TROJAN TRIREMES

Longshot 3.0 — Technical Documentation 2026 MATE ROV Competition

Company: *Trojan Triremes*

School: *Carrollton High School, Carrollton, Georgia 30117, United States*

Competition Level: *Ranger*

Team Members:

Richard Ashlock (Grade 11). *CEO, Electrical Systems, Project Management*. 1st Year.
Christian Long (Grade 10). *CFO, Co-Pilot*. 3rd Year.
Jake Preston (Grade 12). *Pilot Engineering*. 2nd Year.
Elicia Salgado (Grade 12). *Safety Officer*. 5th Year.
Omar DeJesus (Grade 12). *Electrical Systems, Software Engineer*. 1st Year.
Mason Scoville (Grade 11). *Engineering, CAD Design, Lead Tether*. 2nd Year.
Joel Nunez Gusman (Grade 11). *Social Media, Marketing*. 1st Year.
Austin Loolen (Grade 11). Claw Specialist, Float Design. 1st Year
Allie Ashlock (Grade 10). *Social Media, Marketing*. 1st Year.

Team Mentors:

Christina Long. *Science Teacher*
Bill Long. *CTAE Teacher*

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ABSTRACT

The Trojan Triremes is a student-run team based at Carrollton High School in Carrollton, Georgia, specializing in the design and construction of Underwater Remotely Operated Vehicles. For the 2026 MATE ROV Competition, the team presents Longshot 3.0, the third generation of the Longshot series and our most technically advanced build to date.

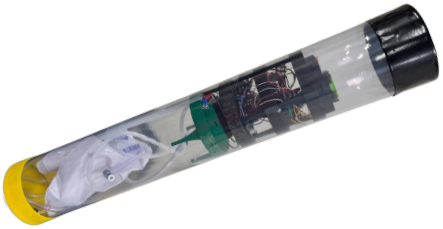
Longshot 3.0 is a compact, octagonal-framed ROV constructed from recycled plexiglass, measuring approximately 52 cm wide by 39 cm tall and weighing 8.4 kg. Six Blue Robotics T200 thrusters provide full six-degrees-of-freedom movement (Blue Robotics, n.d.-d), while a Raspberry Pi 4 running custom Python firmware handles vehicle control (Raspberry Pi Foundation, 2024). A tilt-servo-mounted HD camera provides an adjustable field of view, and a waterproof servo-driven claw enables precise object manipulation. Buoyancy is achieved using closed-cell foam and wrist-weight ballast, refined through pool testing.

The team also designed an autonomous vertical profiling float as the non-ROV device. Controlled by an Arduino Uno, the float uses a dual-pump system to draw in pool water for descent and expel it for ascent.

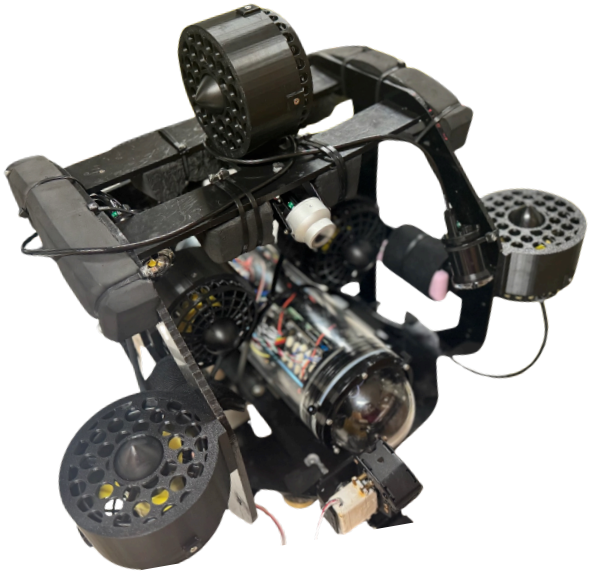
Beyond engineering, the Trojan Triremes mentored a middle school ROV team, delivered a school-wide robotics presentation, and organized a local greenbelt waterway cleanup to include portions of Buffalo Creek. This document details the design, construction, testing, and evaluation of both vehicles in full accordance with the 2026 MATE competition objectives (MATE ROV Competition, n.d.).

Images and Data

See Figures below with related information



Profiling float using a 4.0L fluid bag, insulated fluid pumps, and an Arduino control system.



Longshot 3.0 showing five of the six motors along with the brain, claw, and additional exterior camera.

PROJECT MANAGEMENT

COMPANY OVERVIEW

The Trojan Triremes is a student-run team at Carrollton High School, with nine active members who all share a common interest in marine engineering. Our team has expanded dramatically over the years, welcoming new faces every season. We are passionate about encouraging students of all ages to engage in activities that spark creativity, teamwork, and scientific interest. Every year, our team grows, and new people are given the opportunity to learn the advanced processes by which our corporation operates. Since the program's establishment, the guiding principle has been "Row Simul," which is Latin for Row Together. Our team incorporates this principle into all endeavors. We work together through all challenges and collaborate on ideas to develop our presentation. The Trojan Triremes strive to include all who are interested, to provide superior preparation for potential STEM futures; however, this created a significant learning curve for the majority of the team. This year, many teammates prioritized gaining knowledge for a strong understanding of engineering. Basic workshops on soldering, application of engineering concepts, introductory CAD, and proper power-tool safety instruction were used this season.

It is important to acknowledge that a major part of the engineering design process is identifying an issue and taking steps to solve it. It is unreasonable to expect that all ideas and prototypes will correctly operate on the first try. This can be extremely frustrating; however, it is the primary force that drives the team to become stronger and develop the best possible product. The Trojan Triremes overcome every challenge and are motivated by every failure. As a team, we work together, grow together, and most importantly, row together.

Resource and Protocol Management

Resource management was crucial to a productive assembly process. This season, our team was diligent about taking inventory of the supplies on hand to prevent delays and wasted time due to supply shortages. We were privileged to have the support of our coaches, Christina and Bill Long, who were willing to provide anything the team needed. Our assembly process progressed smoothly throughout the year due to a focus on resource management.

Pool time was arranged through Mrs. Long, who coordinated with the REC department to secure access to their facilities and with teammates who volunteered their own pools. Pool time was valuable; however, assembly was our top priority. On average, Mondays were lab- and workshop-focused, and Wednesdays were pool-focused. As competition approached, additional practice days were added as necessary.

