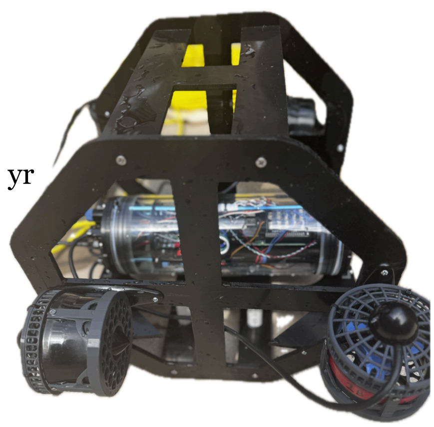
TROJAN TRIREMES

CARROLLTON HIGH SCHOOL
CARROLLTON, GA 30117
US

TEAM MEMBERS

Venkata Koppireddy [11] CEO, Lead Programmer, 3 yr
Christian Long [9] CFO, Co-Pilot, 2 yr
Jake Preston [11] Pilot, Engineering, 1 yr
Elicia Salgado [11] Safety Officer, 3 yr
Mason Scoville [10] Float Lead Engineer, Lead Tether, 1 yr
William Haley [9] Prop and Tether Engineer, 2 yr
Tanya Aggarwal [10] Marketing, 1 yr



Team Mentors
Christina Long, Science Teacher
Bill Long, CTAE Teacher

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ABSTRACT

The Trojan Triremes, a student-run company based in Carrollton, Georgia, specializes in designing and engineering underwater Remotely Operated Vehicles (ROVs). Our seven-person team proudly presents Longshot 2.0—a second-generation ROV that surpasses previous models in both technical sophistication and reliability. Developed through rigorous prototyping and testing, Longshot 2.0 is engineered for precision and efficiency across a wide range of mission tasks. This ROV features four T200 thrusters, offering five degrees of freedom; a serviceable, 3D-printed body; and a plexiglass frame that allows for easy maintenance. Equipped with specialized tools and a claw, it is fully capable of completing assigned missions.

Beyond technical achievement, Trojan Triremes is dedicated to making a positive community impact. This year, we mentored a middle school team, hosted an underwater robotics event, and participated in a river and greenbelt cleanup. Longshot 2.0 reflects our ongoing commitment to innovation and our passion for preserving aquatic environments for future generations.

This document outlines the design and development of Longshot 2.0, detailing its capabilities in support of this year's MATE mission objectives, which include deploying smart buoys, collecting water samples, and monitoring freshwater health in environments such as the Great Lakes.

PROJECT MANAGEMENT

COMPANY OVERVIEW

The Carrollton High School Trojan Triremes team, re-established in 2022, consists of 7 members, and two teachers. The team members include three juniors, two sophomores, and two freshmen. Each student utilizes their skills to help the team. For more information, see Appendix A.

SCHEDULE

Upon encountering significant failures in the 2023-2024 season, the team was forced to take a serious re-evaluation of the company's approach to project management and scheduling. This reflection led our executive leadership to work more closely with all company members, follow a schedule available to all company members, and create overtime meetings to maintain timely progress. Fortunately, our team more than doubled in size from the previous year and responsibilities could be shared and delegated. During the Fall of 2024, executive leadership and subgroup leads came together to brainstorm for the year. At this meeting, deadlines for key components were set, like when the materials needed to arrive or when the ROV CAD needed to be completed. These deadlines helped ensure that the Trojan Triremes were ready to compete.

"Row Simul" or Row Together is a guiding force in what we do. For many of us, this is a new experience and there are lots of new skills to learn and master. Rather than tackling all of these new tasks alone, we tend to work in pairs to help share the load and in turn, shorten the time needed for the project completion. Working in small groups also helped when designing our working schedule. Many members have other extra-curricular obligations and not every member can attend every work session. In this ROV season, the team has worked together to learn basic programming for the Blue Robotics brain and the Raspberry Pi used in the rover and the float, respectively. CAD skills were sharpened and introduced to some new members. Basic soldering skills were gained by all members. The Trojan Triremes are essentially re-starting a program that had once been one of the top in the nation. Carrollton High School was known in our small area as a team that would be successful in any arena. After three changes in teacher leadership, our new Trojan Trireme team has emerged. Beginning from the ground floor, we have worked tirelessly to earn the title of being competitive at any level. We continue to build our protocols and resources, but most importantly our skills to earn that title.

