

2026 MATE ROV COMPETITION

Technical Documentation for Elizabethton Cyclones

Elizabethton High School, Elizabethton, Tennessee, USA



Photo 1: EHS Cyclones

2026 Cyclone Company Members

<u>Xander Jones</u>	– Captain, Lead Mechanic, Pilot	3 rd Year	Class of 2026
<u>Anna Blackwell</u>	– Co-Captain, Design & Fabrication	3 rd Year	Class of 2026
<u>David Roland</u>	– Prop Manager	2 nd Year	Class of 2026
<u>Madison Hardin</u>	– Community Outreach	1 st Year	Class of 2026
<u>Madelyn Stanberry</u>	– Documentation & Design	1 st Year	Class of 2026
<u>Lucas Gillenwater</u>	– Programmer, Float Mechanic	3 rd Year	Class of 2027
<u>Nathan Edwards</u>	– Safety Manager, JSEA	3 rd Year	Class of 2027
<u>Holly Holsclaw</u>	– Safety Manager	2 nd Year	Class of 2027
<u>Chloe Statham</u>	– Prop Builder	2 nd Year	Class of 2027
<u>Colby Mitchell</u>	– Prop Builder, Safety Assistant	2 nd Year	Class of 2027
<u>Prentice Trivette</u>	– Prop Builder	1 st Year	Class of 2027
<u>Ryan Darnell</u>	– Photographer	1 st Year	Class of 2027
<u>Joshua Asche</u>	– Safety Manager	2 nd Year	Class of 2028
<u>Elodie Neal</u>	– Programmer, Assistant Mechanic	1 st Year	Class of 2028
<u>Logan Miller</u>	– Prop Manager	1 st Year	Class of 2028
<u>Gavin Rodeback</u>	– Prop Builder, JSEA	1 st Year	Class of 2028
<u>Bela Blackwell</u>	– Community Outreach	1 st Year	Class of 2028
<u>Abigail Watson</u>	– Documentation & Design	1 st Year	Class of 2028

Mentors: John Lee – Instructor

Table of Contents

Abstract - Page 3

Project Management - Pages 3, 4

Overall Vehicle Design & Systems Approach - Pages 4, 5

ROV Design Components - Pages 5, 6

Build Vs. Buy Rationale - Page 6

Software, Control & Electronics - Pages 7, 8

Float Design Details and Processes - Pages 8

Client Applications - Page 9

System Integration Diagrams (SID) - Page 10

Safety - Page 11

General Safety Checklist - Page 11

Operational Checklist and Protocol - Page 11

Testing & Troubleshooting - Page 12

Budget & Cost Accounting - Pages 12-15

References - Page 15

Appendix - Pages 17-24

A : Sub Team Structure

B : Project Schedule

C: Otter 1 Custom Fabricated Parts

D: Build Vs. Buy, New Vs. Old

E: EHS MATE Worlds 2026 Budget

F: Decision Trade-off Table

G: 2026 Job Safety and Environmental Analysis for Deck Ops/Launch and Recovery

H: List of Tables and Figures

Acknowledgments - Page 24



Abstract

The Cyclone Company is back for our third year in the MATE ROV competition and we are ready to take the competition by storm. This season, we have made crucial modifications to our ROV, *Otter 1*, and built an all new vertical profiling float named *Mussel*. With many new members for the company here at Elizabethton High School, our robots have been well-equipped to solve the problems and address the needs of our global community. *Otter 1* aims to complete each task with speed and efficiency. Based on the criteria of task 1, we plan to equip *Otter 1* with a photogrammetry camera system to practice mapping and monitoring changes in order to better explore and understand new areas of our oceans. Task 2 will also help us to practice monitoring ecosystems and gather key data of the environment to make decisions and ensure safety of the ecosystem and people in the area. Task 3 has shown us that we can be a part of the work for a better energy solution in our world and will help us find ways to use our ROV to do work under the sea for that goal that would otherwise be impossible. Finally, task 4 has given us our own opportunity to create a vertical profiling float and it has taught us to problem solve around potential hazards in the environment so that we can deploy it anywhere that we need to.



Photo 2: EHS Cyclone Team

Project Management Challenges:

This year, many new and inexperienced members joined the company or came back for their second year of competition. This made training newcomers how to code, build, and communicate as a team a major priority. Although many members have competed previously, with the graduation of many integral members of the team, they became necessary to the success of the company. Overall, the team struggles with time management and deviating from sub-unit goals. It is very easy to put aside the task at hand and talk with one another, which makes camaraderie a strength of the company. This deviation negatively impacts the team, however, as deadlines approach and members are forced to put in long hours on a time crunch.

Company Structure:

EHS robotics is a student-led engineering organization focused on solving real-world challenges through innovation, teamwork, and technical skills. The team is made up of members with varying levels of experience, allowing beginners to learn directly from those with specialized skill sets. To manage responsibilities effectively, the team is separated into various sub-units with designated jobs such as prop building, coding, electrical systems, design, and community outreach. Each group is led by a leader who is responsible for guiding their members, assigning tasks, and keeping their unit on track. Oversight of the entire team is handled by a team captain, who ensures that all groups are working toward a common goals and that communication remains consistent. Rather than working alone, groups coordinate with one another to solve problems and improve overall products. This allows the team to stay organized, maintain steady progress, and create an environment where members can develop both technical and life skills.

Scheduling and Planning:

Scheduling and planning has been a major focus for our team, as staying organized is essential to completing a complex project on time. To keep everyone on track, we developed a structured timeline that outlines key milestones such as design, building, testing, and documentation. Tasks are divided among our sub-teams, with clear deadlines and priorities so that progress in one area does not delay another. We regularly check in as a team to review progress, address challenges, and adjust our schedule when needed. Communication tools and shared documents help ensure that all members stay informed and accountable for their responsibilities. By maintaining a consistent plan when necessary, our team is able to work efficiently and meet our goals throughout the season.

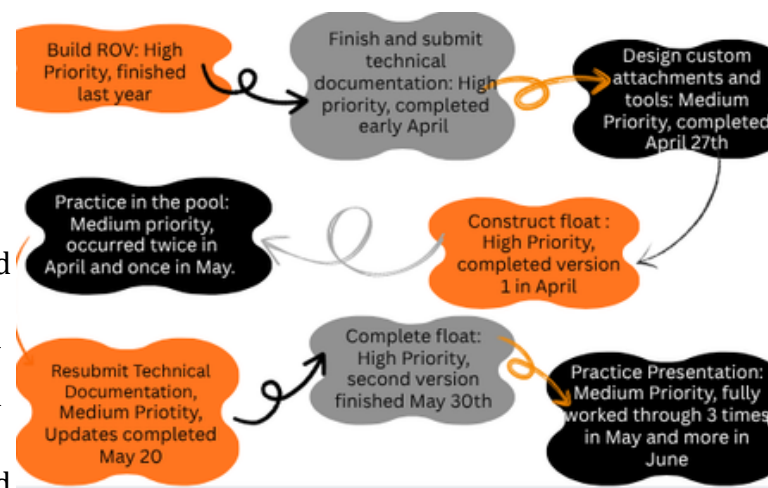


Figure 1: Scheduling Flow Chart by Elodie Neal

Overall Vehicle Design & Systems Approach:

Two years ago after our company's first SEA MATE competition, we were invited to a summer camp led by Ned Vorhees at STREAMWORKS where we learned about the basics of ROV technology and how to build one of our own. Based on what we learned, we constructed the base model of *Otter 1*. He recommended our thrusters and design, which we confirmed through research. From there, we added new parts and systems based on the tasks for that season, including a new claw and an updated camera system. This year, we've also created custom 3D print attachments to better complete the tasks. Our design prioritizes sustainability and safety above all else, with dozens of re-used components. We focus on