The Trojan Triremes operated as a united team, with separate focuses that best suited personal experience level and strengths. The team captain, V, served as Lead Programmer. He was responsible for all software development, control system configuration, and firmware testing. Mason served as Lead Builder, overseeing ROV frame fabrication, thruster installation, and mechanical assembly. Austin and Aaron co-led the Non-ROV Device, overseeing the design, construction, and testing of the autonomous vertical-profiling float. Christian served as Financial Officer, maintaining the budget, tracking expenditures, and documenting all cost accounting. All members contributed to pool testing, troubleshooting, and documentation as needed. (See Appendix [A] for full personnel roster and role descriptions.)

The team set timeline goals at the start of the season to implement constant motivation and consistency. Key milestones included: completion of CAD frame design, frame fabrication, electronics integration, initial pool test, float prototype, full-system pool test, and submission of technical documentation. Sessions were structured around the active milestone, with available members assigned to tasks within their area of responsibility. Due to technological issues, many of these timelines were delayed; however, the initial goals kept the team focused and motivated throughout the season.

Day-to-day operational decisions were made at the start of each session through a brief team check-in that established the session's priorities and assigned tasks. Materials and components were tracked by the Financial Officer to ensure budget compliance. Protocols were established for pool testing, including pre-run checklists, tether inspection procedures, post-run documentation results, and any observed obstacles. These procedures are further explained in the Safety and Critical Analysis sections.

SCHEDULE

Date Range	Team Accomplishments
September–October 2025	Team formed; reviewed 2024-2025 season failures; set goals; exec leadership brainstormed with subgroup leads; key deadlines established for material arrival and CAD completion.
November 2025	Frame material selection (plexiglass chosen over aluminum); octagonal shape selected over rectangular and hexagonal; initial CAD

	of Longshot 3.0 started; T200 thruster placement prototyped.
December 2025	Electronics ordered; training for all members; CAD finalized.
January 2026	Frame cut and sanded; motor guards 3-D printed in PGTA+; waterproof enclosure assembled; tether fabricated and strain-relief points designed.
February 2026	Brain wired and installed; Python control code written and bench-tested; claw servo waterproofed and mounted; buoyancy tuned with; float team began assembling Legos.
March 2026	Pool testing, Phase one buoyancy trim, motor direction checks, vertical thrust limiting; waterproofing failures diagnosed and fixed; claw remounted for camera alignment; float buoyancy engine tested; SID completed.
April 2026	Pool testing, Phase two mission task simulations, pilot practice; tether management protocol refined; final documentation; safety checklist verified.
May 2026	Pool testing, Phase three refining mission task plan, redesign float, reimplement float, update the marking presentation, update paperwork.

DESIGN RATIONALE

ENGINEERING DESIGN RATIONALE

Before we started designing Longshot 3.0, we sat down as a team and tried to identify the key challenges we had experienced. The problems kept coming back to the same issues: unreliable waterproofing, motors that didn't deliver enough power, electronics that were hard to access when something broke, and no real plan for managing the tether. So those became our five main things to fix.

We looked at a few different frame shapes in CAD: rectangular, hexagonal, octagonal, and cylindrical. We went with the octagon because it gave us flat faces to mount motors and tools on, it's naturally more rigid than a rectangle, and it balanced the weight well (see Figure A). We considered using aluminum for the frame because it's strong, but it's more expensive. Plexiglass was already in the lab, easy to cut with a jigsaw, and we already knew how to work with it from the previous season. It ended up being the right call.