Date Range	What We Did
January	A team formed, reviewed last year's ROV, listed goals
Early February	Prototyped frame shapes and picked an octagon layout
Late February	Cut frame panels, mounted motors, ordered parts

Early March	Installed brain, soldered wires, added electronics
Mid-March	Pool-tested buoyancy, tested motors, and claw
Late March	Fixed waterproofing issues and claw alignment
April	Final testing, documentation

Figure One*: Longboat 2.0 Build Timeline*

DESIGN RATIONALE

ENGINEERING DESIGN RATIONALE

To begin this year, we tried to identify the key challenges experienced in last year's ROV season. We brainstormed how to fix those problems and developed possible improvements that would allow Longshot 2.0 to complete all of the mission tasks. During our brainstorming sessions, we identified our top priorities: sleek design, reusability of parts, easy to fix, and reliability to complete the tasks. We prototyped multiple frame shapes and materials trying to incorporate our top priorities before selecting an octagonal-shaped layout. This shape allowed for excellent structural rigidity, simplified motor placement, and buoyancy control. We thought about using aluminum, but it was heavier and harder to cut. Plexiglass, on the other hand, was lighter, available at no cost from our ROV lab, and easy to work with. So we decided to make our ROV an Octagonal shape made out of plexiglass. Using recycled Blue Robotics T200 thrusters provided strong, smooth control in all directions and seamless integration with our control system. The high thrust-to-weight ratio enabled us to achieve complex movements using only four thrusters. We selected a servo-based claw for its simplicity and low power requirements. We avoided pneumatic or hydraulic claws due to their complexity and high risk of failure. We laid out all the electronics like a pit stop setup — clean, and fast to access. Our clear-top enclosure lets us see everything inside. Wires are shrink-wrapped and sealed.

FRAME AND STRUCTURE

The Longshot 2.0 was specifically built to compete in the MATE ROV competition at Dauphin Island. It measures approximately 16 cm wide and 15 cm tall, keeping it compact and within the competition's size limits. The total vehicle weight is 7.9 kilograms, making it lightweight and easy to maneuver during missions. The frame is constructed from reused plexiglass panels that are joined together with bolts. We chose plexiglass because it was cost-efficient, readily available in our lab and online, and easy to work with. The main body of the ROV is shaped like an octagon, which gives us enough flat sides to mount all four motors and the claw without making the design bulky. This shape also gave the ROV a sleek appearance and improved stability and balance in the water. We cut the panels using a jigsaw and carefully sanded every edge to remove sharp spots that could cause injuries or damage wires during testing and competition.

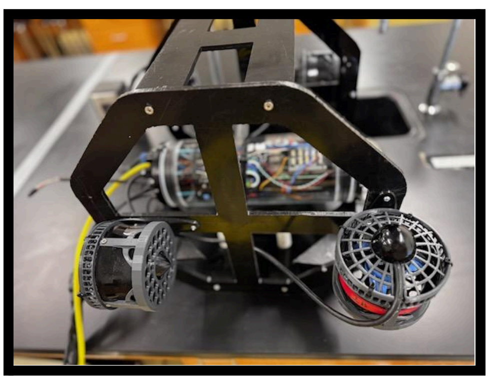


Figure 2: Initial build of Longboat 2.0

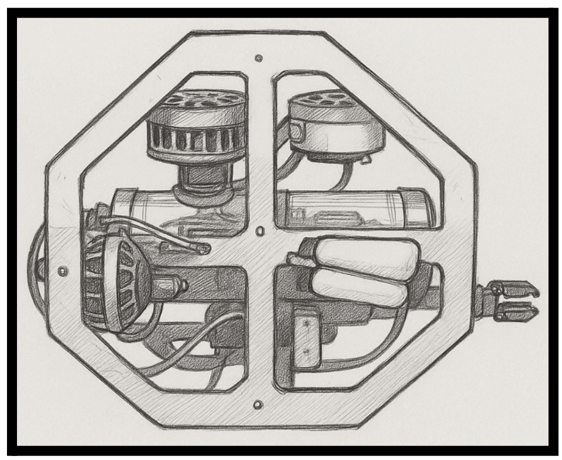


Figure 3: Computer-aided sketch showing the motor placement and claw

Figure 4: Longboat 2.0 with enclosure and motors

BUOYANCY

To achieve stable buoyancy on Longshot 2.0 we used a combination of yoga blocks and wrist weights. The yoga blocks were used as flotation devices due to them being almost completely water-resistant and easy to shape making them able to fit what we needed perfectly and they were relatively affordable. Due to the yoga blocks being almost completely water resistant, we decided it was the best option to maintain buoyancy. To balance the positive buoyancy and ensure the ROV could remain stable and maneuverable underwater, wrist weights were added as ballast. Diver belts inspired the idea of using wrist weights; they aid divers to help keep them stable underwater. Both the yoga blocks and the wrist weights were securely attached to the ROV using zip ties. Compared to other buoyancy methods such as rigid water bottles, the yoga blocks were softer making them safer and less likely to cause any issues during demonstrations or with water pressure, especially at greater depths.

