

One of the most important documents we manage is our project schedule. Most team members have various commitments throughout the school year, such as sports, academic clubs, and other extracurricular activities. For example, most of our team members are in a highly competitive FFA chapter, and two of our members are FFA officers. We also share members with the Alcona First Robotics team. Since our school is small, not all students can have the luxury of being a one-sport or one-club student. Knowing this, we built our schedule to be flexible and inclusive. When potential conflicts arise, we work as a team to reassign tasks and support one another to maintain momentum.

Team members who are unable to attend weekday meetings contribute in other meaningful ways. For example, those with limited availability during the school week focus on tasks such as budgeting, documentation, or design work independently. These contributions help complete tasks that need to be done, but may not be a high priority during the first half of the season. This approach ensures that every member plays a vital role in our success, regardless of their availability, and reinforces our collaborative, solutions-oriented team culture.

Communication & Scheduling Tools Used:

- Google Docs – collaborative documentation
- Google Calendar – team schedule and deadlines
- Gmail – formal communication with mentors and vendors
- iMessage – quick team updates and coordination

Design Process

The building process for our ROV was a long and detailed journey, requiring about 150 hours of dedicated work to bring our initial concepts to life. Throughout this process, we consistently applied core engineering practices such as iterative design, prototyping, and continuous modification.

The diagram we created outlines the structured steps we followed — from choosing a whale shark-inspired shape for compactness and hydrodynamics, to selecting materials and refining our assembly for efficiency.

One of the major challenges we faced was integrating multiple tools and attachments, such as the claw and camera, into a compact frame. Often, parts that worked in theory didn't fit or function as expected during assembly. Rather than settling for a less effective design, we embraced an iterative engineering approach: testing each configuration, identifying weaknesses, and redesigning or rebuilding components as needed.

One thing we also considered in the design process if the buoyancy of the ROV. We placed various floats and weights to make the ROV naturally buoyant in the water column. This was a series of tradeoffs where we needed to add weight or buoyancy to make the ROV neutrally buoyant.

The cycle of design, test, and modify helped us progressively improve our ROV. Each adjustment, although time-consuming, made the robot stronger, more efficient, and easier to maintain. Our final frame design, along with the modular top hatch and strategic material choices, reflects the result of careful, repeated engineering decisions aimed at optimizing performance within the competition constraints.
Through this process, we demonstrated important engineering mindsets like resilience, problem-solving, and adaptability — all critical in real-world technology development.

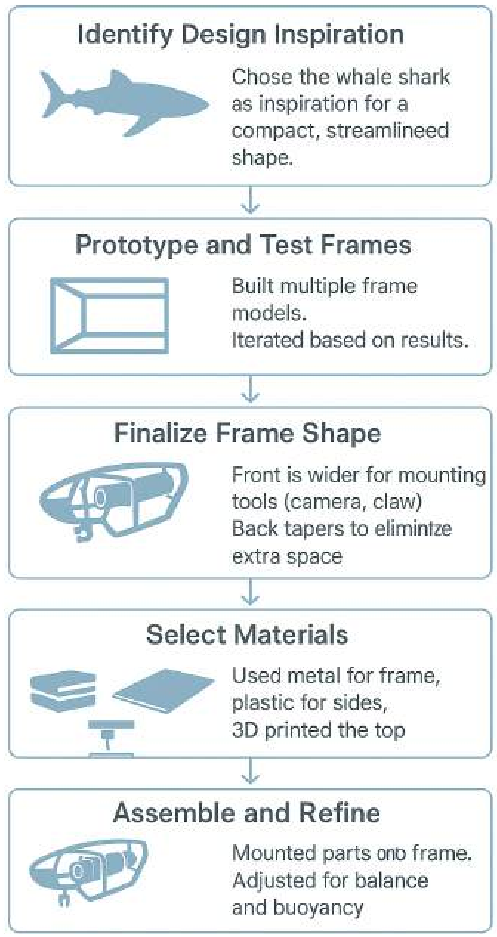
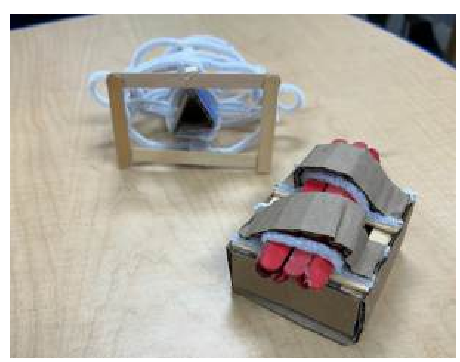


Diagram Credit: Myra Armstrong

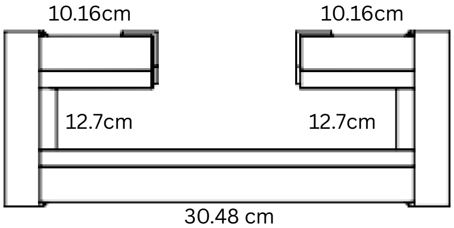


Early drafts of the frame were made out of popsicle sticks and pipe cleaners.
Photo Credit:
Emma Schroeder

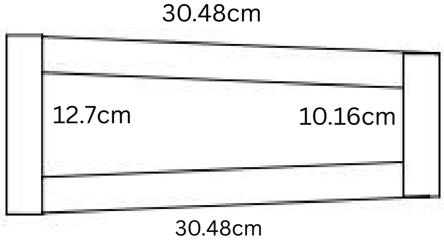
RAFT Robotics Company
Design Rationale

Structure and frame

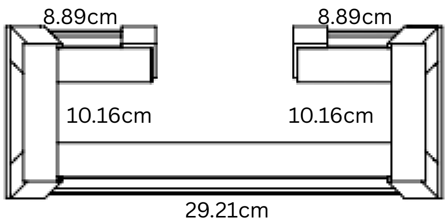
Our frame design was inspired by the shape of a whale shark. We chose this design because it enables a more compact and hydrodynamic build, helping our ROV move smoothly through the water while keeping the overall size manageable to meet size and weight restrictions. We met this goal with a weight of 14.4 KG.