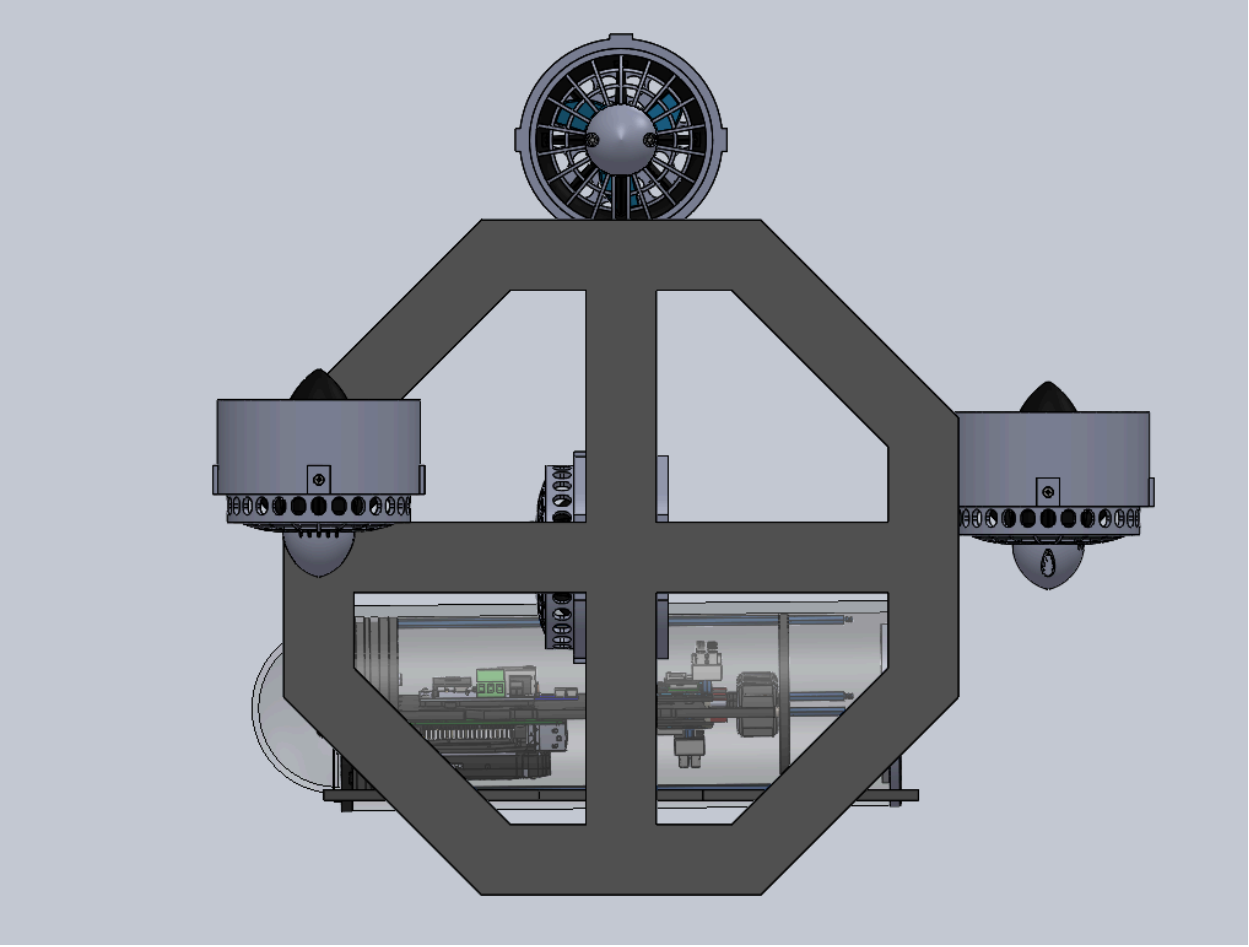


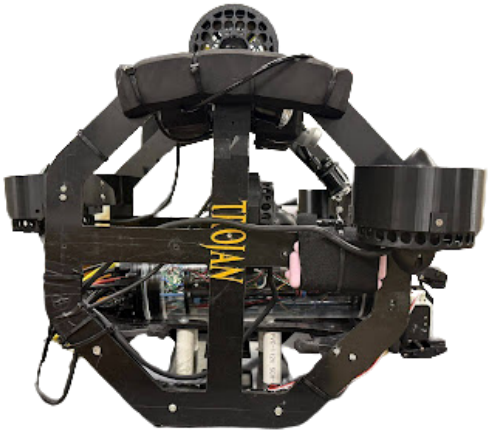
Figure A.

FRAME AND STRUCTURE

The frame is made from recycled plexiglass panels, held together with bolts and locknuts. Every edge was cut with a jigsaw, then sanded down to prevent any sharp spots that could harm someone or damage a wire (see figure B). Inside the frame, the wires are protected with heat-shrink tubing and securely clipped in place to prevent rubbing against anything during operation.

We have six thruster mounting spots built into the frame. Four on the sides for moving up and down, and two in the middle for horizontal movement. Each thruster has a 3-D printed guard around it to protect the blades. We originally intended to print the guards with carbon-fiber filament because of its strong material, but the printer failed to produce enough heat for proper use. This obstacle resulted in the use of a PETG+, which accomplished the desired outcome (see Figures C and D).

Figure B. Side view of Longshot 3.0 illustrating the octagon frame design



Figures C & D.

Custom designed T-200 motor shrouds with aerial and side views.

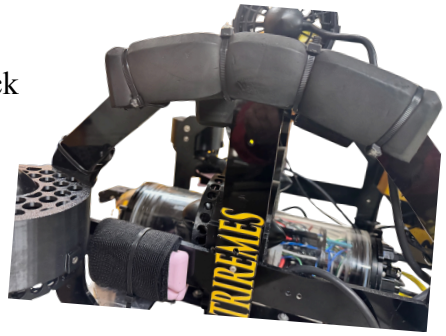


BUOYANCY AND BALLAST

Getting the buoyancy right took a bit of time to come up with an innovative idea, but the basic idea is Archimedes' principle: the ROV floats when it displaces enough water to equal its weight, and we want it to be just slightly positively buoyant so it rises to the surface if something goes wrong.

To achieve stable buoyancy on Longshot 3.0, we took a few sessions in the ice tub and used closed-cell yoga-block foam as our main float material because it barely absorbs water, it's easy to shape, and it was cheap. We strapped it to the upper part of the frame with zip ties. For ballast, we used wrist weights, the kind you'd use for exercise, attached to the front middle beam of the ROV. The wrist weights idea came from how divers use weight belts to control their depth. The nice thing about wrist weights is that you can add or take one off quickly between runs without needing tools, which helps us adjust them between different mission tasks (see Figure E). We tested a few other options, such as water bottles and fixed foam blocks, but the wrist weights gave us the most flexibility and were less likely to cause any issues during demonstrations or with water pressure, especially at greater depths.

Figure E. Detailed view of cut design of yoga block and wrist weights attached to the rover.



CAMERA SYSTEM AND LIGHTS

This year, we upgraded to the Blue Robotics DeepWater Exploration exploreHD USB Camera. The camera that came with the original Blue Robotics setup did not perform well in outdoor pools with inconsistent lighting; the DeepWater Exploration exploreHD USB Camera version was a real improvement (Blue Robotics, n.d.-a). We can actually see what is ahead of us when the water and the lighting in the pool aren't great.

We added two Blue Robotics lights mounted on the front of the frame (see figure F). This was something we didn't have before, and it made a bigger difference than we had anticipated. The lights illuminate the work area in front of the ROV, so the pilot isn't guessing at what's right in front of the claw. They're wired into the same power system as everything else and controlled via the laptop's interface.

The original camera is still mounted on a tilt servo at the front of the enclosure, which lets the pilot look down at the claw or back up to navigate if needed. An additional external camera mounted on the top of the ROV handles everything we need to see in front of us, and the other, located in the brain, handles viewing the claw (see Figures G and H)

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Figure F. External lumen subsea light



Figure G. View of external camera, DeepWater Exploration HD USB Camera

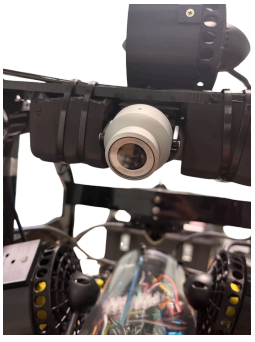
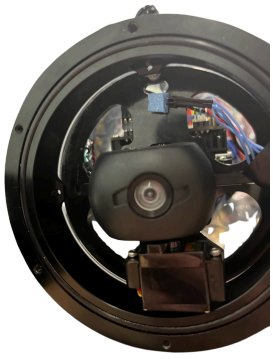


Figure H. View of internal camera



MOTORS AND PROPULSION

Our team used six Blue Robotics T200 thrusters (Blue Robotics, n.d.-d), 2 of which are reused from previous builds. Before installing them, we tested each one to confirm it still worked properly, checked the spin direction, measured current draw, and made sure nothing was binding.

This year, we changed the thruster configuration compared to Longshot 2.0. Instead of trying to do everything with two mounted horizontally and two mounted vertically, we went for three thrusters mounted vertically, two mounted horizontally, and one on top (See figure I). After thoroughly reading through the competition (MATE ROV Competition, n.d.). The three vertical thrusters give us strong, stable control over depth and vehicle tilt; we can hold a hover much more steadily than before. The two horizontal thrusters handle forward, backward, and turning. We lose sway (pure sideways movement) compared to a full six-DOF layout, but for the missions we're doing, the improved vertical control is the better trade.

The T200 is what Blue Robotics builds its whole system around, so it works cleanly with our ESCs and control framework. Having used them before meant we already knew the quirks and didn't have the hardware learning curve we had in previous years.