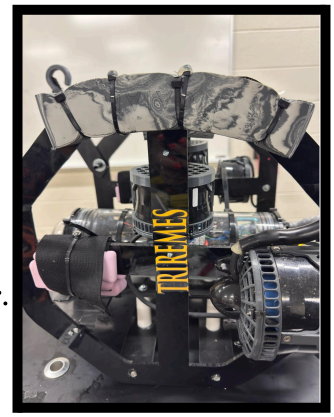


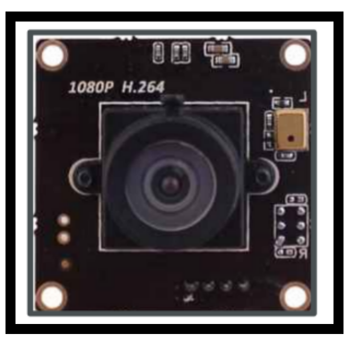
Figure 6:

Longshot with molded yoga block on top and wrist weights on the middle beam of the rover.

CAMERA

The camera system onboard Longshot 2.0 is designed to maximize the pilot's perspective while minimizing the number of cameras required. A single camera is mounted at the front of Longshot's central enclosure, providing the pilot with a clear view of the task area. This camera serves as both the primary navigation tool and a key source of situational awareness. To enable the pilot to monitor both the manipulator and the area ahead of the ROV, the camera is mounted on a tilt servo, allowing the pilot to adjust the field of view as needed.

Figure 7: USB HD Video Camera



MOTORS

For Longshot 2.0, we used four recycled Blue Robotics T200 thrusters. We chose these motors because they gave us strong power and smooth control in the water, and they were easy to connect to our control system. Fortunately, the motors we utilized were recycled from a previous team's ROV build, so they did not add any additional cost to our budget. Two motors are placed on the sides of the frame for forward and backward movement. Two motors were mounted vertically on opposite sides to control up and down movement. We tested different placements before deciding on this layout because we wanted to make sure the ROV could move in all directions but still stay balanced. Having just four motors made the build easier and used less power while still giving us five degrees of movement. It also made the control system much simpler, since each motor had a clear purpose. We made sure every motor was mounted tightly and added 3D-printed guards around them to keep them safe and prevent anyone from getting hurt.

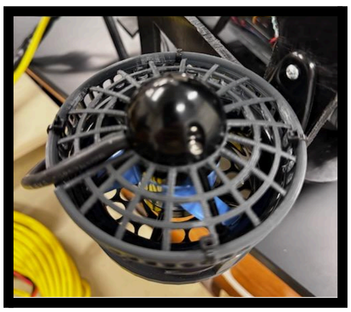


Figure 8: Vertical view of shrouded motor

Figure 9: Horizontal view of T200 motor

CLAW

The Longshot 2.0's claw is designed for durability and torque to ensure it can successfully complete tasks. It is positioned in the center of the ROV, directly beneath the brain, to help maintain balance and provide the driver with better visibility and control. We use a waterproof servo motor to operate the claw because it is simple, lightweight, and energy-efficient. The servo opens and closes quickly without lag, which is ideal for fast, precise grabs during tasks. We chose a servo motor over a pneumatic or hydraulic system because it has fewer moving parts, is easier to repair if something goes wrong, and is less prone to failure. It also simplified the overall wiring setup. During testing, we adjusted the claw's positioning to ensure it could grab objects both from the side and directly underneath. The claw performed best when centered under the camera, allowing the driver to always see what they were grabbing. We also tested it on various shapes and materials to confirm it had sufficient grip and torque to securely hold different objects.

BRAIN

We used the Blue Robotics electronics enclosure for Longshot 2.0's brain. Inside the enclosure, we installed the main control board along with all the connections that power and control the ROV. This waterproof enclosure keeps all our electronics safe during pool tests and missions. Since the case is clear, we can easily check the wiring and connections without opening it up every time. The transparency of the brain enclosure helped us during troubleshooting. For the control board, we used a Raspberry Pi 4. It connects to the ESCs (Electronic Speed Controls) that control the four T200 thrusters, as well as the waterproof servo motor that powers the claw. The Raspberry Pi sends PWM(Pulse Width Modulation) signals to the motors and the claw based on inputs from the controller. We used a simple Python script to manage motor direction and speed, which let us fine-tune responsiveness—especially for vertical movement where we wanted more control. To keep the brain secure inside the enclosure, we mounted it using zip ties and a 3D-printed omega bracket. We made sure all wires were tight and heat-shrunk for protection. Every connection was organized and separated to make repairs easier in case anything failed. We also installed a fuse on the main power line for safety, just in case of a short circuit or electrical issue.