Front view



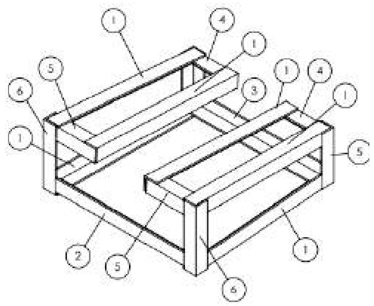
Side view



Back view

Throughout the design process, we went through numerous iterations, experimenting with different shapes and materials before finalizing a frame that satisfied all our functional needs. The final design features a wider front section and a gradually tapering back. This layout provides ample space at the front to mount important tools such as the claw while reducing unnecessary material and drag toward the rear.

This year, we decided to move away from using PVC pipe, which we found to be bulky and difficult to customize. Instead, we opted for a lightweight yet durable metal for the primary frame structure. To cover the sides, we used plastic sheets to protect the internal components without significantly adding to the weight. It is better to have a smaller robot so it's easier to bring in and out of the water, plus move in the water. Using Plastic PLA filament for our 3D-printed components is good because it is lightweight. Aluminum is also relatively lightweight, so it doesn't add too much to our ROV's weight.



Second draft of the aluminum skeleton

For the top of the ROV, we designed and 3D-printed a custom piece. This 3D-printed top functions as a hatch, allowing us to easily open and close it for access to the cylinder housing all the critical electrical components. By only 3D printing the top, we kept the build simple and lightweight while maintaining quick accessibility for maintenance and troubleshooting.

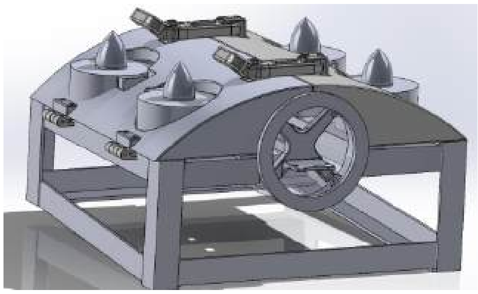


Photo Credit:
Myra Armstrong and Kyle Smith

Overall, each design decision was made to balance strength, maneuverability, and ease of use, ensuring that our ROV can perform reliably in the competition environment. This design presented multiple challenges, mostly because we manufactured and designed every component of this vehicle. From printing and designing the hatch tops to constructing the metal framing of the ROV, everything was developed and manufactured by our team.

Payload Tools

This year, our main payload tool is the claw, which is affixed to the front of our robot. It is necessary for completing all kinds of tasks. From collecting artifacts to identifying shipwrecks to maintaining renewable energy systems, picking up a cargo lid, removing and replacing thermosters, completing pCO2 censor tasks, taking caps off, pulling pins, placing velcro strips, plugging things in, completing the sacrificial anode task, releasing objects, and collecting different things. This claw can do it all. While some may argue that it is better to have multiple, more area-specific tools, we believe that it would be more efficient and cost-effective to have one major tool that is able to work in a variety of circumstances. In the future, we would like to find a way to better improve this system and move away from an analog system as our primary payload tool. We have two other payload tools for this mission that work directly with the ROV. These payload tools would include the pH meter and the lift crate to recover the sample. The pH meter will be placed into the claw of the ROV and then taken down to the sample area. The crate is 3D printed and should work (based on provided measurements from MATE) to collect the sample once it is released from the bottom of the pool.

Claw and Linear Actuator. Photo Credit: Amazon Business

Original Thruster Look Photo Credit: Diamond Dynamics

Thruster placement

The thrusters are placed as they are to improve stability in the water. The robot must be upright to make sure that it will not fall crooked in the water. Part of the reason the thrusters are where they are is to improve hydrodynamic forces. The thrusters are housed within the frame of the robot to keep the robot condensed so we can still maneuver well in the water, but not so that we don't lose any power in the thrusters from being blocked, and this helps it drive in the water more efficiently and quickly. We also had safety in mind, like any team should have. We put the four top thrusters on the inside so it significantly decreases the chance of getting hurt by the thrusters, as well as the two directional motors. The reason we have 4 up and down thrusters is so that it is easier to go up and down because we had challenges with that in previous years. These motors are bi-directional brushless motors that use ESCs. This was a large skill jump for our company, as most of our experience is with bilge pump motors that get modified with a propeller adapter kit. This was a jump we felt to be necessary to be competitive at the ranger level, and we all worked hard to learn how electrically these are different and how to modify the frame design to fit within the whale shark shape. Overall, this was a challenge, but a challenge worth taking to improve our company. Our thrusters were a cost-effective purchase because other thrusters that performed as well were more expensive.