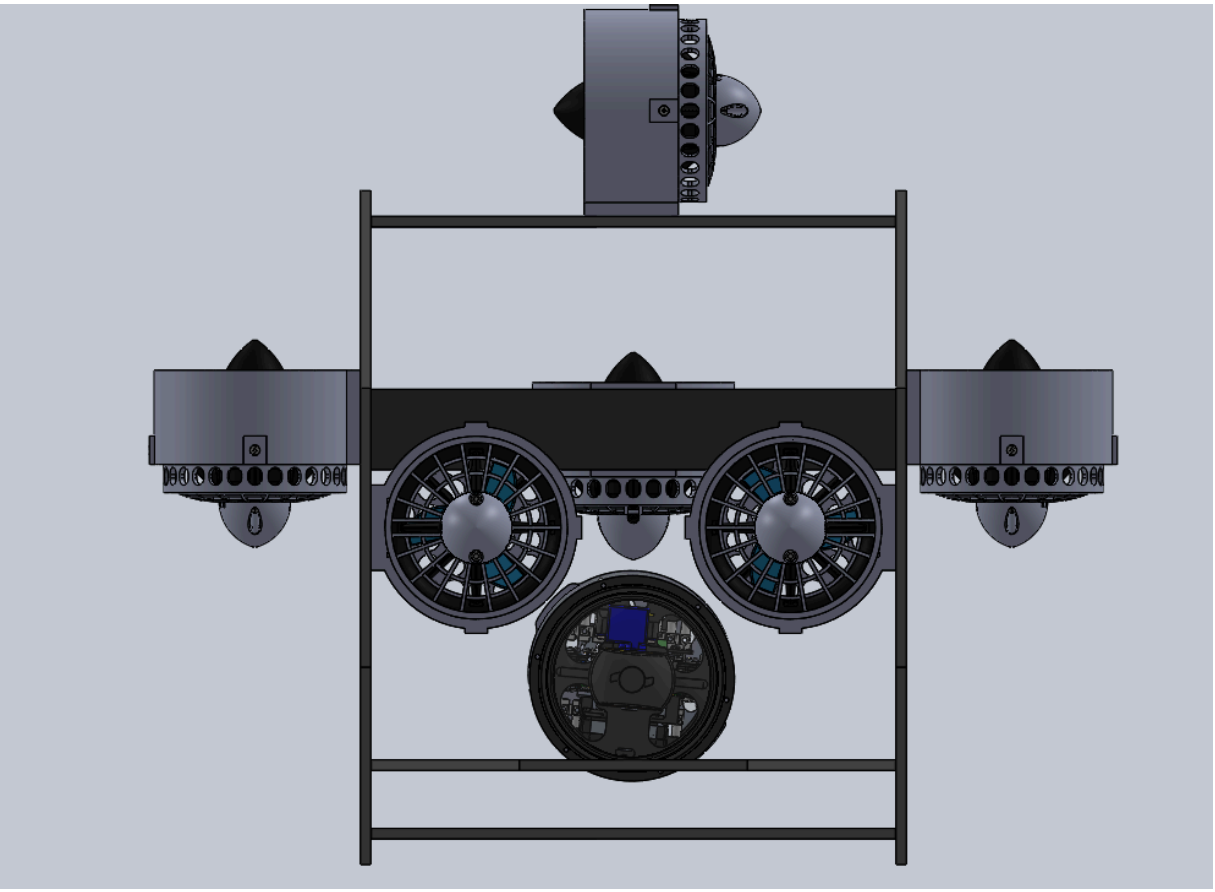


Figure I.

CLAW AND PAYLOAD

The Longshot 3.0's claw is designed for durability and torque to ensure it can complete tasks successfully. 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 hold different objects securely (see figure J).

Figure J - View of claw and placement in front of rover.



BRAIN AND CONTROL SYSTEM

The brain is a Blue Robotics electronics enclosure. 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. The clear case allows for the brain's wiring and connections to be easily checked 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 (Raspberry Pi Foundation, 2024). It connects to the ESCs (Electronic Speed Controls) that control the six T200 thrusters, as well as the waterproof servo motor that powers the claw and the camera tilt inside the ROV. The two Blue Robotics lights are also controlled through the system.

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 allowed us to fine-tune responsiveness, especially for vertical movement,

where we wanted greater control. To keep the brain secure inside the enclosure, we mounted it with zip ties and a custom-cut plexiglass holder. 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.

The pilot sees the camera feed live on the laptop screen. The controls are set up to feel natural, driving the ROV is pretty similar to a video game controller layout, which helped Jake (our pilot) get comfortable quickly. Settings like thrust sensitivity can be adjusted through a config file without touching the code itself.

One real limitation is boot time. The Raspberry Pi takes about 30 seconds to start up, so if it crashes during a run, then you're waiting. We added a watchdog process that automatically restarts the main program if it stops responding, which reduced how often that became a real problem. After a great deal of deep dive research, we have found that by reducing the video quality of the camera streams we are able to reduce the load that Chrome is putting on the CPU from 99% to much lower levels. This has reduced the number of crashes we have experienced.

TETHER DESIGN AND MANAGEMENT

The tether is 15 m long and carries power (12 V), the camera signal, and the data connection back to the laptop. There's a strain-relief clamp at the ROV end, so a tug on the cable doesn't reach the internal connections.

We sized it at 15 m by adding up the operating depth, the distance from the pool edge to the water, and a reasonable safety buffer; longer than that just adds drag and weight without helping.

Mason handles the tether during runs. Before each run, Mason lays it out in coils on the deck. During the run, Mason pays out slack as Jake moves the ROV forward and takes it back in. The goal is to keep the tether as close to vertical in the water as possible; a tether pulling sideways creates drag, making the ROV fight to hold its line. Two bottle warning buoys clip onto the tether at the 5 m and 10 m marks to indicate that there is an active rover under the water. We drew inspiration from diver warning buoys that are used to indicate divers in the water.

After every flight in the water, the tether is gently laid out and unwound from any stress it may have accumulated in flight. Along with this, the mesh covering the two main cables of the tether is looked over and adjusted back to its original position to account for any possible shifts during flight.

Build vs. Buy and New vs. Reused

The team's general procurement philosophy followed a clear priority order: build in-house when feasible, purchase only when necessary, and reuse components that remain functionally viable. This approach was instrumental in managing costs across a total operating budget of $8,460.00 for the 2026 season (see Finances). The claw, motor guards, tether, and float components were fabricated entirely by team members, while sensors, servos, the camera, lights, and the electronics enclosure were purchased from vendors. Of the six T200 thrusters used in Longshot 3.0, two were carried over from previous builds after passing functional verification tests, and two additional units were held in reserve against unforeseen hardware failures (Blue Robotics, n.d.-d).