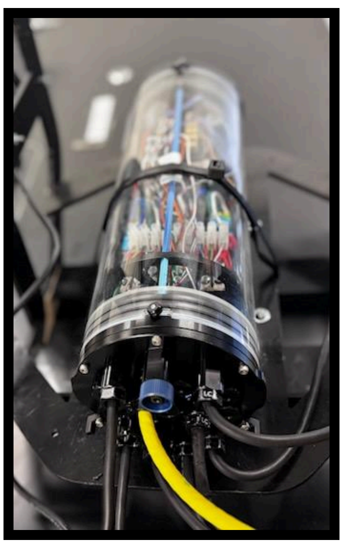


Figure 10: Bird-eye view of BlueROV2 electronics enclosure

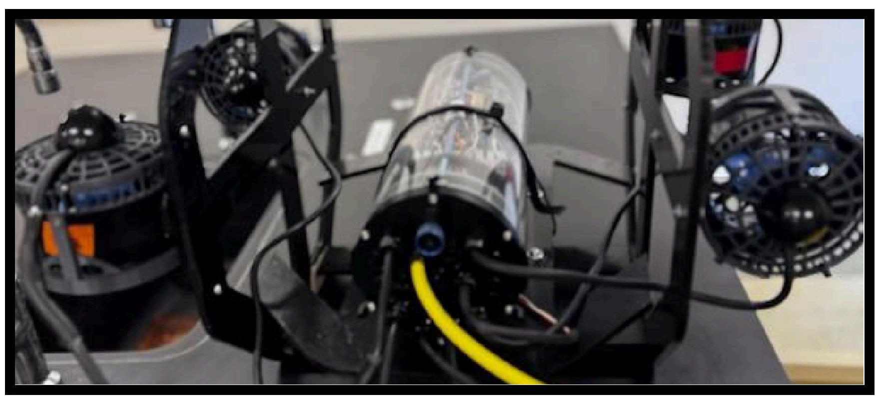


Figure 11: Horizontal view of BlueROV2 Electronics Enclosure

SID

SID for both the Longshot 2.0 and our Float can be found in APPENDIX B, page 18.

TROUBLESHOOTING/CHALLENGES

Throughout the design and development of the Longshot 2.0, we encountered a few problems.

1. Battery

When we first designed our ROV, we planned to make it battery-powered, with the battery housed in a vacuum-tight enclosure mounted next to the brain. However, we quickly discovered that submerging any type of battery—especially lithium—is prohibited under MATE safety regulations. This rule forced us to redesign our ROV's power system. Since we were not allowed to submerge a battery, we transitioned to a regular power setup. We used Anderson Powerpole connectors to safely connect to the power system above water. The ROV side used an XT90 connector. Since the XT90 uses a different connector than the Anderson system, we had to run an extension cord going from XT90 to Anderson. By doing that we had to waterproof the XT90 connector since it was going to be in the water. This required a little reworking of the ROV's tether to compensate for the additional weight due to the waterproofing and additional wire.

2. Waterproofing Failures

During our early testing, while trying to figure out buoyancy, we experienced water going into the brain. Thankfully the ROV was turned off and a slight leak without harming the electronics. After close examination, we discovered that three penetrators were not fully tightened and one O-ring was misaligned. We addressed this by: replacing the O-ring with a brand new O-ring and ensuring it was properly fitted. The penetrators were then tightened until we were certain there wouldn't be another water leak. We also discovered that using a plumber's type water-roofing tape was beneficial in making all of our connections water-tight. The main water-proofing challenge came from securing our power line penetrators. In the end, we used acrylic to encapsulate the joints to finally waterproof them.

3. Claw

During our testing, our pilot had a difficult time aligning the claw with props because the claw was not positioned in the frame of the camera. This made it hard to judge the distance and grip objects cleanly. Solution: We re-mounted the claw in a position that allowed the driver to see and do the task by using the claw. This gave us a better visibility of both the claw and the target, greatly improving task accuracy.

NON-ROV - FLOAT RATIONALE

Fulfilling this year's non-ROV task was challenging for our team. This was the first year that our team attempted to build a working autonomous float. After much research, trial, and error, our team designed and constructed a functional vertical profiling float. The float utilizes a buoyancy engine, of which the buoyancy can be altered on command, allowing it to ascend or descend through the operating area of water. The profiling float also accumulated data using onboard sensors, allowing it to be sent to an on-shore computer through the float's onboard antenna. We are programmed to collect sensor data for depth, pressure, and temperature. We are using a 12 cm antenna which maximizes our wifi signal. The ideal length for our relative distance is 11.5 cm and this 12 cm antenna fits nicely within the needed size.

The internal components of the float are fully enclosed with a 4' diameter acrylic enclosure. The top end of the acrylic tube is sealed by an end cap and the bottom of the enclosure is sealed with a 3D-printed syringe holder that fits tightly inside the acrylic tube. The System Integration Diagram is included in Appendix B, page 18.