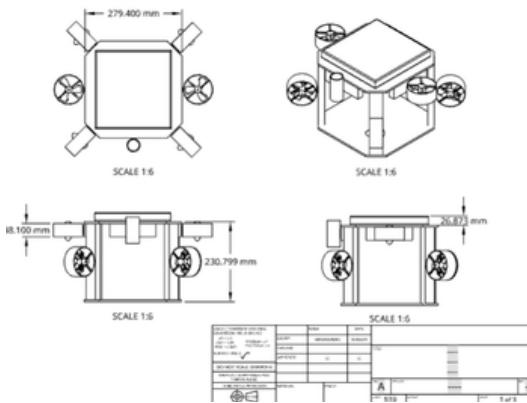


Figure 2: CAD diagram of ROV created by Anna Blackwell

innovation within a budget, carefully calculating all costs based on available funds. *Otter 1* is carefully constructed to ensure it efficiently meets the needs of the customer. It is light weight and fairly compact by design. In order to find the best parts for our ROV, the company held many research sessions to compare and contrast different parts online. This helped us to decide why we wanted each part and how they would fit onto our ROV. We worked our way up based on how important a task was. Our ROV was the highest priority, but as it was roughly prepared at the beginning of the competition, we were able to dedicate a lot of time towards growing the specific functions of the ROV. This also allowed us to focus our funds on the float.

Building on that, we are sharing further details of our design process. As with any good engineering firm, our builds have grown a lot over time. Each brainstorming session introduces new ideas and improvements. In fact, the first year of competition, an ROV was prepared from a MATE kit. It was made of PVC piping and used a bottle for ballast. As evidenced by the pictures, our ROV has updated as we've grown. We replaced our initial ROV with a sleek, efficient model. Rather than continuing to work with PVC piping, we've switched to boat board and furniture grade PVC to get a stronger ROV. While this made it heavier, the risks of flooding have decreased exponentially. The hull is also much more compact because of this decision. Our engineers added 6 thrusters to properly drive the ROV and allow for thorough balance. Based on our runs from last year, the company decided that a new camera system would be needed for the future. The downside of this was replacing a working camera system that now has no real use. We also had to disconnect this system to implement the new one, but the quality of the

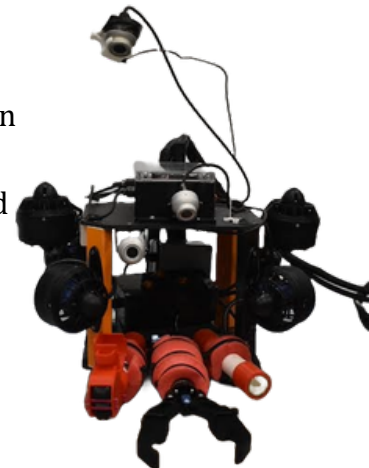


Photo 3: *Otter 1* taken by Ryan Darnell



Photo 4: brain box taken
by Ryan Darnell

new cameras will allow us to have a wider and clearer view of the field. With any modification of an ROV comes the problem of buoyancy. The camera system, the new attachments, and the additional tether cord had a major effect on the ROV buoyancy. We spent a lot of time adjusting how much styrofoam and weights we have on the ROV in order to have neutral buoyancy once again. We prioritize innovation and building what we can from existing materials. The more we re-use the more environmentally friendly we are, so most of our designs are extrapolations of previous years. In this case, our design is almost identical to the previous year's, excepting the aforementioned updates.

ROV Design Components:

This year, we chose to purchase a large number of our components. We did this to maximize time spent on innovation and thorough documentation. However, in assembly, we made several critical choices. This section focuses on the ROV, for the information on *Mussel* please refer to the **Float Design** section of this document. The ROV frame is made of a mix of materials, including boat board, and plastic. We chose to construct the pillars with PVC due to low weight/cost and the top and base plates with High-Density Polyethylene because of its durability. The buoyancy is polyurethane because of its water resistance.

Buoyancy and Ballast: As aforementioned in this document, the addition of fresh components required major adjustments to our buoyancy systems. Our current design features a polypropylene box atop the ROV, designed to create buoyancy. The ROV is as close to neutrally buoyant as possible, with slight positive buoyancy for retrieval in the event of an emergency. In our updates, we've carefully distributed buoyancy through testing to ensure an even setting for the ROV in the tank. Full range of motion is preserved and drifting is mitigated. In order to balance out the buoyancy box, we added fishing weights as ballast. After initial pool testing, we increased the number of weights as the ROV was too positively buoyant. Overall, after testing,

we increased our precision, settling on 7 weights. This number may be subject to change with further testing. Our general strategy is to keep the thrusters in linear symmetry along the sides of the ROV, with a buoyancy box at the top and ballast at the bottom of the ROV.

Camera Selection: Our cameras are another key component of our ROV. Otter 1 is fitted with three Blue Robotics Deep Water Exploration ExploreHD USB cameras. These cameras offer a high definition view, color correction, low-light sensitivity, and waterproof housing. This clarity makes it especially good for task 2.1. Each camera costs \$325, so the use of three cameras maximizes our cost efficiency without sacrificing the pilots's view

We've mounted one camera on the front of Otter 1 to ensure a good view of the claw. It is angled to look both forward and at the claw. The other camera is mounted on the top, looking up so that it's easier to go back up through the returning point. The third camera is mounted on a higher space to give a general view. The ExploreHD cameras are essential to ROV function, offering a light weight, high quality stream in real time. The cameras plug into the USB ports of a RaspberryPi. Footage flows through the RaspberryPi and is viewed via the Discovery app when connected to the DWEOS webpage.

Payload Tools: Otter 1 has a Blue Robotics 9-18VDC Gripper attached to the front of its body. Our company employed this tool in previous years with high success rates, scoring excellently in the pool. It is due to this success, as well as our desire to effectively budget, that we re-used the claw.



Photo 5: Blue Robotics Camera
by Ryan Darnell

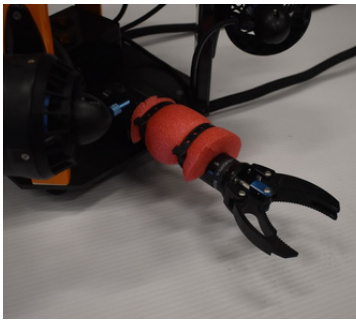


Photo 6: ROV claw taken by Ryan Darnell

The claw is controlled manually by the ROV pilot to ensure consistent results. We are using this on several tasks in several ways: task 1.1, to collect coral samples; tasks 2.3-2.5, to spin the handle and retrieve several components; and the various components of task 3, to move the components needed to complete the tasks. The claw offers a grip applicable to objects 6.2 cm in diameter. It is made of noncorrosive material ideal for underwater usage. The body has a pressure rated for safety. It can draw a variety of current, making it ideal for our multisystem, dynamic wiring and usage. After pool testing, we realized our claw was not suited to pick up coral by the substrate. To address this, we are also using an additional set of custom claw extenders to improve the suitability for task 1.1 and task 2.5. This expansion widens the claw to safely collect coral species and eDNA sensor. We've

also created custom magnet and measuring tape holders for this competition. The measuring tapes are used in tasks 2.2 and 1.2 to gather accurate data on the depths of ice bergs and the sizing for the coral garden. The magnet is used to pull the pin in task 3.1 with the micropile.