The custom motor guards merit specific attention. In prior seasons, guards were produced quickly with minimal design iteration. For Longshot 3.0, guards were engineered to match the precise geometry of the T200 thruster mounting points and frame faces, resulting in improved blade protection, cleaner integration, and a more secure fit (see Figures C and D). Though this required greater upfront design time, the outcome justified the investment.

The reuse of thrusters and ESCs produced measurable financial benefit. Total expenditures directly attributable to ROV hardware were $2,395.71, while total project expenditures across all categories — including equipment, materials, travel, indirect costs, and outreach — reached $6,452.57, representing 76% of the available budget (see Finances). When accounting for reused and donated components, the total realized value of the build is estimated at approximately $5,870.71, indicating the team leveraged roughly $3,475.00 in assets beyond those directly purchased. The four primary purchased equipment items — four T200 thrusters ($1,080.00), one Lumen Subsea Light set ($385.00), one exploreHD USB camera ($325.00), and frame and float materials ($278.80) — accounted for the largest share of direct hardware spending (see Finances; Blue Robotics, n.d.-a; Blue Robotics, n.d.-b; Blue Robotics, n.d.-d). It is also worth noting that the iterative development of the non-ROV float device required four design revisions at approximately $250.00 per iteration, contributing meaningfully to overall material costs (see Finances).

Systems Integration

The full System Integration Diagram for both the Longshot 3.0 and our Float can be found in APPENDIX B, page 26.

NON-ROV DEVICE: VERTICAL PROFILING FLOAT

Building the float was new territory for us this year. We had never designed a non-ROV device before, so there was a real learning curve — figuring out how to make something move autonomously through the water column while collecting data and staying within the mission's 18 cm diameter and 1 meter height limits.

Float Design and Buoyancy Engine

The float changes its buoyancy using a water-transfer buoyancy engine. Two WYNK USB electric peristaltic pumps move water in and out of an internal storage 4.0L bladder through the DieseRC 2-channel relay module. When the intake pump runs, water enters the bladder, increasing the float's overall density and causing it to sink. When the output pump runs, water is expelled, reducing the density and causing the float to rise. Only one pump runs at a time; the relay module enforces this at the hardware level using interlock mode, and the Arduino code enforces it in software as well.

We chose this approach because peristaltic pumps are self-contained and don't require valves. The automotive 12V-to-5V USB panel steps down battery voltage to the 5V that the pumps require, eliminating the need for a separate buck converter board. The relay sits on the 12V side of the panel, so the pumps connect and disconnect via a clean USB plug, which also avoids cutting wires.

Sensors and Electronics

An Adafruit MPL3115A2 barometric pressure, altitude, and temperature sensor is connected to the Arduino Uno via I2C (SDA → A4, SCL → A5). Depth is calculated from the difference between live pressure and surface pressure using the standard hydrostatic formula ($\Delta P / \rho g$), where ρ is 1000 kg/m³ for freshwater or 1025 kg/m³ for the EGADS solution used at the World Championship. Surface pressure is sampled and stored at boot before deployment.

An HM-10 Bluetooth LE module (DSD TECH, 3.6–6V, pins STATE / RXD / TXD / GND / VCC / EN) handles wireless data transmission. The HM-10 is connected to the Arduino via SoftwareSerial on pins 10 (RX) and 11 (TX). The shore-side receiver is a laptop running a serial Bluetooth terminal (LightBlue or equivalent) that logs and graphs incoming packets in real time. The HM-10 is disconnected from pins 10 and 11 during code upload to avoid upload conflicts.

Mission Profile Logic

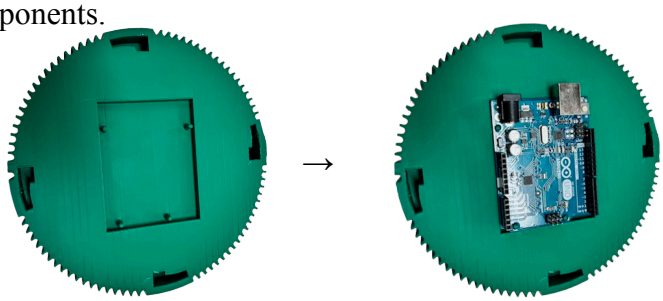
The control loop runs as a state machine on the Arduino. Before descending, the float transmits one defined data packet to confirm communication with the shore station. It then completes two full vertical profiles automatically: descending to 2.5 meters, holding for 30 seconds with data

logged every 5 seconds, ascending to 40 cm below the surface, and holding again for 30 seconds. A shallow-stop guard in the code cuts the ascent pump before the float can reach the surface, preventing the 5-point penalty for breaking the surface or contacting the ice sheet. After both profiles, the float enters a recovery-wait state. Once retrieved, a manual button press triggers transmission of all stored data packets to the shore laptop for graphing.

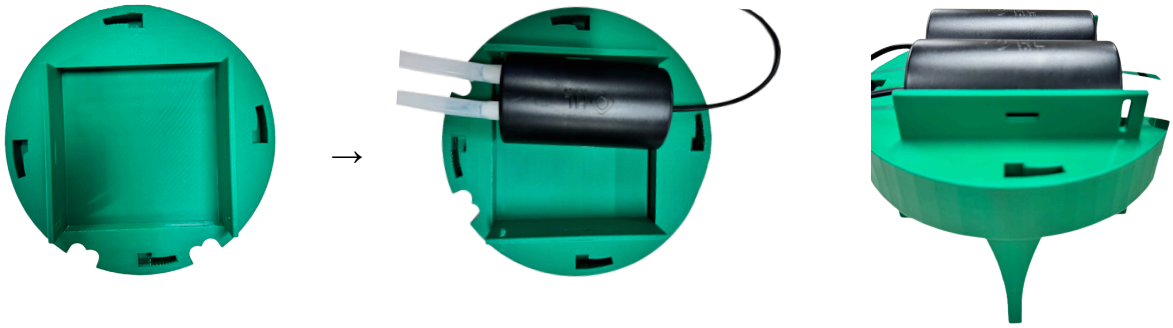
Housing and Physical Specs

The Non-Rov device uses a 6-inch-by-36-inch acrylic tube to house it. The interior is contained by 3D printed shelves that each hold a separate segment of the Non-Rov device. Each interlocking shelf was meticulously designed by Mason to specifically house each component from the Arduino system, the two pumps, the sensor housing, and even the smaller wires and hoses that connect the system (see Figures K - Q.