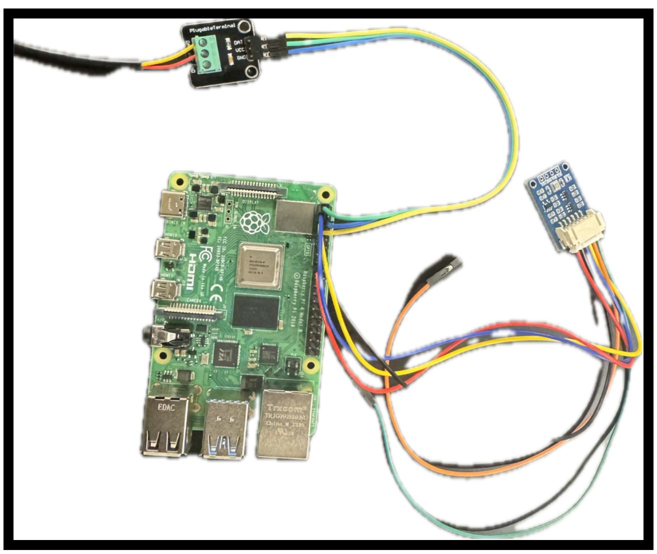


Figure 12: Raspberry Pi with connected sensors

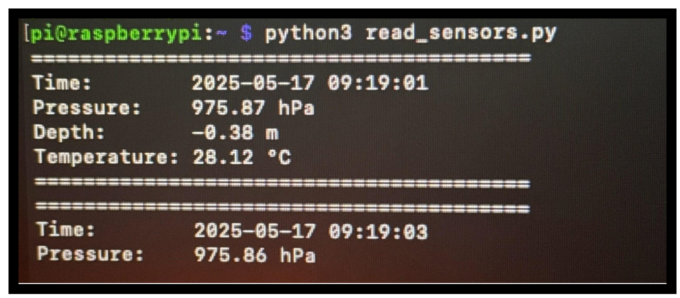


Figure 13: Sensor readings from the initial Python coding test

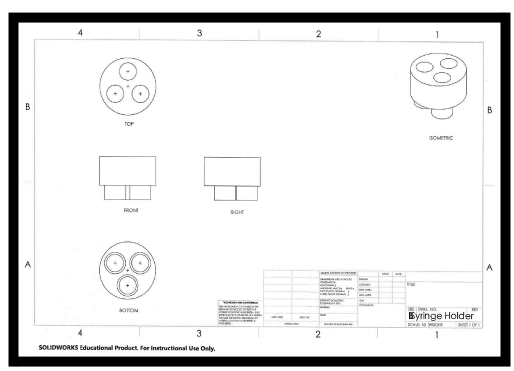


Figure 14**:** CAD rendering of the 3D printed syringe holder

SAFETY

Safety was one of our biggest priorities while building and testing Longshot 2.0. We made sure that everything we did followed safety guidelines, especially when soldering electrical stuff, using power tools, or working around the pool. While building our ROV, we wore safety goggles when using tools like the jigsaw or the bandsaw. We always had an adult to supervise when we were working in the lab. When drilling or cutting plexiglass, we clamped everything down and made sure our hands stayed clear from the blade. We kept the workspace clean and organized so no one tripped over wires or dropped tools. On the ROV, we used heat shrink tubing on all exposed wires and made sure no connections were open. We sealed all electronics inside the waterproof enclosure and tested it for leaks before using it in water. The control box was sealed and tested for any leaks and we added a fuse to the main power line to prevent any short circuits or overloads. We spent great effort and time identifying the best 3D-printed guards to use around the motors to protect people's hands and to keep the motors safe during use. We found that choosing the best raw material and machine to print the guards was an important step in the process. Not all materials are the same. Initially, we attempted to use a carbon fiber filament in our 3D printing but found that our printer did not get hot enough to effectively use the carbon fiber filament. Ultimately we ended up using PLA filament. We were able to 3-D print in-house all the guards for the four motors used. All sharp edges on the frame were sanded down to avoid cuts, and any edges inside the frame near the wiring were covered in hot glue. In addition to these safety precautions, we also included two warning buoys deployed on our tether to notify others that there was a device in use in the water.

Safety checklist

- Safety glasses are worn when soldering or using tools (drill, Dremel, bandsaw)
- The fume extractor and ventilation are on when soldering
- Team members wear closed-toed shoes in the workspace
- No food or drinks are present near electronics or build area
- No running in the workspace or around the pool
- A fuse with overcurrent protection is installed on the power line
- All wiring is sealed, and no exposed conductors present
- All motor guards are installed and secure
- The watertight enclosure is sealed and leak-tested
- Sharp edges are sanded down or covered
- Tether has proper strain relief
- The kill switch is accessible and working
- The control system passes a dry run test before pool operation

Figure 15: Warning Buoy

- Adult supervision is present during pool testing
- Additional tether control and support via warning buoy

TESTING & EVALUATION

We developed our skills from the start and worked well together as a team. Over the past three months, we've worked almost every day to get Longshot 2.0 fully built, tested, and ready for competition. While working on the ROV, we also mentored our middle school team by walking them through our design process, explaining what we were doing, and helping them model their build.