Propulsion And Related Decisions: We chose to use Blue Robotics T200 Thrusters for their excellent thrusting capacity, reliability, and reasonable price. We used 6 of these thrusters to create a balanced flow of movement. They are arranged with three motors on each side of the ROV. These were the perfect combination for speed as well. This was the most cost efficient method that also maintained full range of motion. These thrusters were recommended by Ned Vorhees at our seminar. After further research from Blue Robotics, we decided that these motors were the right fit for our company. Each thruster runs from an ECS to ensure even distribution of power and proper safety standards. This set up reduces strain and ensures smooth throttle response. Since these motors are very precise, they are perfect for working in a delicate area such as the coral garden. These also give us exact control of position, ideal for tasks in section 3 especially.

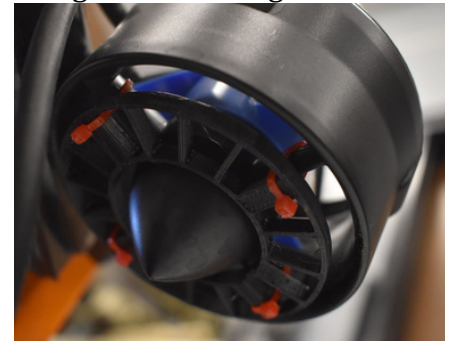


Photo 7: T200 Thruster by Ryan Darnell

Tether Design and Managenment: For optimal tether management our team has threaded all power and signal wires through a length of braided split loom. This keeps the wires organized and under control while the ROV is in and out of use. We chose the braided split loom because it is lightweight and flexible, exactly what we wanted for the material. Even with its overall lightweight, the braided split loom was still dragging our ROV down in the pool, so we added styrofoam blocks at intermediate intervals to counteract the weight. These blocks also act as length indicators for how much tether we have out in the pool.



Photo 8: Tether by Ryan Darnell

Build Vs. Buy Rationale

It is apparent that most of our components are re-used. We made this decision as we are a small school with limited funding. For us, it's extremely important to budget well, and it simply did not make sense to purchase new components. The overall float, though built from re-used components, is a completely fresh design. We built the complete product using items that we couldn't create ourselves. For example, it's not feasible for us to create our own wires or circuitry. The ROV was built from near scratch last year. We chose to reuse it to conserve funds. Additionally, all components met the safety requirements, and we were concerned that trying to adjust it would create dangerous scenarios. The cameras, attachments and the Pi box are new components and the overall set-up is a build. Despite the lack of individual built components, the overall design is entirely original and hand-made. Full data available in Appendix D.

Software, Control & Electronics:

Our Systems Design: All of our electronics on *Otter 1* are run via a tether cable that is connected to our control box. This tether is attached to the back of the ROV and the wires are able to run from the tether to a waterproof box. From there, they connect to all of our thrusters as well as the claw. Cable management was needed in order

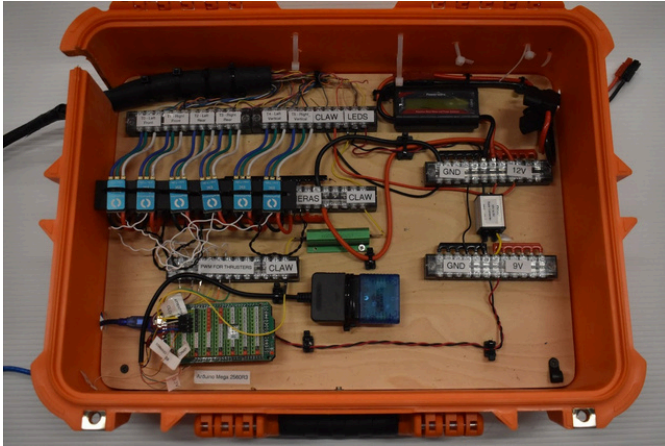


Photo 9: Brain Box by Ryan Darnell

to keep the wires out of the way of the thrusters. We also added a 3D printed cover to the thrusters to better protect them. The thrusters are placed in areas that allow the ROV to freely move in any direction and even spin if needed. Everything in our electrical control box can be easily shut off by directly flipping the switch on the power supply. The power supply is simply hooked up to the connectors that are sticking out of the box on the right side. The computer we are using to see through the cameras is connected to the arduino on the ROV with an ethernet cable that runs through the tether for a direct connection.

power supply that provides a steady 12 volt connection. Part of the connection travels through a 9 volt converter that our arduino mega can use as power. The rest of the connection provides power for the ESCs, claw, and other board on the ROV. The arduino mega is then connected to the ESCs in order to give power and direction to our thrusters as well as the claw. The claw wire is run through a resistor to limit too much voltage. The dongle for our controller is also connected into the arduino mega so that the correct inputs are for the correct buttons.

Wiring and Electricity: the ROV control box includes our power box, fuses, voltmeter, and 12V power strip. Additionally, we have LEDs, cameras, thrusters, and a buck converter running from the power strip. The buck converter leads to a 9v powerstrip that connects to an Arduino Mega running a bluetooth adapter for the controller, the resistor to the claw, and the PWM for the thrusters. Our fuses are 25 amps, well within safety limits for our electrical load. Our wires are encased in protective material and there are no areas of exposed current. Each load has been carefully calculated to ensure optimal performance. Our control box is run off of a Powerwerx. To verify that everything is connected and getting the correct voltage, we used multimeters to check the voltage at each point of the circuit. We also have LED lights attached on the ROV that light up once everything is getting power. Test runs are also completed to ensure that everything works correctly such as the thrusters and the claw.

Code Decision and Software Usage: The majority of our code is written on Arduino IDE, since we like the syntax of C++ and Arduino is a reliable company with large amounts of documentation. We used various libraries, including Arduino BLE and MS5837. Our code focuses on a structure of consistency. The ROV is piloted with a playstation controller that communicates with our Arduino Mega control board. This Arduino Mega serves as the central control for all of the ROV functions (except the cameras, which run through a RaspberryPi) and is home to our code. ROV code was originally authored by Owen Vorhees and Ben Liebkeman, and we've chosen to continue use of their code, with updates by our programming team to adjust T200 speed with the d-pad. Each function by the ROV is controlled through a sample code provided by the manufacturer using the Servo.h library and boolean control function. We have built in debugging using the serial monitor function. Though ideally we would create fresh code, our programming team is very small and has to analyze each opportunity cost for our projects. This year, we've chosen to prioritize cameras, the float, and image recognition software. All float code was originally authored by our programming squad. However, the sketch draws heavy inspiration from the example sketches for MS5837 sensors as those were a new process for us. The overall function focuses on a series of loops based on those sensors. The float code is more heavily detailed later on. Our cameras require two independent operating softwares: RaspberryPiOs and DWEOS. Running the stream

provided its own challenges, but these two softwares were key in our process. These saved time and ensured consistent results. The AI was prepared using python and the open cv library. Our software engineers annotated various images to mark the European Green Crabs using Roboflow and then trained the model using this data in Google Colab. The recognition software is then run through colab. All code is available at our GitHub: Betsy Robotics. The link is bolded below this text.