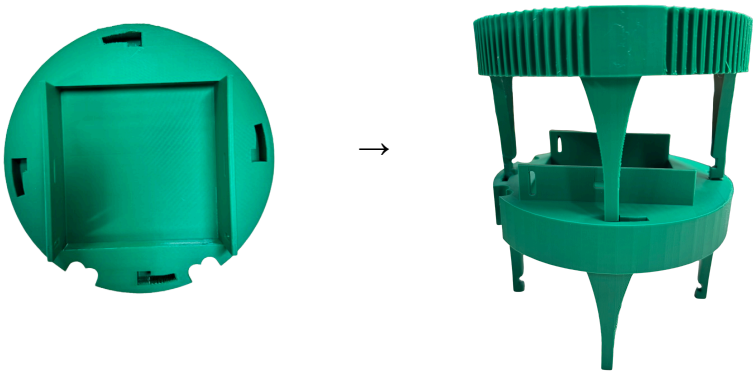
Figures K and L. These photographs illustrate the pre-designed housing inset into the shelf with pegs to allow the arduino system to “lock” into place. The grooves along the circumference of the shelf allow for the passage and management of the many small wires connecting the Arduino to the other components.



Figures M, N, and O. These photographs illustrate the pump housing shelf. The cut outs provide a hidden ledge that allows for the tabs attached to the pumps to slide into to give extra stability to the system. There are slots designed to help with tubing management and guidance.



Figures P and Q. These photographs show the interlocking system designed to connect and manage the various portions of the float electronics and components.



Power and Fusing

The float is powered by a NiMH or AGM 12V battery pack in compliance with ELEC-NRD-003. A single ATO-type blade fuse is installed within 5 cm of the battery positive terminal in compliance with ELEC-NRD-004. Full-load amps were measured in both waiting mode (motors off) and buoyancy-change mode (motors on) to determine the correct fuse size per ELEC-NRD-005. The automotive USB panel limits pump current to the 5V/3.1A rail, providing additional overcurrent protection downstream of the main fuse.

Safety Rationale

Safety was a primary priority throughout the design, construction, and competition operations of Longshot 3.0. The team designated Elicia Salgado as Safety Officer, a role with full authority to halt any activity at any time if a safety concern is identified. The team's safety framework is organized into three categories: personnel safety, equipment protection, and vehicle recovery safety.

Personnel safety measures included mandatory PPE during all tool use and soldering, the requirement that a supervising adult be present during all lab and pool sessions, and the requirement that all team members performing pool-deck operations wear closed-toe shoes with wet-surface grip. Team members assigned to float deployment and retrieval tasks identified in the team's Jobsite Safety Analysis (JSEA) as higher risk were also required to pass a baseline swim test before competition. Roles were pre-assigned and practiced before competition day, so no team member had to determine their responsibilities for the first time at the event.

Equipment protection measures included fuses installed on the main power line, custom PETG+ motor guards on all six thrusters with no gaps wider than required clearance, and O-ring-sealed enclosures on the electronics brain. Vehicle recovery safety was addressed by designing Longshot 3.0 to maintain slight positive buoyancy at all times, ensuring passive surface return in the event of a power or control failure.

All frame edges were sanded smooth following fabrication to eliminate sharp surfaces that could cause injury or damage internal wiring. Interior frame edges near wiring runs were additionally sealed with hot glue as a secondary abrasion barrier. The battery and all lithium-based power components were kept topside at all times, in compliance with MATE ROV competition rules prohibiting the use of lithium components underwater.

Vehicle-Specific: Safety Precautions

- All underwater power connections are sealed with marine heat-shrink; no bare conductors are permitted anywhere on the vehicle.
- All six custom motor guards are inspected and confirmed secure before the ROV approaches water. The kill switch is confirmed OFF before anyone handles the ROV.
- All frame edges are sanded smooth; edges near wiring runs are sealed with hot glue.
- The brain enclosure O-rings are inspected, greased, and leak-tested before every competition day.
- Motor guards are custom-designed and printed in PETG+ after carbon-fiber filament proved incompatible with the team's printer.
- Warning buoys are deployed at the 5 m and 10 m tether marks before the ROV is submerged, consistent with JSEA Table 2.
- The pilot verbally calls "disarmed" before the tether operator touches the ROV during retrieval. This step is never skipped.

Safety Checklist: Construction and Build Sessions

- Safety glasses are worn for all soldering and power-tool work
- Fume extractor running during all soldering
- Closed-toe shoes are required for all team members in the workspace
- No food or drinks near electronics or the build area
- Adult supervisor present
- Fuse installed and rated correctly on the main power line
- All wiring covered with marine heat-shrink; no bare conductors
- Frame edges sanded smooth; wiring areas covered with hot glue

Safety Checklist: Pool Sessions and Competition Operations

- Closed-toe shoes with wet-surface grip are worn by all team members on deck
- Adult supervisor present
- All six motor guards are attached, secure, and inspected
- Brain enclosure O-rings inspected, greased, and a leak test passed
- Tether strain-relief clamp tight at both ends
- Kill switch tested and confirmed working
- Kill switch confirmed OFF before anyone handles the ROV poolside
- Dry-run test passed — all thrusters and lights respond correctly before the ROV enters the water
- Warning buoys confirmed deployed at 5 m and 10 m marks before submerging
- Float pressure vessel sealed and tested before float runs
- Two-person deployment and retrieval confirmed for both ROV and float

TESTING AND EVALUATION

Testing Methodology

We broke testing into three stages: bench testing, dry-land testing, and pool testing. Doing it in stages meant we caught the obvious problems early, before we were standing at the pool trying to debug something that could have been found in the classroom. After each stage, we made a list of everything that didn't work, figured out the fixes, and didn't move forward until those were addressed.

Bench Testing: On the table, before anything touched water, we checked each ESC, spun up each thruster by hand to confirm direction, checked for loose wiring, and confirmed everything was secure. We also checked that the lights powered on correctly and that the Blue Robotics camera feed was coming through cleanly to the laptop.

Dry-Land Testing: With the enclosure sealed and the ROV on a stand, we ran everything at low power. Confirmed all six thrusters spun in the right direction, ran the claw to check for servo issues, tested the camera tilt across its full range, confirmed the lights worked through the control interface, and hit the kill switch to make sure it cut power reliably every time.