Vertical Thrusters viewed with ROV panels open for easy access. Photo Credit: Emma Schroeder

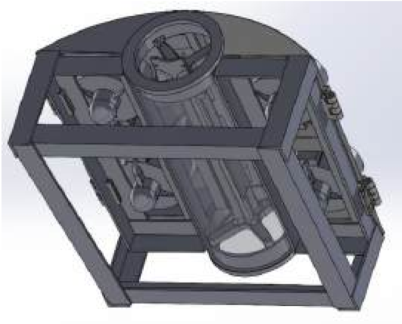
Camera placement

This year, the camera we are using is a car backup camera. We chose the backup camera because it is in color, which makes distinguishing objects in the water easier, and we can use the guidelines to measure in the water. Even though it is water-resistant, we are putting it into the cylinder. This keeps the camera in good condition longer and protects it from any outside force that could damage it. The camera is positioned front and center, letting the driver clearly see what is in front of them and what they are interacting with. Not only that, but the claw and anything attached to the claw will be easier to see.

Camera located inside the electrical enclosure. Photo Credit: Emma Schroeder

Buoyancy

For our company's buoyancy system, we use the trapped air in the enclosure that houses our electronics underwater. In the past, we struggled with our buoyancy system as it was mostly comprised of pool noodles. Pool noodles have a crush point around 2 meters and struggle to function any deeper. With our regional pool set up, we had to focus on a way to make a more reliable buoyancy system, and using trapped air did the job. Overall, our robot is light enough that it does not require any additional buoyancy systems. While balancing our buoyancy, we referenced Archimedes' principles by using the weight of our robot to determine how much displacement our robot needed to have in order to be fully buoyant.



3-D model of final design. Photo Credit: Myra Armstrong and Kyle Smith

Build vs. Buy and New vs. Reused

Every year our company works off a fixed budget; for this year, the funds came from Michigan's Department of Education (MDE) 99h funds. That being said, we have to be very particular with what we buy new and what we reuse or build. We knew that we would struggle building an entire 3D printed frame, so we decided to buy aluminum angle and flat bar pieces to create a unique bottom of the ROV (this also included rivets and fasteners). Using Aluminum allowed the bottom half of the frame to be sturdy, light, and cost-effective. However, for the top of the ROV, we wanted it to be 3D printed PLA material that can be opened and closed, allowing easy access to the enclosure that holds the electrical systems. Alongside that, if we were going to upgrade our electrical control system, we would need to keep some parts we know to be reliable, including our camera and primary payload system (the linear actuator). The most important buy choice we made this season was our enclosure purchase. We do not have the technology or tools to build an enclosure, and we knew this was something we had to buy if we did not want to accidentally flood the enclosure tube.

The rivet gun and rivets, we used to put our robot together. Photo Credit: Myra Armstrong

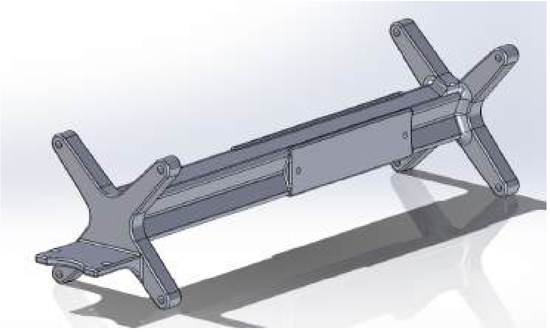
RAFT Robotics Company Design Rationale

Electrical system

Our electrical system is powered by a portable battery, which supplies energy to our control box, camera, thrusters, and linear actuator. Using an Anderson Powerpole connector, we connect to a portable battery that provides power to our control box (surface) and to the enclosure (subsurface). Inside the enclosure is a bus that allows us to connect our thrusters and camera to receive power. The control box uses an Arduino system to connect the joysticks to the thrusters. It features two joysticks for vertical and horizontal movement, along with a switch for the claw. Inside the control box, the camera links to a screen powered by the same battery. A mesh wire covering protects the tether to prevent damage to the power and data wires. This tether enables the control box to transmit information to the ROV, allowing the pilot to operate it effectively.

Inside the enclosure is the electronics tray. We made our own to save on costs and customize for our needs. This enclosure tray holds two buses that power the entire electrical system. Using penetrators, we can seal the wires running into the enclosure and running out of the enclosure. In front of the enclosure sits the camera so we can see out the dome of the enclosure.

Inside the control box, we have our digital system. Learning the Arduino was a challenge, as we had operated a fully analog system for the past 4 years. However, a small group of the team were determined to learn how to transition the system to digital. To learn how to make the digital system, these members learned the basics of C++ and how to successfully wire an Arduino to the joysticks and thrustors.



3-D model of the electronics tray that holds all electrical components. Photo Credit: Myra Armstrong and Kyle Smith

Innovative Components

Our robot has many innovative components, such as a 3D-printed top that opens up with latches. We chose to do this as we know our wires are shorter and it would be less effective to tip our robot up and take out the electronics holder rather than to unlatch the top and have easy access to all of our electronics.

We also have 3D-printed thruster caps to prevent finger injury and things from getting stuck in the propellers.

Our frame design is compact, making it easier to maneuver in the water and avoid obstacles such as the shipwreck, which can cost you points for hitting it. We made these parts so that we are overall cost-effective and keep the budget relatively low. These components all work together to make an effective working ROV.