Github Link: [Betsy Robotics GitHub](https://github.com/betsyroboticsehs-code/SeaMate-2026-EHS)

Manual link: <https://github.com/betsyroboticsehs-code/SeaMate-2026-EHS>

Float Design Details and Processes:

Float Design Process: In our previous years, we’ve designed a float with pumps to complete the mission tasks, but as we’ve experienced almost no success on that point, we chose to scrap our old float entirely. The wiring system, which we planned to reuse, also was replaced due to the new components in our float. The float runs through a buoyancy engine consisting of a stepper motor and a 30 cc syringe. This system allows us to have precise control over our float’s buoyancy. Our casing is a blue robotics 50 mm by 300 mm tube. At our regional, we used a 6" PVC pipe that was simply too buoyant. We chose to pivot and completely redesign our buoyancy engine to fit in the smaller tube as the other options were on back order. We’ve added weight to

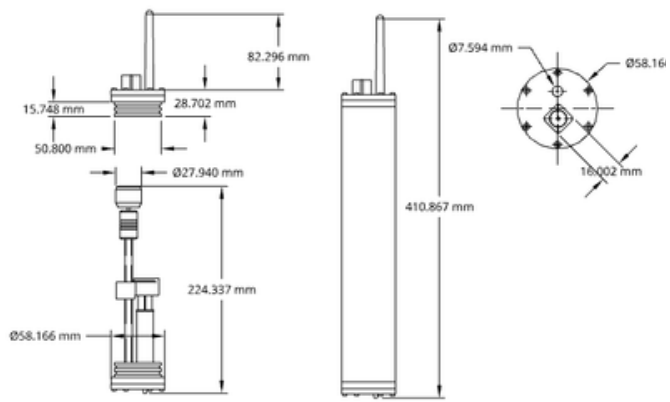


Figure 3: *Mussel* CAD by Anna Blackwell



Photo 10: *Mussel* by Ryan Darnell.

neutralize the buoyancy of the float. We calculated the necessary buoyancy and ballast using the buoyancy equation $F_b = pVg$. We’ve purchased a Blue Robotics Lid of the appropriate size. Embedded in this lid, we have a depth sensor as well as an antenna to ensure bluetooth functions smoothly. We have O ring flanges (50 mm diameter) installed within this lid to ensure pressure relief is within safety standards. Looking at the bottom of the float, 3 “legs” are attached to the lid section where the syringe is attached. These were custom printed and are designed to protect the bottom of the float and the syringe tip if the float is dropped.

Sensor Choices: Mussel is fitted with a Blue Robotics Bar High-Resolution Depth/Pressure Sensor. Specifically, it is the Bar30 model for higher pressures with capacity to measure up to 30 bar with a depth resolution of 2 mm. It contains a temperature sensor integrated into the software. The sensor runs off of an arduino portenta C33, alongside the motor. They are key for our profiling float to transmit data. Data is read by the portenta and sent to the Light Blue app for easy reading and compiling. Data packets consist of depth in meters, temperature in celsius, and pressure in kPa. We used the MS5837 library available for arduino IDE, as well as the Bluetooth Low Energy library to complete data transmission and collection.

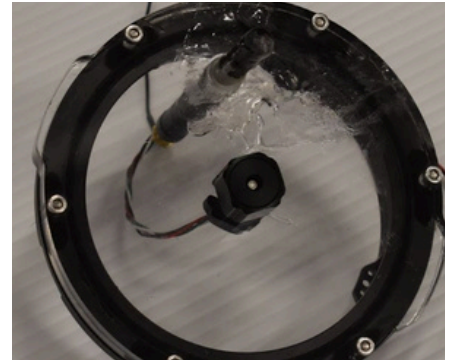


Photo 11: Sensor and Antenna by Ryan Darnell

Float Wiring: For the Vert-Float, the battery(12v) connects to the fuse(5V), this connects to the screw strip. From the screw strip it connects to the stepper motor driver and a 12 volt to 5 volt buck converter. The buck Converter connects to the portenta C33. The portenta outputs variable 3.3 volts to an I2C converter, and the stepper motor driver. The I2C converter connects to a sensor at 3.3 volts. The stepper motor driver connects to the motor at variable 12 volts. Our code is written in arduino IDE to control the portenta C33. We chose to use a series of while loops that read based on the depth. This in turn triggers a descent. Once the descent is completed, measurements are broadcast to the light blue app.

Buoyancy: $0.0005889 \text{ m}^3 * 1025 \text{ kg/m}^3 * 9.81 \text{ s}^2/\text{m} = 5.922 \text{ N}$
buoyant force; 880 g needed to neutralize buoyancy.
Float mass: actually 870 g ish
Added water with full syringe: 10.4 g
1.2 % of the mass

Descent Speed: $v = \sqrt{((2 * F_n) / (P_f * C_d * A))}$
 $P_f = 1025 \text{ kg/m}^3$;
 $C_d = .87$;
 $A = \pi * .025^2 = .00196 \text{ m}^2$;
 $F_n = (.0104 * 9.81) = .102 \text{ N}$;
 $V = .342 \text{ m/s}$
Estimated time to reach 2.5 m: 7.31 seconds.

Client Applications For Company

Products:

ROV Applications: This season, the client requested an ROV capable of working in a northern environment. Our team has more than delivered, with a study ROV carrying removable tools and high definition cameras. The ROV itself is sturdy and efficient, proving itself capable of surviving in the various conditions underwater research demands. We've created a lot of essential prototypes that can be expanded to greater use in any underwater application. The client requested an ROV capable of inspecting icebergs and finding the keel depths of said icebergs. Additionally, they requested capacity to measure a coral garden. Our response to this was a custom measuring tape attachment, holding two tapes: one for length and one for height. These tools could easily be transferred to research teams looking to determine the threat levels of icebergs in real life or find the dimensions of shipwrecks and habitats. We also fabricated a custom magnet to pull the pin, as requested by the client pertaining to the micropile. In the future, scaling up this attachment could contribute to ocean cleanup efforts, removing junk from the sea floor. Finally, our major innovation was a claw extension that allows the ROV to collect coral species by the substrate, leaving the actual organism undamaged. This expansion has real-world applications in the research department, as it could be greatly scaled and altered to work on a variety of claws and save costs when collecting different shapes and sizes of species.



Photo 12: Custom Claw Expansion by Ryan Darnell



Photo 13: Float Iterations by Ryan Darnell

Float Applications: In order to meet the needs of the client, we've scaled our vertical profiling float down quite a bit. Initially, we created a float that barely fit within the size restrictions. It weighed an insane amount and was very difficult to move and use. Now, we've switched to a tiny 50 mm diameter tube that's 300 mm. This tube is much more user friendly and applicable to the client's requests. It is equipped with a pressure/depth/temperature integrated sensor that can be used to analyze changes in water temperature and variations in climate over time. The client put a special emphasis on using a buoyancy engine rather than pumps and such, so we elected to use one

consisting of a syringe and a stepper motor. The float broadcasts using a system available to any and all: the light blue app.

Other Responses to Client Requests: In this competition, we've also created a few other responses to client requests. For example, the client wanted to use image recognition software to identify invasive species. We answered that request using a YOLOv8s model designed to select and count invasive European Green Crabs. Since the data can be annotated quickly in Roboflow, it is easily alterable to fit any creature needed. This could be widely applied to mitigate invasive species and identify biome types based on species. Finally, we've established a GitHub to share our code with other underwater enthusiasts so as to expand knowledge.