Once the ROV was complete, we started testing on land to check the motors, power system, controller, and brain. After everything worked, we started to test at the pool. The first problem we saw was that Longshot 2.0 was front-heavy in the water. We added foam to the back and adjusted some of the weight on the ROV. That helped level out and improved the overall buoyancy. Next, we noticed the tether was pulling the ROV sideways while driving. To address this issue, we zip-tied part of the tether to the side of the frame to help center the tether to reduce drag and stop it from pulling the ROV.

After that, we tested the motor controls. All four thrusters worked, but the vertical movement was too fast. To fix that, we added a limit on how long you could hold the button for vertical thrust. That made it easier to stay at one depth and avoid crashing into things. We also were able to adjust the settings in the onboard controls within the Blue Robotics software to allow for individual motor control. This change allowed for greater control in movement.

In testing the claw, our pilot had a hard time lining the claw up with the props because on the camera you couldn't see it well. To solve this, we re-mounted the claw so it was centered in the camera's view. This change made a huge difference in being able to grab things quickly and accurately. We also found that it is necessary to have several servo units waterproofed and ready to be changed out should the one we are using goes down.

Overall, we feel confident that Longshot 2.0 can complete all the mission tasks. It moves in all directions, the camera gives good visibility, and the claw grabs well. In the future, we plan to fine-tune the controls and increase the turning speed, and possibly add another camera.

One challenge we had this year was finding time to work together. Some of our teammates are in other clubs and sports, so not everyone could make every meeting. Our pool time was more limited than we would have liked due to scheduling conflicts and technical issues. Even with these detractors, we made a great deal of progress.

Longshot 2.0 is a much stronger product than last year's ROV. Next year, we plan to build an even bigger team and spend more time testing and upgrading our design.

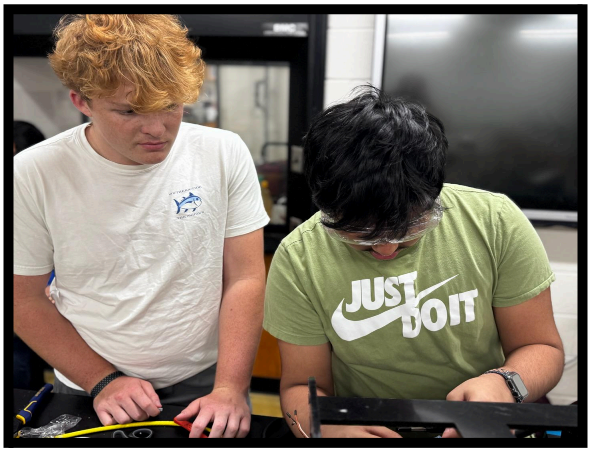


Figure 16: Mason and "V" Engineering Longshot's wiring

Figure 17: Christian and "V" working on the placement of Longshot's brain.

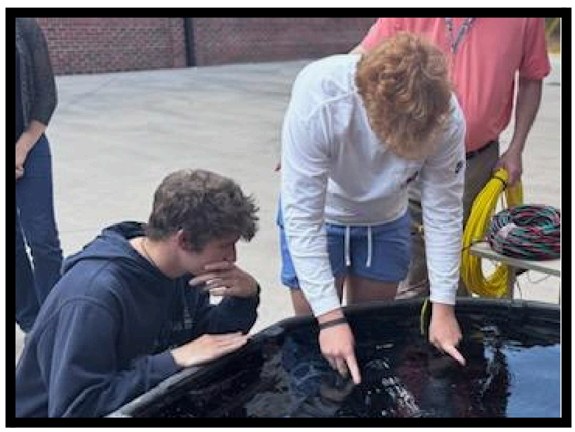


Figure 18: Christian and Mason working on Longshot's buoyancy.