Pool Testing: We have spent over 30 hours in the pool testing. Each session had a list of specific things to test or fix. Developing a list and writing it down beforehand kept us from just driving the ROV around without purpose and missing things that actually needed attention.

Troubleshooting and Challenges

Power System: The originally planned system was on a submerged battery. Reading the MATE rules more carefully made it clear that it wasn't allowed, so we redesigned around a topside power supply connected through the tether. It meant reworking the tether and waterproofing the connector that goes underwater, but it had to be done.

Waterproofing: During the first pool session, we got water in the brain enclosure. Not enough to cause monetary harm, anything, we caught it fast, but it was a bad moment. We pulled the ROV, dried everything, and found three penetrators that were only finger-tight and one O-ring sitting crooked in its groove. We re-tightened everything with a 16 mm wrench, swapped the bad O-ring, added hot glue over all the penetrators as a backup, and ran a quick water-ready test in the ice tub before going back in the pool.

Anytime water is involved, extra precautions must be taken. After several lost battles with servo units used with the claw system, we purchased a water-proff servo to be used. Failed attempts to water proof the original servos included water proofing the servo with mineral oil, coating the servo with “flex seal” types of materials and even waterproof tape. None of our fixes allowed for more than one or two underwater runs using the original servos. Instead of repeatedly replacing the originals, we opted to buy a specifically designed water-proofed servo. This change has made an enormous positive difference.

Float Design and Development: The float design and development took exceptional persistence. Our current float is the fourth iteration of the design. There has been considerable work done designing, redesigning, and then again redesigning the float structure and electronics. Finding a “motor” system that works for our purposes has been a challenge and a constant source for innovation and improvement.

FINANCE

All costs are in United States Dollars (USD).

Trojan Triremes Financial Report

Project Title: __Longshot 3.0_____

Organization / Institution: __Trojan Triremes, Carrollton High School___

Mentor / Team CEO: _Christina Long/Richard Ashlock_ __

Prepared By: __Richard Ashlock_ _____

Reporting Period: ___August 2025 – May 2026_ _____

Date Submitted: ____May 2026_ _____

Executive Summary

Key Highlights

- Total Budget: $__8,460.00_ __
- Total Expenditures to Date: $_____6,452.57_ ___
- Remaining Balance: $___2,007.43_____
- Percentage of Budget Utilized: ____76_ __%
- Major Budget Variance(s): ___International Travel_ _____
- Financial Risks or Concerns: ___Need for additional patrons and sponsors_ __

1. Project Overview

1.1 Project Description

The Trojan Triremes is a student-run company based at Carrollton High School in Carrollton, Georgia, specializing in the design and construction of underwater Remotely Operated Vehicles (ROVs). For the 2026 MATE ROV Competition, the Trojan Triremes team proudly presents Longshot 3.0, the third-generation model that surpasses previous models in technical sophistication and reliability. Longshot 3.0 is the company's flagship ROV engineered for precision, reliability, and mission-task versatility.

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1.2 Funding Sources

Grant / Contract type	Amount earned / Rewarded	Funding Source
Annual Budget	**$3000.00**	**Carrollton City Schools**
STEM Field Grant	**$800.00**	**Carrollton City Schools**
STEM Grant	**$800.00**	**Yamaha Corporation**
Field Trip Grant	**$1600.00**	**Carrollton City Schools**
Poinsettia Fundraiser	**$460.00**	**Local Nursery(?)**
Chocolate Fundraiser	**$1000.00**	**Worlds Finest Chocolate**
Donation	**$1000.00**	**Community Benefactor**

2. Financial Summary

Budget Category	Actual Expenditures
Equipment	**$4879.29**
Travel	**$454.50**
Indirect Costs	**$370.77**
Other misc charges	**$748.01**
Total Costs	**$6452.57**

3. Detailed Financial Analysis

3.1 Equipment and Capital Expenses

Item	Vendor	Cost	Funding Source
T-200 Thrusters (4)	**Blue Robotics**	**$1080.00**	**Annual Budget**
Lumen Subsea Lights (2 light set)	**Blue Robotics**	**$385.00**	**Annual Budget**

DW Exploration exploreHD USB camera	**Blue Robotics**	**$325.00**	**Annual Budget**

3.2 Materials and Consumables

Item Description	Individual Costs
Plexiglass sheets, LiMH Batteries, and Syringe sets	**$278.80**
Electrical Components (Arduino and sensors)	**$104.13**
LEGO Float Components and Pieces	**$223.78**
PVC pieces and glue	**$78.32**
3rd and 4th Float Components	**$1041.4**
Marketing Supplies	**$146.79**
Marketing Supplies	**$223.98**
Team uniforms	**$245.00**
Total cost	**$2620.00**

3.3 Travel and Field Operations

Purpose	Destination	Cost	Justification
Mate ROV Regional North Gulf Competition	**Dauphin Island, AL**	**$454.50**	**Meal and food expenses**

4. Budget Variance Analysis

Significant Variances

* Equipment capital outlays were larger than anticipated this competition season. A concerted effort was made to recycle materials where possible to not only conserve financial resources, but also to adhere to the saying “Don’t fix it if it’s not broken”. The construction of a usable, working float has caused our capital outlay to be much larger than anticipated. We are currently on our fourth iteration of the float design, with each new float project costing approximately $250.00.

5. Forecast and Future Financial Planning

5.1 Remaining Budget Forecast

The remainder of our budget will be directed to the travel costs associated with competing at MATE ROV Internationals in Canada. The approximate cost per competitor is $2,200 for the week of travel and competition.

5.2 Sustainability and Long-Term Funding

Long-term, our plans are to increase funding through outside-the-system grant opportunities and possible fundraising efforts. The small size of our team tends to limit our ability to make significant amounts in comparison to grants received or even local donations from companies that specialize in robotics and tech.

ACKNOWLEDGMENTS

Trojan Triremes would like to express our sincere gratitude to our mentor, Christina Long. Through every challenge this team has faced, Ms. Long has been a steady and dedicated presence in keeping us organized, motivated, and focused. Her willingness to go above and beyond, including staying late whenever we needed her, has made an incredible difference. Simply put, this team would not be where it is today without her. Thank you, Ms. Long.

Trojan Triremes would also like to thank Mr. Long for his invaluable technical mentorship throughout this season. His expertise and willingness to help at a moment's notice made a real difference when we needed it most. Time and again, his guidance during the more complex

stages of our design process kept us on the right track and saved us from costly mistakes. We are deeply grateful for his time and knowledge.