System Integration Diagrams (SID)

Elizabethton High School, 2026

System Integration Diagram (SID)

System Integration Diagram (SID) for Float Device

Measured Float Full Load Amps (FLA) in Water = 0.21

Fuse Size Based Upon FLA = 3 Amps

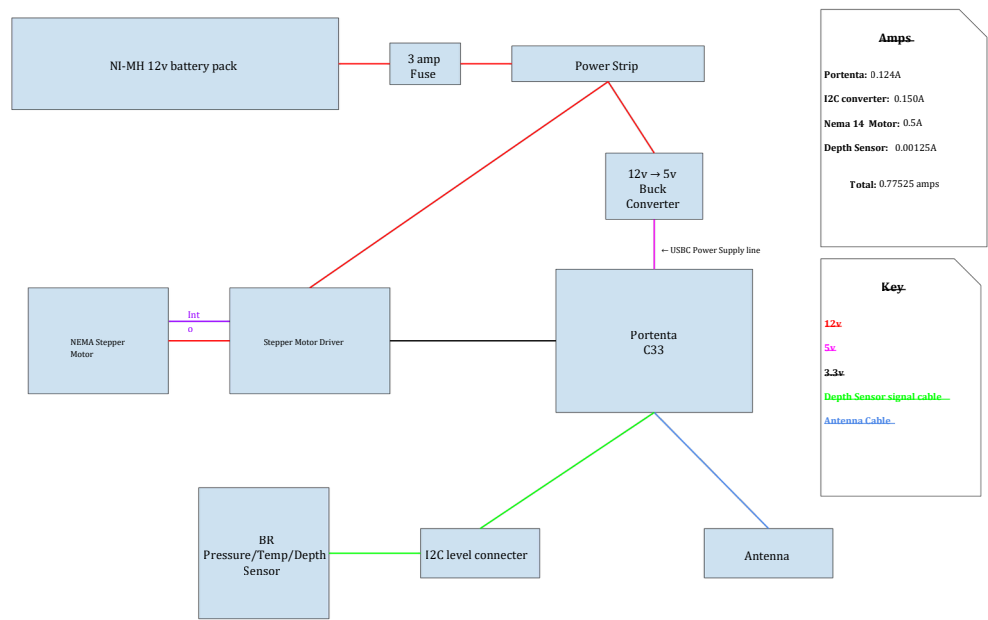


Figure 4: SID for Float by Anna Blackwell

System Integration Diagram (SID) for ROV

ROV Full Load Amps (FLA) in water = 18

Fuse size selected based upon FLA = 25

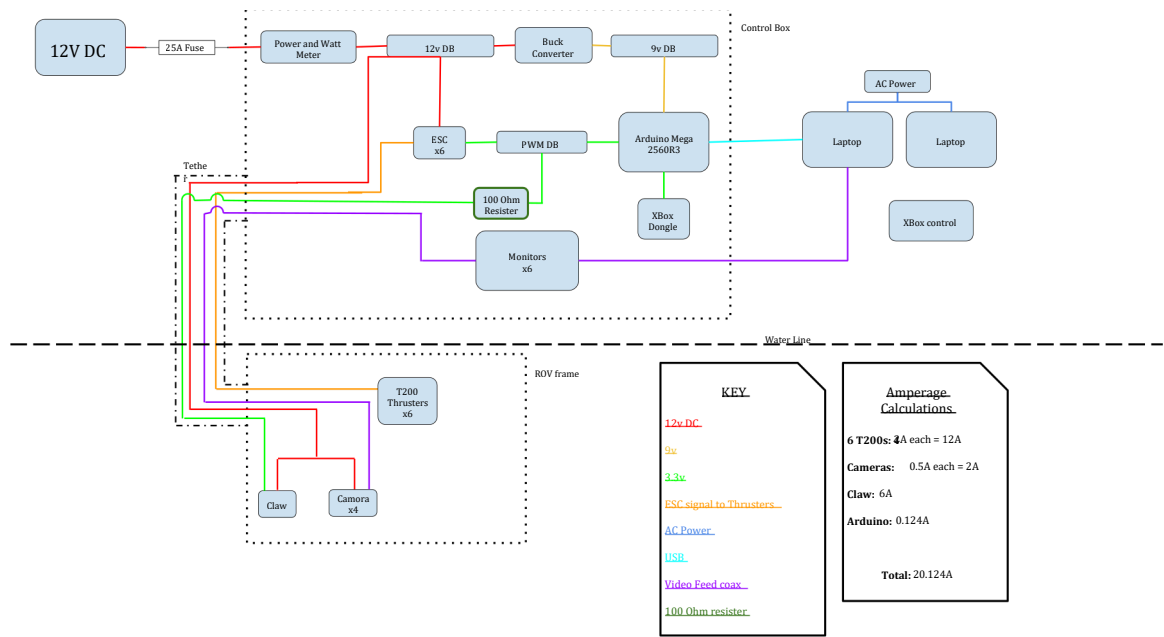


Figure 5: SID for ROV by Anna Blackwell

Safety

The Cyclone Robotics Team makes efforts to prioritize safety above all else. All members of the team make an effort to always ensure safe protocols while working. In addition, many members of the team are safety and hand tool certified by NC3Certs as well as being general electrical safety certified. Along with safe practice procedures and certifications, there are several safety measures in place with the team's ROV. All of the team's electronics and wires are waterproofed and the ROV's claw is waterproofed along with two 25 amp fuses in place to ensure the safety of team members and equipment. Furthermore, job steps and safety procedures for the field are listed in the JSEA document.

General Safety Checklist:

- _Establish communication with co-workers.
- _Ensure everyone has hair tied up, sleeves rolled up, and earphones/jewelry put away while using any tool.
- _Ensure everyone is wearing closed-toed shoes.
- _Ensure everyone is wearing safety glasses.
- _Remove loose accessories and distractions.
- _Ensure passageways are clear of objects and wires.
- _Clean workspace to avoid disorganized environment.
- _Keep hazardous objects and materials away from members and ROV when not being used.
- _Keep all electronics, aside from tether, away from water.
- _Ensure all wires are carefully and effectively covered, with no exposed ends.
- _Ensure the power connection and controller are connected before powering on the control box.

Operational Checklist and Protocol

Tether Protocol

Set up:

1. Unwind the tether completely and remove any tangles.
2. Attach the strain relief to the control box to reduce risk of disconnection.
3. Make others aware of tether placement.
4. Secure the strain relief to the ROV.
5. Attach Tether to the ROV.

Deck Operation Checklist:

1. Follow the tether setup procedure
2. Connect the power supply and switch it to 12V
3. Turn on ROV
4. Test the movement of thrusters and the claw
5. Check camera feeds on the display screens.
6. Carefully lower the ROV into the water.
7. Release any trapped air bubbles.
8. Wait for the deck crew's "ready" confirmation
9. Pilot initiates launch countdown

After Operation:

1. Neatly coil the tether onto the reel.

Pre-Operation Checklist:

1. Inspect all electrical connections.
2. Perform a dry test to ensure cameras function properly and are unobstructed.
3. Confirm all waterproof seals are tight.
4. Test thrusters to ensure proper operation and no blockages.
5. Verify that the claw is working correctly.

Post-Run Checklist:

1. Power down the control box.
2. Turn off the main power supply.
3. Dry the ROV and place it securely on the cart.
4. Clean and organize the workspace, removing all materials and debris.

Testing & Troubleshooting

Prototyping And Testing Methods: Our team implements several different prototyping methods to achieve optimal operation in all of our competition components. We build upon our past attempts of MATE and learn from errors that either happened during the competition or at the class room. This year we have implemented CAD design prototyping with our profiling float. We had to completely redesign our profiling float from the last competition year, so to reduce stress and unnecessary purchases we first modeled our new buoyancy engine and built around it to figure out the exact size of casing we needed and what material to go with. After everything is built, we use our schools pool to test both the ROV and profiling float functionality. We have recreated this year's playing field to practice tasks and optional ROV orientation. Prototyping usually occurs as a stepping stone to the final product, with most materials being reused for sustainability. When we test, we try to document exactly what problems we ran into during the session. It's very important to us to have 2 people involved in testing at all times so that if anything goes wrong there is always help around. Additionally, we believe that having more eyes is always helpful for solving problems. With mechanical/hardware projects, we begin our process by creating a CAD design, doing any related calculations to ensure a proper balance, buoyancy, etc, and doing a "common sense" check in which we talk through our plan. Then, we build a basic version of our design. We get at least 3 people to check the design for structural integrity, functionality, and safety. Finally, we run our project in the pool. If it works well, we test it a few more times and then move on to the next objective. If we run into issues, we go back to the second step and then test again until we succeed. With our software, we have a very specific process for testing new programs/software. First, we double check our code and look for any small errors. Next, we switch projects with another programmer to get a fresh set of eyes on the code. If that still does not reveal the issue, we look at the documentation and check our hardware. Finally, we double check all wiring and board issues. Currently, we haven't had any issues we can't solve.