RAFT Robotics Company Design Rationale

Control Box

This year, we decided to move out of a fully analog system and started incorporating coding into our systems. To accomplish this, we used Arduino to wire the joysticks and run the code. The code we used was pulled from an open-source code from Bluerobotics. This decision was made due to the fact that, while we are actively learning and improving our C++ skills, it would be more time efficient to pull from reliable code that has been used and tested before. Additionally, this allowed us to focus on the many different parts and systems that we developed ourselves. Exploring this method of setting up controls allowed us to have a much larger range of motion than ever before because not only do we have control over direction, but the ESCs in the thrusters allow us to control the amount of force outputted.

Control box interior. Photo Credit: Emma Schroeder

Enclosure System

The wires from our tether are fed through the wet link penetrators. We tightened and put epoxy on them to make them waterproof. They are fed through to our enclosure. The trapped air inside the enclosure is very buoyant to combat the weight of the robot. However, we did have to adjust the buoyancy because the wires made the robot back-heavy. To help with this, we attached weights to the front to make it neutrally buoyant.

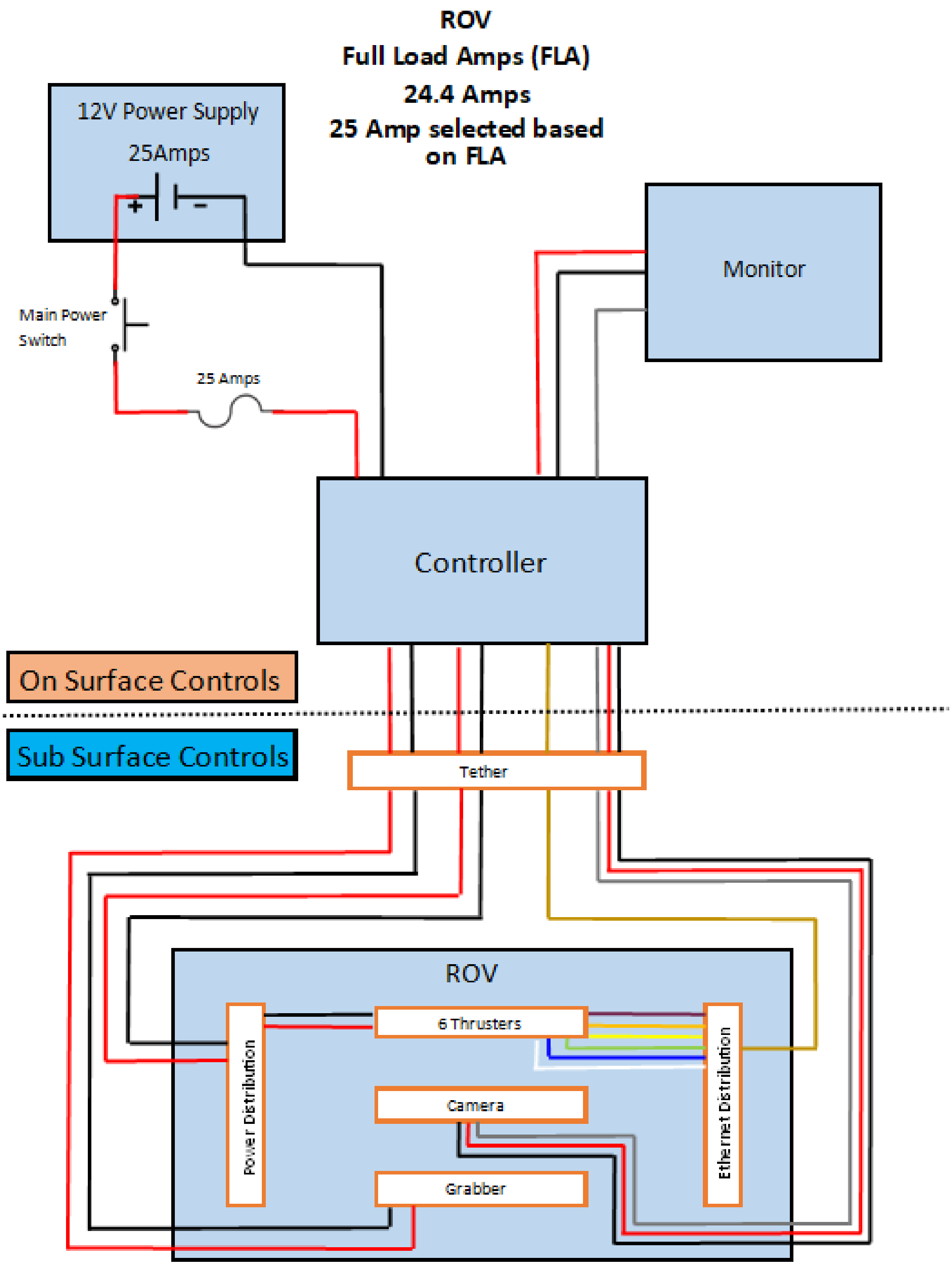
Close-up photos of the electrical enclosure from the back and the side. Photo Credit: Emma Schroeder

Tether and Tether Management

Our tether is approximately 7.5 meters long in order to accommodate the depths at which these tasks will need to be accomplished. When choosing the length of the tether, we had to consider that, while a longer tether would allow us greater mobility in the pool, it made for a challenge and hazard during transportation. In order to circumvent this issue, we always ensure that the tether is properly wrapped up before moving the ROV from place to place. Additionally, the weight of the tether, while underwater, can affect the buoyancy of the ROV. As such issues provide difficulty to the driver that we want to avoid, we put floats on the tether roughly every meter to ensure it is neutrally to positively buoyant at all times and won't affect the robot's reaction time or cause an awkward tilt while in the pool.