We would like to thank Carrollton High School for providing the funding, dedicated workspace, and institutional support that make a program like this possible. We are also grateful to Coach Young for generously lending us tools throughout the season and to Mr. Blakemore for providing hardware and software for the Non-ROV Device.

We would like to thank MATE ROV for hosting this competition and for challenging students to design ROVs that address real-world environmental problems. The experience has been both educational and deeply rewarding. Finally, we extend our sincere appreciation to our grants and sponsors for their generous contributions.

REFERENCES

1. Argo Program. (n.d.). *How do floats work?* https://argo.ucsd.edu/how-do-floats-work/
2. Blue Robotics. (n.d.). *DeepWater exploration exploreHD USB camera*. https://bluerobotics.com/store/sensors-cameras/cameras/deepwater-exploration-explorehd-usb-camera/
3. Blue Robotics. (n.d.). *Lumen subsea light*. https://bluerobotics.com/store/thrusters/lights/lumen-r2-rp/
4. Blue Robotics. (n.d.). *Navigator2 flight controller*. https://blueos.cloud/docs/stable/integrations/hardware/required/flight-controller/
5. Blue Robotics. (n.d.). *T200 thruster technical documentation*. https://bluerobotics.com/store/thrusters/t100-t200-thrusters/t200-thruster-r2-rp/
6. MATE ROV Competition. (n.d.). *Mission and competition information*. https://materovcompetition.org/ranger
7. Raspberry Pi Foundation. (2024). *Raspberry Pi 4 Model B specifications*. https://www.raspberrypi.com/products/raspberry-pi-4-model-b/specifications/
8. Waveshare. (n.d.). *Antenna*. https://www.waveshare.com/product/accessories/adapters-cables-antennas/antennas/ord-cm4-antenna.htm

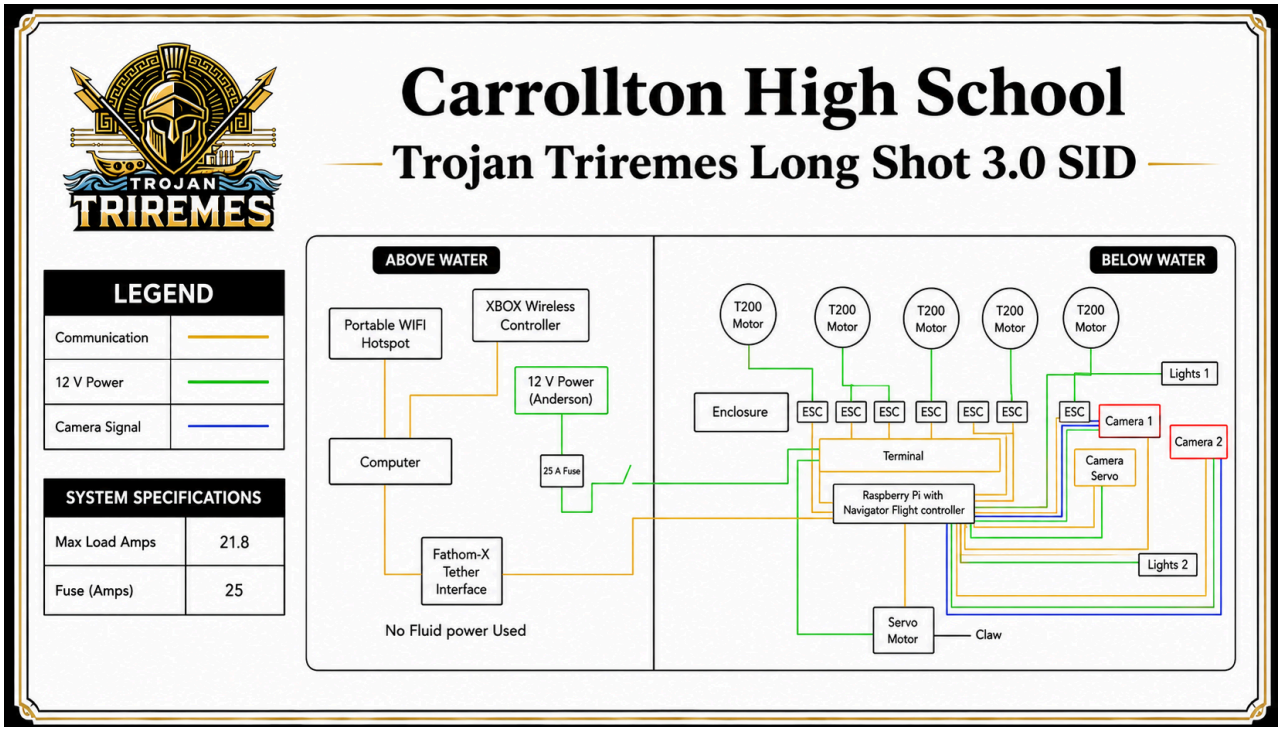
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APPENDIX A — Personnel Roles and Responsibilities

Name	Grade	Role	Responsibilities
Richard Ashlock	11th	CEO, Electrical Systems, Project Management	Oversees team operations, leads electrical systems, and tracks project milestones and meeting action items.
Christian Long	10th	CFO, Co-Pilot	Manages team budget, assists the pilot on deck during competition, and supports float design and deployment.
Jake Preston	12th	Pilot, Engineering.	Pilots the ROV during competition, contributes to mechanical design, and leads pool testing sessions.
Elicia Salgado	12th	Safety Officer	Conducts safety inspections, enforces protocols during builds and competition, and maintains safety documentation.
Omar DeJesus	12th	Electrical Systems, Software Engineer.	Assembles electrical systems and wiring, writes and debugs control software, and ensures electrical-software integration.
Mason Scoville	11th	Engineering, CAD Design, Lead Tether	Designs CAD models, leads mechanical fabrication, and manages tether operations during pool runs.
Joel Nunez Guzman	11th	Social Media, Marketing. 1st Year.	Manages team social media, documents build progress, and creates outreach content for the school and community.

Allie Ashlock	10th	Social Media, Marketing	Designs graphics and multimedia content, supports community engagement, and maintains a consistent team brand.
Austin Loolen	11th	Claw Specialist, Float Design.	Designs waterproofing solutions for claw, designs the different float variations, and works as a engineering on the float and the ROV.

APPENDIX B — System Integration Diagram (SID)



Device	Current Draw (Amps)
Pressure Sensor	0.00004
Arduino	0.06
Pump In	1.5
Pump Out	1.5
HM-10	0.0085
Total Current (Amps)	3.06854
Maximum Load Amps	4.0 A
Fuse Capacity	5.0