Budget & Cost Accounting

Budget:

EHS Robotics team began the season with a goal of fundraising \$35,000 and successfully exceeded it by raising a total of \$37,175.66. These funds were carefully allocated to support both educational opportunities and team needs. A total of \$15,102.36 was used to take 15 members to Disney, where they participated in a magical experience working with the imagineers. Additionally, \$8,735.40 was spent on attending the RDL competition, while for MATEs we used \$5,102.13. The team also spent \$1,002.50 on uniforms and invested \$5,787.59 into classroom resources, including equipment such as laser cutters and 3D printers. Overall, the budget was managed effectively to enhance both student learning and team success. After qualifying for the world competition, the team successfully raised another \$29,483.05 dollars to cover travel expenses.

Funding:

The Cyclone Robotics Team receives a significant portion of its funding through the support of generous organizations and individuals, including Toyota of Bristol, Snap-On, Nor-Well, Donna Estes-Crye - We Like Realtors, Farm Supply, Two Dudes, Gaming, Appalachian Orthopedics, Jessica Sloan, J's Corner, Big John's, Mid City Grill, Barry Heating & Air, Northeast Community Credit Union, Erie Insurance, Lingerfelt Drug, BB & Boys Cleaning, Tango Romeo Cafe, and Joshua Cukhert CPA. Their contributions help make it possible for our team to compete and continue growing each year. In addition to these sponsors, the remainder of our funding is raised through school-based fundraisers and team led efforts such as selling laser-engraved items, hosting coffee sales, and creating banners and signs for the school community. The team also earned additional funding by winning the TVA Robotics Award, which included a financial prize that contributed directly to our budget.

Spending:

Before any spending is done, the Cyclone company makes sure to research parts needed thoroughly to make sure we purchase the best possible parts for our tasks. Once we have decided, we log the part name, where we are purchasing from, and the cost into a spreadsheet so that we can see the total amount we have spent on everything throughout the year. There are many things that we have reused as well (see new vs. old) in order to save some funds for next season.

Table 2: Purchased Items

Table 1: Otter 1 Budget

Item	Quantity	Unit Value (\$)	Total Value (\$)
Acrylic Sheets	2	37	74
Amp/Volt Meter	2	82	164
Anderson Power Pole Mounters	4	20	80
Blue Robotics T200 Thrusters	6	230	1,380.00
Arduino Mega	1	50	50
Control Box	1	750	750
			2,498.00

Cat.	Qty	Part Name/ Description	Price, each	Total (\$)
ROV				
	3	DWE ExploreHD USB Camera	325	975
	4	JST GH to DF13 Adaptor: 4-pin	12	48
	1	Screw and Nuts Kit	10	10
	1	Heat Shrink Tubing Kit 355 pcs	20	20
	4	WetLink Penetrator	12	48
	1	Cat 8 Cable 35ft.	35	35
	6	Speed Controllers	38	228
	6	T200 Thrusters	200	1,200
	1	Screws	30	30
	1	Powerpole Connector Contact	25	25
	4	PVC sheets	21	84
	6	Washers	1	6

Cat	Qty	Part Name/Description	Price Each	Total (\$)
	6	Hex nut 1in.	2	12
	1	Arduino Mega	50	50
	1	Outdoor Electrical Enclosure For Electrical Applications	49	49
	1	Raspberry Pi Model 4 B	75	75
	1	30ft CAT7 Cable	9.99	9.99
	1	MAKERELE Waterproof Box	13.29	13.29
	1	SB Raspberry Pi 4 Case	5.99	5.99
	1	72 Pc Cable Gland Kit	22.78	22.78
	1	50 Pc Adj Kit	12.73	12.73
	1	½ NPT Cable Gland	12.3	12.3
	1	¾ NPT Cable Gland	14.24	14.24
tot.				\$3,061.32

Float				
	1	Blue Robotics Watertight Enclosure	36	36
	2	Blue Robotics End Caps	16	32
	2	O Ring Sealing Flange	34	68
	1	Pressure Valve	32	32
	4	I2C Converter	30	120
	1	Bar30 Pressure sensor	80	80
	1	Stepper Motor Driver	10.24	10.24
	1	Arduino Portenta c33	49.4	49.4
	1	Stepper Motor	60	60
	1	30cc Syringe	1	1
	1	Geekstory Antenna	14.98	14.98
Total				503.62

Props				
	1	Velcro	16.81	16.81
	1	Cable Wire	8.99	8.99
	1	Bubble Wrap 61cm wide	19.99	19.99
	1	Pin	13.99	13.99
	2	O-ball	4.74	9.44
	1	½- inch PVC pipe- 10 ft lengths	5.46	5.46
	1	1- inch PVC pipe	3.93	3.93
	1	1 ½-inch PVC pipe	5.98	5.98
	1	2-inch pipe	14.36	14.36

	1	3-inch pipe	15.53	15.53
	1	3-inch to 2-inch reducer	7.36	7.36
	1	Corrugated plastic sheeting	37.98	37.98
	1	2-inch vinyl numbers	3.47	3.47
	1	Brick	reuse	
	1	Rope	5.26	5.26
	1	#310 U-bolt	2.41	2.41
	1	½ -inch PEX tubing	4.73	4.73
	1	½ -inch brass PEX tee	4.31	4.31
	1	2-gallon bucket	2.98	2.98
	1	2-gallon bucket lid	0.98	0.98
	1	Milk crate	11.98	11.98
	1	Screw hook	1.57	1.57
	6	Spray paint, various color	6.98	48.88
	1	Chenille pipe cleaners	2.99	2.99
	96	½ -inch tees	0.47	45.12
	14	½ -inch 90 elbows	0.41	5.74
	1	½ -inch crosses	1.41	1.41
	6	½ -inch sideouts	1.97	11.82
	10	½ -inch end cap	0.38	3.8
	1	¾ -inch to ½ -inch reducing tee	0.58	0.58
	1	1-inch coupling	0.61	0.61
	1	1-inch to ½ -inch reducer bushing	0.7	0.7

	1	1 ½ -inch end cap	0.87	0.87
	1	1 ½ -inch tee	1.85	1.85
	6	2-inch end cap	1.13	6.78
	1	3-inch PVC end cap	3.88	3.88
Total				\$336.50

Travel				
	15	Flights	1414.17	21,212.55
	4	Hotel Rooms	147.07	588.28
	4	Hotel Rooms	1169.67	4,678.68
	3	Rental Cars	1,000	3,000
Total				29483.05
Year Total				33,955.05

Other				
	1	MATE ROV Registration	450	450
	1	Micro SD two pack 128GB	44.98	44.98
	1	USBC to USBC 5pack	8.99	8.99
	2	USB to USBC 5pack	9.95	19.58
	1	2pack HDMI to Micro HDMI	11.2	11.2
	1	USB USB Micro charge station	16.95	16.95
	1	10 port USB charge station	18.91	18.91
Total				\$570.61

References:

1. Mate ROV Competition Website <https://www.materovcompetition.org/>
2. BlueRobotics T200 Thruster, <https://bluerobotics.com/store/thrusters/t100-t200-thrusters/t200-thruster-r2-rp/>
3. BlueRobotics Basic Electronic Speed Controller, <https://bluerobotics.com/store/thrusters/speed-controllers/besc30-r3/>
4. Raspberry Pi 4 <https://www.raspberrypi.com/products/raspberry-pi-4-model-b/>
5. Arduino Mega 2560 Rev3, <https://store-usa.arduino.cc/products/arduino-mega-2560-rev3?selectedStore=us>
6. BlueRobotics Depth Sensor Library https://docs.arduino.cc/libraries/ms5837_30ba_library/
7. Deep Water Exploration Operating Software Website https://dwe.ai/products/dwe-os?srsId=AfmBOpgC_rsQIqjKkl46d-rttyHqOfwwwBlqVroZaJxtv6uMnQSRX6
8. Blue Robotics Bar High Depth/Pressure Sensors <https://bluerobotics.com/store/sensors-cameras/sensors/bar-depth-pressure-sensor/>
9. Arduino Servo Library <https://docs.arduino.cc/libraries/servo/>
10. Arduino Bluetooth Low Energy Library <https://docs.arduino.cc/libraries/arduinoble/>
11. Blue Robotics Website <https://bluerobotics.com/guide-tag/calculators/>
12. Buoyancy Calculator <https://www.epa.gov/pesticide-worker-safety/buoyant-force-calculations>
13. Open CV Library <https://github.com/opencv/opencv>
14. Canva User Guide <https://www.canva.com/learn/how-to-canva-beginners-guide/>
15. Arduino Portenta c33 Guide <https://docs.arduino.cc/hardware/portenta-c33/>
16. Onshape User Guide <https://learn.onshape.com/learning-paths/onshape-fundamentals>
17. MATE ROV 2026 Competition Manual <https://materovcompetition.org/2026>

Appendix

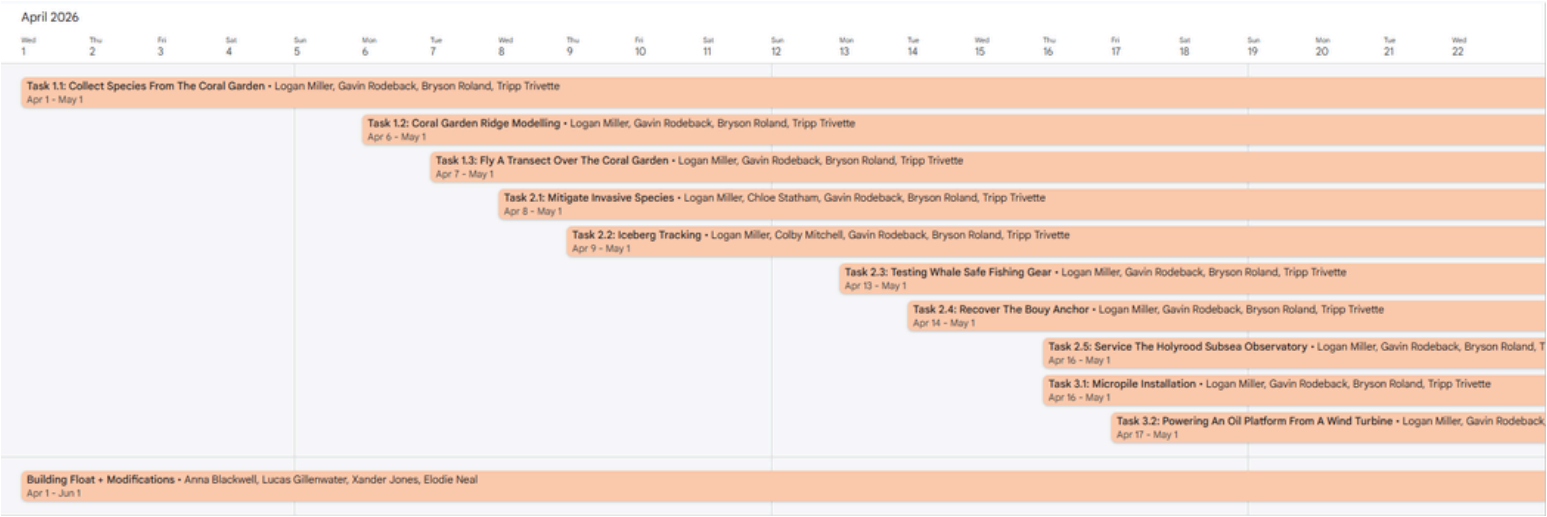
A : Sub Team Structure

*Head of Unit

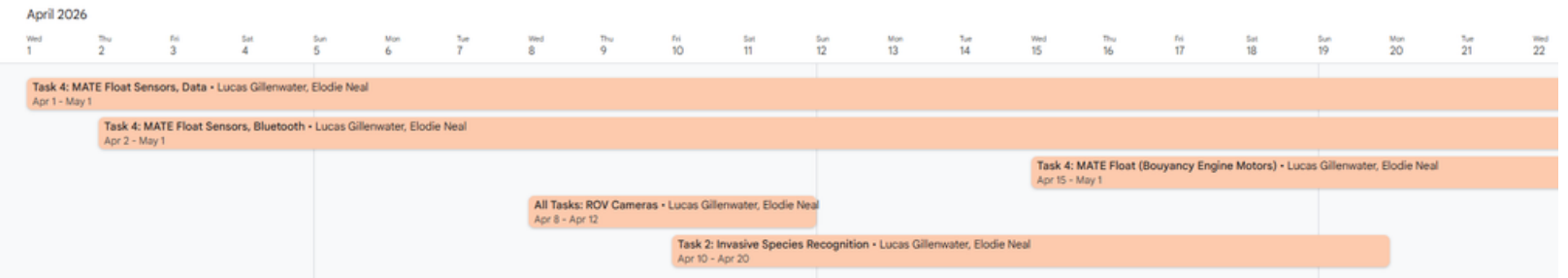
Engineering Design	Mechanical Engineering	Safety Management	Props Managers		Documentation	Programming	Community Outreach
*Anna Blackwell	*Xander Jones	*Nathan Edwards	*David Roland		*Abigail Watson	*Lucas Gillenwater	*Madelyn Stanberry
Abigail Watson	Elodie Neal	Joshua Asche	Colby Mitchell	Chloe Statham	Anna Blackwell	Elodie Neal	Bela Blackwell
	Lucas Gillenwater Logan Miller	Gavin Rodeback	Prentice Trivette	Logan Miller	Ryan Darnell		Madison Hardin
	Colby Mitchell Chloe Statham	Holly Hosclaw	Gavin Rodeback	Joshua Asche	Madelyn Stanberry		Ryan Darnell