Coiled up Tether. Photo Credit: Brandon Stanley

RAFT Robotics Company
ROV SID (System Integration Design)



Purpose/Intention

This float functions autonomously to collect data for multiple vertical profiles. A vertical profile is a collection of data showing a correlation between a certain quantity compared to height/altitude, and in this case, that quantity is temperature. The float is meant to independently ascend and descend 2.5 meters two separate times, the whole while collecting temperature readings onto an SD card, every 5 seconds, which will be collected after its mission. It is also programmed to hover at 2.5 meters for 45 seconds, or 10 readings, before ascending.

Buoyancy Engine

Buoyancy is defined in physics as the upward force that opposes the weight of a partially or fully submerged object, and it is represented by the equation F = pVg. The volume of the object (V), the exterior water pressure (p), and the gravitational force (9.8m/s represented by g) are all equal to the buoyant force, which, when equal to the mass, means that the object is neutrally buoyant.

In order to make an object move vertically in the water without the use of motors, one of two things must be able to be altered: The overall mass or the amount of water displaced by the float. This design utilizes the latter.

In order to increase the volume and displace more water, the syringe, controlled by a linear actuator, pushes and pulls air in and out of the exterior pouch. When designing this engine, the most challenging part was figuring out the exact point where the float would be neutrally buoyant. When the pouch is inflated more than this point, it causes the float to ascend because the buoyant force is greater than the weight, and when the air is pulled all the way into the syringe, the float displaces the minimum amount of fluid, causing it to descend.

Coding the Linear Actuator

When deciding how we would approach the buoyancy engine, we knew that using a linear actuator would require more than just the Arduino. Since there are more variables than just on and off that the pins on an Arduino control, we needed to use either relays or a motor driver.

The main difference between them was that the relays control the actuator by using simple high and low values. Meaning that the relays allow you to make it either open or close; however, there is no way to control the speed at which it works. The motor driver, while being slightly more complicated to develop, allows you to manipulate both. We chose to utilize a motor driver because, even though speed isn't the most important factor, it allowed us to have that extra variable to work with when troubleshooting the buoyancy.

RAFT Robotics Company
Data Observation/Collection Float

Materials and Hardware

There is a variety of parts that come from a variety of sources on this float. For starters, the sensor and converter for the sensor are both from the company Bluerobotics, while the syringe, pouch, linear actuator, motor driver, and converters are all sourced from Amazon. Even though it may not be the most fancy to look at, the pouch was made out of a water bottle, as water bottles are designed to keep water in and out, and it would be the most reliable material when working underwater.

Build Process

The process for designing this float started back in December. In the beginning, it took a lot of research and rough ideas before we settled on a design. Since there are so many ways you can create a buoyancy engine, we played around with a couple using very rough builds before narrowing it down to two different designs. While both utilized syringes, they applied them in different ways. The first design used the syringe to pull water into a compartment to increase the mass of the float. The second design, and the one we ultimately ended up going with, used an exterior “swim bladder” that could be used to displace more water.

When putting the first design into motion, we began with the mechanical portion of the build. we prioritized the electrical components, knowing that they would need the most troubleshooting in the end. One of the most challenging aspects of the build was figuring out how to get all of the components to run efficiently off one Arduino. In addition, we utilized a wireless Arduino, so we had to make sure that, when at the surface, it would not lose connection with the computer.

How does the Data Collection and Retrieval work?