FINANCE

		CHS ROV Budget/Accounting		
		2024 - 2025		
Vendor		Item Description	Number	Price
BlueRobotics		BlueROV2 Electronics Enclosure - Acrylic	1	$2,000.00
BlueRobotics		Battery Power Cable Set	1	$70.00
BlueRobotics		Pressure Relief Valve	1	$28.00
BlueRobotics		Fathom-X Tether Interface (FXTI)	1	$220.00
BlueRobotics		Fathom ROV Tether (ROV-ready)	1	$400.00
BlueRobotics		Binder 770 Bulkhead Connector	1	$18.00
Lowe's		Heat Skrink, electrical tape, cable ties		$71.00
BlueRobotics		Wet Link Penetrators	10	$187.00
Blue Robotics		Bulkhead Wrench	1	$16.00
Amazon		FLY RC 5 Pairs Amass XT90S/XT90-S connectors	1	$12.95
Amazon		Priline Carbon Fiber Filament	1	$41.64
Amazon		HOPLEX T-Plu EC3 XT60 Male Female Connectors	1	$13.99
Amazon		Black Plexiglass Sheet 1/4" Thick Cast (24" x 36")	1	$37.50
Amazon		Amoybaby Gold Silk PLA Filament1.75 mm, High Gloss	1	$19.99
Amazon		Official Creality Ultra-Flexible Magnetic 3D Printer Build Base	1	$15.99
Amazon		Creality Clog Poke, 3D Printer Nozzle Cleaning Kit	1	$12.79
Amazon		Creality High End Hardened Steel Nozzle MK8 0.4MM	1	$24.09
Walmart		PDP Wired Controller- XBox Series	1	$26.88
Lowe's		Drill Bit set	1	$52.47
Lowe's		Velcro and Various Fasteners		$38.24
Robinson's		Industrial/Marine Wire - 60 m		$70.95
		- Estimated cost for competition meals	$424.00	
			TOTAL	**$3,377.48**
	Grants Received:	Carrollton City Schools Educational Foundation STEM	$1,000	
		Carrollton City Schools Educational Foundation Field Trip Grant	$500	
	Fund	Sucker Sales	$436.00	
	Allotted Budget:		$2,000.00	
		Total Monies Available:	$3,936	
		Total Spent on Rover	$3,377.48	
		Remaining for 2025	$558.52	

ACKNOWLEDGMENTS

Trojan Triremes would like to thank our mentor, Mrs. Long, for her constant support, encouragement, and guidance throughout this season. Her leadership helped keep our team on track and focused from start to finish. We'd also like to thank Mr. Long for his technical mentorship and for always being available to help us troubleshoot and build. His knowledge and advice were a huge help during the more complicated parts of our design. Thank you to Carrollton High School for providing funding, a dedicated workspace, and continuous support for STEM and underwater robotics education. Your support gave us the tools we needed to build and grow. Thank you to Coach Young for letting us borrow tools and equipment when we needed them — we couldn't have done it without that extra help. Thank you to the Carrollton City School Education Fund for providing financial support to allow us to travel. We'd also like to thank MATE ROV and the Dauphin Island MATE team for hosting this competition and challenging students like us to design ROVs that can help solve real-world environmental problems. Finally, we are incredibly thankful for the grants and sponsors who helped make this project possible. Your generosity allowed us to bring Longshot 2.0 to life.

References

- MATE ROV Competition Website. MATE ROV Competition
- Blue Robotics T200 Thruster. T200 Thruster
- Blue Robotics Basic ESC. Basic ESC for Thrusters and Brushless Motors
- Blue Robotics 4" Watertight Enclosure. Locking Tubes for Watertight Subsea Enclosures
- Raspberry Pi 4. Raspberry Pi 4 Model B specifications