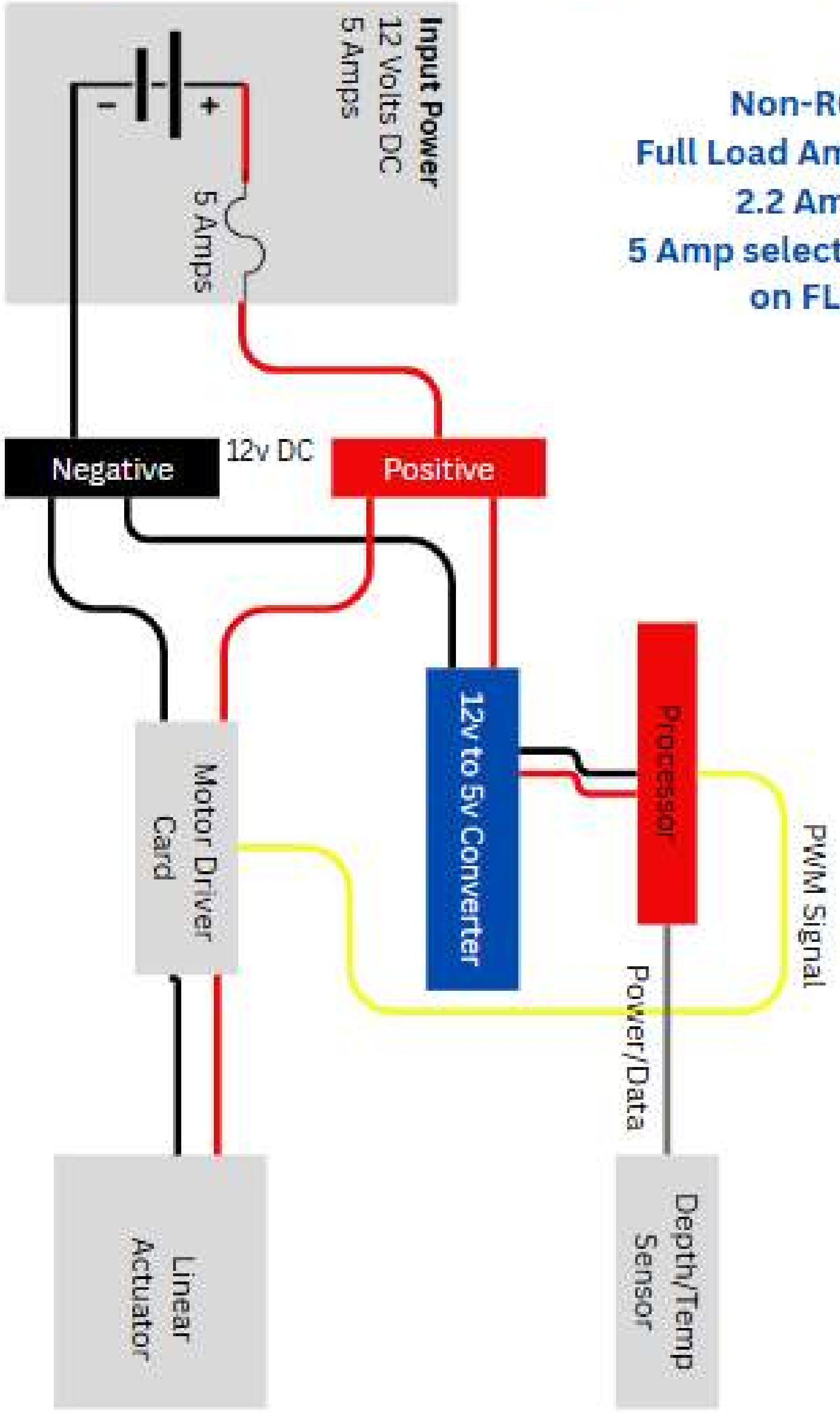
Since this float is fully autonomous and is not connected to the surface via a tether or any wires, it communicates with my computer via a wifi connection. However, since it travels underneath the surface of the water, and since wifi cannot travel through water, it will lose that connection as soon as it is deployed.

The way we circumvented this issue was by having an SD card wired to the Arduino, which collects data readings every 5 seconds as it travels. The data feeds into the SD card during its profile, and once it reaches the surface, it is able to transmit all the data it has collected to the computer's dashboard, where we can then graph it to better show the relationship between temperature, depth, and water pressure.

Inside the tube, the Arduino is placed at the top to ensure that it does not lose connection as we are deploying it. The rest of the electrical components are stored at the bottom of the tube so that the weights of the batteries, motor driver, and converters do not affect the weight distribution.

RAFT Robotics Company
Float SID (System Integration Design)

Non-ROV Device Float
System Integrated Diagram (SID)



Non-ROV
Full Load Amps (FLA)
2.2 Amps
5 Amp selected based on FLA.

Safety Features

Our Safety Officer has tested and made sure our ROV is up to code and is safe to use during competition. She ensured that the thruster caps were applied properly to all of the propellers. Furthermore, she confirmed that the tether had its mesh covering and was connected to the strain relief. All of these things help the ROV safely work underwater. It is crucial that it's up to code inside and out. Observing and helping in the process of building, our Safety officer made sure everyone had the correct safety gear and applied it when needed. This helps keep the entire team safe while working on and around the ROV.

Saftey Components

- **Thruster caps**
  - Thruster caps are essential to keep operations safe when working with the ROV. These caps keep operators safe, so fingers and tools do not get caught in the thruster motors. This also helps keep operations smooth, so lines and cords do not get caught in the thrusters.
- **Tether cover**
  - The tether cover helps keep all our wires in one place. This prevents the tether from getting caught in product demonstration parts, and for members to carefully move the tether in and out of the pool.
- **Strain relief**
  - The strain relief on our robot is essential to keep operations running and safe. There are four strain reliefs on our robot, and they hold the wires in the strain relief with tension, so when the ROV components move, the wires do not come out of the control box or the enclosure of the ROV.
- **Enclosed control box**
  - Our control box is in a water-tight case that locks and protects our electronic system While we are operating near the water.

Fuse and Strain Relief. Photo Credit: Amazon Business

RAFT Robotics Company Safety

At R.A.F.T. Robotics, safety is our top priority. We are committed to protecting our team members, operating our equipment safely and effectively, and the environment during both the construction and operation of our ROV. To support this, we have a designated Safety Officer who ensures that all safety protocols are followed and updated as needed. Each time we operate the robot, we follow our procedures on our safety check sheet. We review this document each time we operate our ROV to ensure that all operations are safe and effective. Below we have listed procedures for working in the lab on the ROV and at the poolside, as well as safety features on our ROV.

Personnel & Lab Safety

All team members must follow strict safety guidelines while working in the lab:

- Closed-toe shoes are required at all times to protect feet from dropped tools or materials.
- Long pants and long sleeves must be worn to reduce the risk of burns, cuts, or other injuries.
- Long hair must be tied back when working near heat sources or electrical components to avoid entanglement or fire.
- Safety glasses must be worn during soldering or any task involving sharp tools or chemicals.
- A mentor or adult supervisor must be present anytime heat tools (like soldering irons) or a power tool is being used.
- The lab is restricted to team members only during work hours to prevent accidents.

ROV Operation & Mission Safety

Whether in a practice session or a competition mission, the following safety rules must be followed:

- Wear closed-toe shoes at all times.
- Tie back long hair to prevent it from getting caught in equipment.
- Wear safety glasses when near electronics or propulsion systems.
- Never run near the pool to avoid slips and falls.
- Follow all poolside safety rules, including no leaning over the water while the ROV is in motion.
- Only trained operators may control the ROV.

Vehicle-Specific Safety Features

Our ROV includes several safety measures to protect both people and equipment:

- All wiring is insulated and securely fastened to prevent shorts.
- The propellers are surrounded by guards to reduce the chance of injury.
- Waterproof seals protect electronics from water damage and prevent electrical hazards.
- A fuse is built into the power system to stop current flow in case of a malfunction.
- We have strain reliefs to prevent wires from being ripped out of the robot and control box.

Alcona Safety Check Sheet

INITIAL SYSTEMS CHECK	YES	NO	ACTION REQUIRED
SID documentation	☐	☐	
Team Spec Sheet	☐	☐	

PHYSICAL ROV CHECK	YES	NO	ACTION REQUIRED
All attachments are secured to ROV	☐	☐	
Any hazardous items are identified and use required protection.	☐	☐	
All moving components are covered and secured. Propellers are either enclosed in the frame or shrouded for protection.	☐	☐	
No sharp edges or elements on the ROV that could harm or injure personnel working with the ROV.	☐	☐	

ELECTRICAL SYSTEMS CHECK	YES	NO	ACTION REQUIRED
Single attachment point for the power source (Anderson Powerpole)	☐	☐	
15 amp single inline fuse	☐	☐	
No frays in tether or conductors.	☐	☐	

Overcoming Challenges

Over the past year, we have learned a lot and grown as a team. We wanted to challenge ourselves this year by moving away from an analog system and to a digital system. We spent many hours learning the Arduino system to ensure we would know how to write code and to wire the Arduino board and breadboard. We worked through the practice kit for about three months. After we felt comfortable using the Arduino system, we started using code and wiring the Arduino to run the six motors on our ROV and for our joysticks in our control box.

We faced massive challenges while building our frame this season. Traditionally, we build our frame out of PVC, and this year, we realized that we needed to find something sturdier and more reliable, that still retained the qualities we liked about PVC, being that it was easy to modify. After making a list of possible supplies, as well as the pros and cons of both, we eventually decided to build our main frame out of aluminum and use 3D filament (PLA) to make flaps on top that would open and close to allow easy access to the electrical enclosure. In order to pull this off, we had to learn how to use CAD and use TinkerCAD to design our hatch top design. This took quite a few tries to get right, and we needed to print multiple times to find the one that would work. We also struggled with getting the print to be perfect when we printed a whole side, as the sides would curl up during the printing process. This made it hard for the print to fit onto the top evenly. Eventually, we decided to print each side of the hatch top in halves and then glue them together, which allowed the print to print flat and evenly.

We also had to overcome the struggle of having a larger team. In the past, we have had little challenge with communication as all three of our members interacted on a regular basis. However, this year we needed to reevaluate our communication strategies. We needed a reliable way to reach all of our members. We initially assumed a group chat would be enough, but we quickly realized we would all need to share documents and pictures as well. By setting up a company drive, we were able to increase our capacity by allowing all of our members 24/7 access to the schedule, list of tasks, and documentation that needed to be completed, We were able to get things done quicker and more efficiently.

There were many challenges this year since we decided to take on many new concepts and systems. As a team, we have grown in many areas and have improved our company's operations and collaboration skills. The challenges we faced this year have taught us resilience, new skills, and improved our communication skills.   At times, it felt overwhelming, but we learned how to break big problems into smaller steps and support each other through trial and error.

Trouble Shooting Techniques and Strategies

Troubleshooting seems to be the middle name of RAFT Robotics company. We faced several problems as we worked on improving our operations as a company and improving our robotic performance. Naturally, when you start learning anything new, you have to make a lot of mistakes and learn from your failures. Our troubleshooting techniques include prototyping and testing. These helped to improve our operations and our understanding of the systems we were operating.

Using the Arduino starter kit, each of our electrical and software engineers worked through the starter kit to have a deep understanding of the system. This was also important because, as a team, we need a safe space to make mistakes with low-risk parts. With our actual ROV parts, we could not afford to buy extras, so we did not want to risk damaging or ruining these parts. The starter kit was very helpful to learn the basics and to understand the functions of the Arduino board, wire a breadboard, and use basic motors and sensors. When we started working with the actual ROV parts, we were able to use our troubleshooting skills we learned from the Arduino kit to apply to the actual ROV system we were building. During testing, we often ran into problems like motors not responding or joysticks sending incorrect signals. We used step-by-step debugging—checking each wire, sensor, and line of code one at a time—to figure out where the problem was. We also used the serial monitor in the Arduino IDE to check our code outputs and identify where signals were being lost.

When we started designing our ROV frame, we made many prototypes to aid in the design process. We first built a prototype from popsicle sticks and pipe cleaners. Then we built a prototype out of PVC pipe. Then our final design was made from aluminum. From the start, we knew we wanted to build a hybrid frame that uses two different types of materials. We thought that this might be PVC and 3D PLA filament. Ultimately, we decided to go with the aluminum framing because it was lighter in weight and we had more design options.