APPENDIX - A

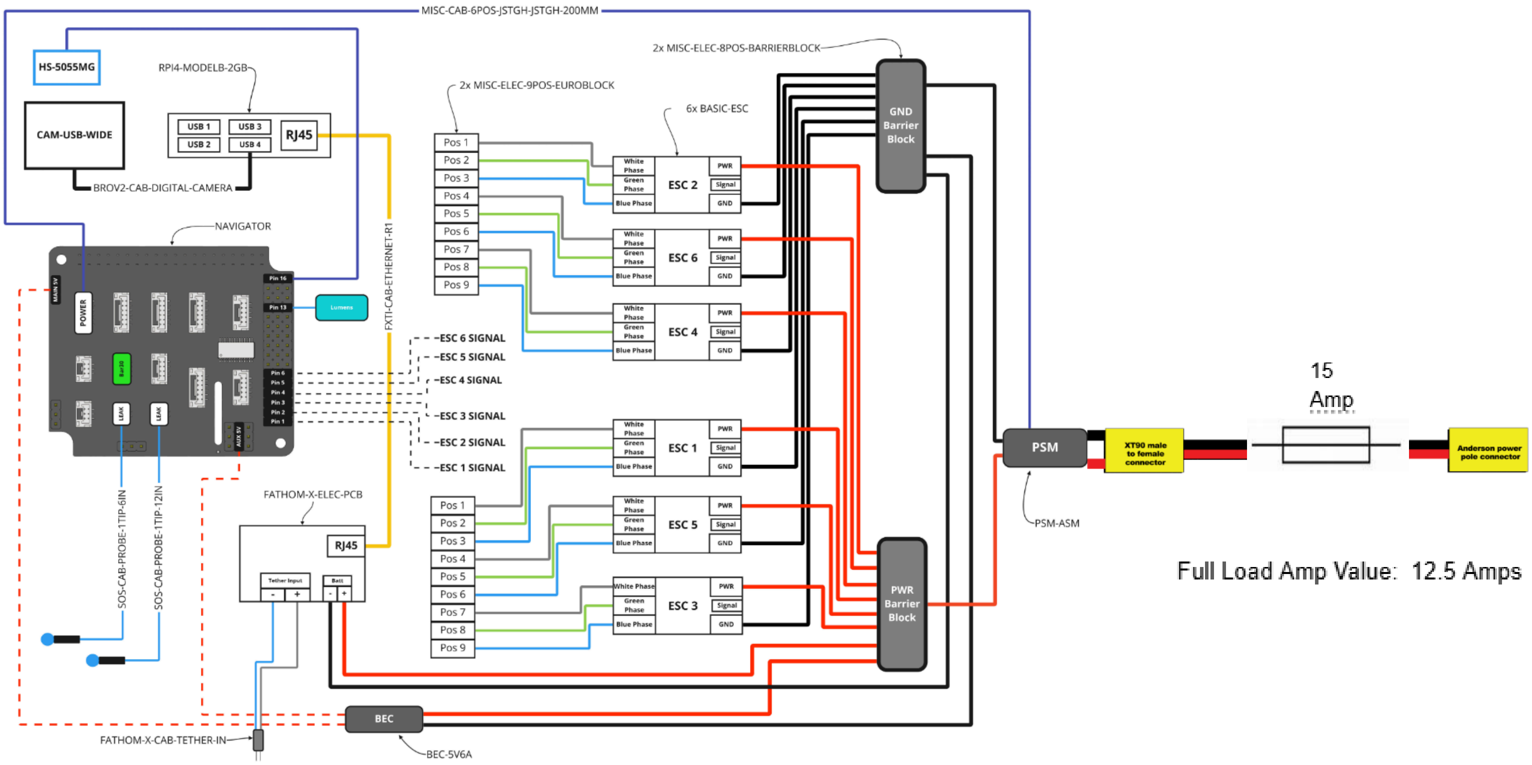
JOB DESCRIPTIONS

TEAM MEMBER	JOB DESCRIPTION
Venkata Koppireddy [11]	CEO, Lead Programmer, On-Deck manager - Leads team meetings and presentations, oversees all modifications; leads coding for ROV and Float control; oversees installation of electronics; on-deck manager in demonstrations
Christian Long [9]	Co-Pilot, CFO, Float Assistant - Timer and assistant on-deck manager during product demonstrations, chief member documenting and managing financial items; lead assist in Float designing, engineering, and deployment
Jake Preston [11]	Pilot, Engineering - Pilots ROV, assists in engineering, design, and design modification of ROV
Elicia Salgado [11]	Safety Officer - performs regular safety checks during construction, testing, and demonstration; conducts water testing during product demonstrations
Mason Scoville [10]	Float Lead Engineer, Lead Tether - Leads float team; constructs and handles frame of non-ROV devices; designs 3D models using CAD software
William Haley [9]	Prop and Tether Engineer - constructs the props and leads the team in prop building instructions, assistant tether management
Tanya Aggarwal [10]	Marketing - Composes most technical documentation; controls social media accounts; manages traditional media communications and marketing opportunities; assists in water testing and simulations during product demonstrations.

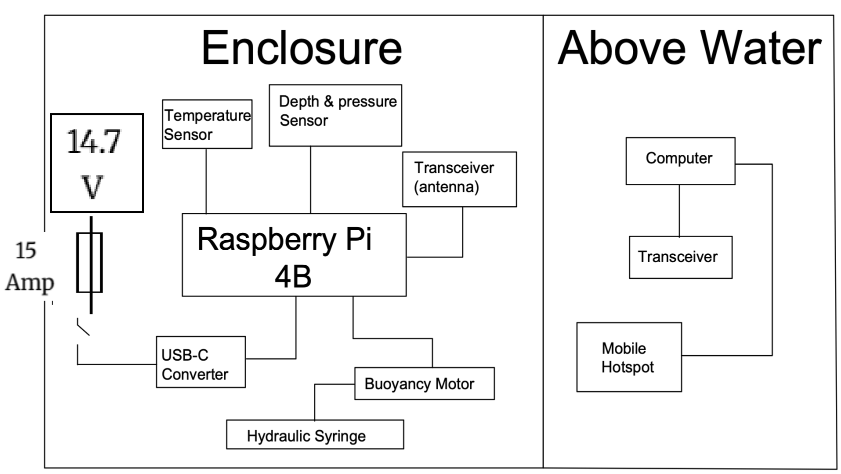
APPENDIX B

SID

LONGSHOT 2.0



Non-ROV Float



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