Through these challenges, we learned to test early and often, always trying small changes and checking results before moving forward. We used a cycle of build test revise throughout the season. Testing in real conditions, like in the pool or under load, helped us discover problems we couldn't see just in the lab.

These troubleshooting experiences helped us grow as engineers and team members. We learned how to solve problems step by step, stay calm when things went wrong, and use teamwork to find creative solutions.

Vechicle Testing Methodology

Our team employed an iterative testing methodology throughout the development of our ROV. Each major design modification or new component was evaluated through a cycle of prototyping, testing, analysis, and refinement. We utilized a water tank provided by our mentor to conduct most of our in-water testing, which was essential for assessing buoyancy, thruster configuration, stability, and overall maneuverability.

Electrical components and software systems were initially tested outside of the water to ensure safety and functionality before integration with the full vehicle. Once validated, these systems were tested in conjunction with the ROV in the water to monitor real-time performance.

One notable aspect of our testing process was the evaluation of structural and mechanical features. For example, we tested and implemented a custom top that allowed us easy access to our enclosure electronics and our thursters. Conversely, some design ideas were tested but ultimately discarded. Early in the season, we explored a frame that was oval rather than rectangular. However, repeated issues with our 3D design, print quality, and a lack of performance improvement led us to revert to a more reliable material configuration with a partially 3D-printed frame and a more durable aluminium base.

An example of when troubleshooting became valuable was the first test in the pool. When we were practicing piloting, our controls stopped working. In order to figure out what was wrong, we made a list of possible issues and ran through tests. The first possible issue we tested was heat damage. We allowed it to cool down in a darker room and, sure enough, the controls worked again within the hour. Because of this, we discovered that our Arduino is sensitive to the heat that comes from the sun.

Our testing process was essential not only for verifying individual subsystems but also for evaluating how components functioned together. This approach allowed us to identify unforeseen interactions between parts and make informed decisions that improved the reliability and effectiveness of our final vehicle design.

Test Name	Purpose	Method	Result / Outcome
Electrical & Software Bench Test	Ensure safety and basic functionality of electronics and control code	Powered and tested components individually outside water	Verified proper operation; safe for integration with the vehicle
Buoyancy & Stability Test	Achieve neutral buoyancy and stable operation underwater	Submerged vehicle in provided tank; adjusted foam and weights	Achieved near-neutral buoyancy; improved thruster positioning
Thruster Access Design Evaluation	Improve accessibility for wiring and maintenance	Prototyped and tested custom top hatch for thruster and enclosure access	Final top design implemented; significantly improved accessibility
Hybrid Frame Integration	Test aluminum base with 3D-printed components for strength and balance	Built hybrid frame and tested in water for mechanical integrity and stability	Final design used; offered greater durability and easier assembly
Full System Integration Test	Ensure all systems work together under real-world conditions	Conducted complete ROV pool test with electronics, controls, and mechanical subsystems	Identified and corrected small software timing issue; confirmed full functionality

2025 Budget ROV

MATE ROV Budget 2025

Part	Ordered From	Build vs Buy vs Reused	Cost
Aluminum Angled Plates	Amazon	Buy	$22.00
Aluminum Flat Plates	Amazon	Buy	$33.00
3D Printed Top Hatch (PLA costs)	N/A	Build	$13.00
Latches	McMaster Carr	Buy	$32.00
Thrusters	Amazon	Buy	$120.00
Enclosure	Blue Robotics	Buy	$700.00
Penetrators	Blue Robotics	Buy	$140.00
Joysticks (2)	Amazon	Buy	$25.00
Monitor	N/A	Reused	$0.00
Control case	N/A	Reused	$0.00
Ardunio Kit	Amazon	Buy	$20.00
Power Wire	Amazon	Buy	$40.00
CAD 6 Wire	Amazon	Buy	$32.00
Enclousure Tray (PLA costs)	N/A	Build	$22.00
Camera	N/A	Reused	$0.00
Buses	N/A	Reused	$0.00
Linear Actuator	N/A	Reused	$0.00
Tether Mesh	Amazin	Buy	$23.00
pH Probe	Amazon	Buy	$36.00
Trash Grabber (claw)	N/A	Reused	$0.00
Travel Expenses (gas milage to MATE Inernation Competition in Alpena MI)	Gas	Buy	$20.00
		MATE ROV Costs	$1,278.00

RAFT Robotics Company Accounting

2025 Budget Float

MATE Float Budget 2025

Part	Ordered From	Build vs Buy vs Reused	Cost
4inch PVC	Amazon	Buy	$16.00
4inch PVC End Caps	Amazon	Buy	$20.00
1/4 inch Plastic Sheet	Amazon	Build	$25.00
2inch linear actuator	Amazon	Buy	$30.00
Power Converter	Amazon	Buy	$14.00
Ardunio Rev2	Amazon	Buy	$27.00
Depth and Temperature Sensor	Blue Robotics	Buy	$85.00
Data Converter	Blue Robotics	Buy	$28.00
Large Syringe	Amazon	Buy	$18.00
Drive Power Pack	Amazon	Buy	$11.00
Mirco Sd Adapter	Amazon	Buy	$6.00
Battery Powerpack	Amazon	Build	$10.00
		MATE Float Costs	$290.00