B: Project Schedule

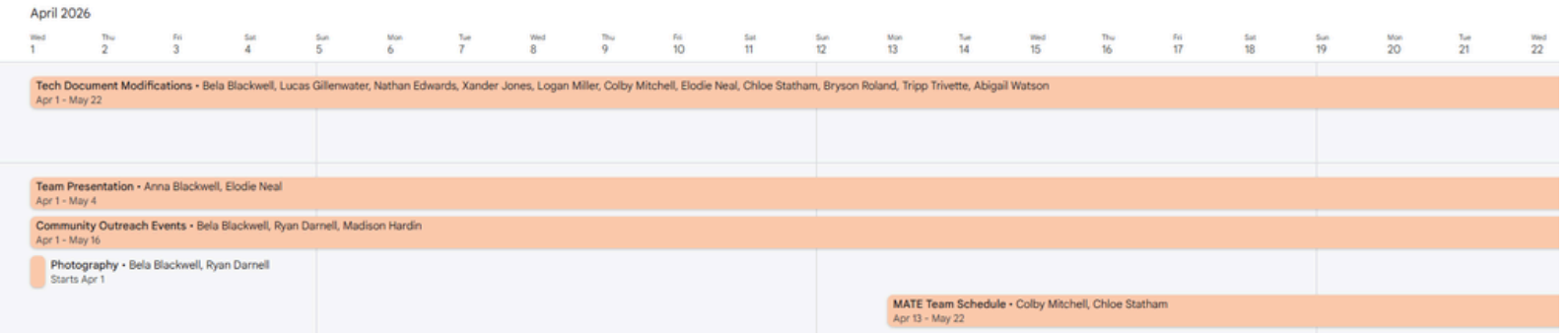
Building Props And Robot							
Tr	Task	Priority	Tr	Worker(s) (Last Name Alphabetical)	Status	Start Date	Due Date
	Task 1.1: Collect Species From The Coral Garden	Low		Logan Miller, Gavin Rodeback, Bryson Roland, Tripp Trivette	Complete	4/1/2026	5/1/2026
	Task 1.2: Coral Garden Ridge Modelling	Low		Logan Miller, Gavin Rodeback, Bryson Roland, Tripp Trivette	Complete	4/6/2026	5/1/2026
	Task 1.3: Fly A Transect Over The Coral Garden	High		Logan Miller, Gavin Rodeback, Bryson Roland, Tripp Trivette	Complete	4/7/2026	5/1/2026
	Task 2.1: Mitigate Invasive Species	High		Logan Miller, Chloe Statham, Gavin Rodeback, Bryson Roland, Tripp Trivette	Complete	4/8/2026	5/1/2026
	Task 2.2: Iceberg Tracking	Low		Logan Miller, Colby Mitchell, Gavin Rodeback, Bryson Roland, Tripp Trivette	Complete	4/9/2026	5/1/2026
	Task 2.3: Testing Whale Safe Fishing Gear	High		Logan Miller, Gavin Rodeback, Bryson Roland, Tripp Trivette	Complete	4/13/2026	5/1/2026
	Task 2.4: Recover The Bouy Anchor	High		Logan Miller, Gavin Rodeback, Bryson Roland, Tripp Trivette	Complete	4/14/2026	5/1/2026
	Task 2.5: Service The Holyrood Subsea Observatory	Medium		Logan Miller, Gavin Rodeback, Bryson Roland, Tripp Trivette	Complete	4/16/2026	5/1/2026
	Task 3.1: Micropile Installation	High		Logan Miller, Gavin Rodeback, Bryson Roland, Tripp Trivette	Complete	4/16/2026	5/1/2026
	Task 3.2: Powering An Oil Platform From A Wind Turbine	High		Logan Miller, Gavin Rodeback, Bryson Roland, Tripp Trivette	Complete	4/17/2026	5/1/2026
	Building Float + Modifications	High		Anna Blackwell, Lucas Gillenwater, Xander Jones, Elodie Neal	In Progress	4/1/2026	6/1/2026



Programming Worlds																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
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Documentation Worlds							
Tr	Task	Priority	Tr	Worker(s) (Last Name Alphabetical)	Status	Start Date	Finish Date
	Tech Document Modifications	High		Bela Blackwell, Lucas Gillenwater, Nathan Edwards, Xander Jones, Logan Miller, Colby Mitchell, Elodie Neal, Chloe Statham, Bryson Roland, Tripp Trivette, Abigail Watson	In Progress	4/1/2026	5/22/2026
	Team Presentation	Medium		Anna Blackwell, Elodie Neal	Complete	4/1/2026	5/4/2026
	Community Outreach Events	Low		Bela Blackwell, Ryan Darnell, Madison Hardin	Complete	4/1/2026	5/16/2026
	Photography	High		Bela Blackwell, Ryan Darnell	Complete	4/1/2026	
	MATE Team Schedule	Medium		Colby Mitchell, Chloe Statham	Complete	4/13/2026	5/22/2026
	JSEA	High		Joshua Asche, Nathan Edwards	In Progress	5/4/2026	



Team And Event Timeline		Start Date	Finish Date
MATE Regionals @ ETSU (Johnson City, Tennessee)		5/1/2026	5/2/2026
MATE Worlds @ Fisheries and Marine Institute of Memorial University (Newfoundland & Labrador, Canada)		6/23/2026	6/28/2026
Disney & Workshop With Imagineers		3/22/2026	3/26/2026
STEM Mini-Camp With Streamworks		m/d/yyyy	



C: Otter 1 Custom Fabricated Parts

Laser Cut
Frame Side Panel x2
Frame Lower Panel x2
Float Supports x2

3D print
Thruster Guards x6
Float Legs x3
Claw Adapter x2
Magnetic Grabber
Measuring Tape Holder

D: Build Vs. Buy, New Vs. Old ROV COMPONENTS:

Power & Distribution

Powerwerks 13.8V PSU (re-used)

- Bench power supply for testing topside.

Powerwerks Precision Watt Meter (re-used)

- Lets you monitor current draw from thrusters and accessories.

Bus Bars (re-used)

- Clean power distribution for 12V lines.

12V → 9V Converter (re-used)

- Steps down voltage for Arduino or accessories.

Screw terminals (re-used)

- For modular wiring and easy swapping of components.

100 ohm resistor (re-used)

- limits the volts moving into the claw.

Propulsion

6 × Blue Robotics T200 Thrusters (re-used)

- High-thrust brushless motors for movement in all axes.
- ESCs — Required to drive each T200 (one ESC per thruster).

Manipulation

Blue Robotics 9–18VDC Gripper (re-used)

- A solid underwater gripper that runs directly off your power bus.

Control & Electronics

Arduino Mega 2560 R3 (re-used)

- Main microcontroller for reading sensors and sending PWM to ESCs.

DeepWater Exploration exploreHD USB Camera (bought)

- Underwater camera for visuals of surroundings

Del Laptop (re-used)

- Runs camera videofeed

Cat 8 Cable (bought)

- Provides a connection between the Raspberry Pi4 and Laptop

Raspberry Pi4 (bought)

- Micro controller used for video communication, autonomous 360 photography of core bed, and autonomous identification of invasive crab species.

PS2 Dongle Controller (re-used)

- Used for remote control input (wired or wireless depending on your setup).

PS2 Dongle Controller (re-used)

- Used for remote control input (wired or wireless depending on your setup).

Cat 8 Cable (bought)

- Provides a connection between the Raspberry Pi4 and Laptop

Raspberry Pi4 (bought)

- Micro controller used for video communication, autonomous 360 photography of core bed, and autonomous identification of invasive crab species.

PS2 Dongle Controller (re-used)

- Used for remote control input (wired or wireless depending on your setup).

Frame & Structure

Styrofoam (re-used)

- Buoyancy blocks (must be sealed or replaced with ROV-safe foam).

Wood + Epoxy Coating (re-used)

- For a sealed, rigid frame (though wood underwater is risky long-term).

Polycarbonate Plates (re-used)

- Great for mounting electronics, thrusters, and structural panels.

Cable Management

Split Sleeve Cable Wrap (re-used)

- Protects wiring from abrasion and keeps bundles tidy.

Sensing & Navigation

MS5837-BA30 Pressure/Depth/Temperature Sensor (re-used)

- Provides real-time depth and environmental data for navigation and buoyancy control.

Geekstory Antenna (re-used)

- Wireless communication, telemetry, or topside data.

FLOATER COMPONENTS:

Power & Distribution

12V Nickel-Metal Hydride Battery Pack (re-used)

- Main onboard power source for motors, sensors, and control electronics.

DC 12V → 24V Converter w/ 5V USB-C Output (re-used)

- Boosts voltage for higher-demand components while also providing regulated 5V for microcontrollers or accessories.

2A Gray Fuse (bought)

- Overcurrent protection for critical circuits.

Control & Electronics

Portenta C33 (bought)

- High-performance microcontroller for running navigation, sensor processing, and control logic.

Stepper Motor Driver (bought)

- Allows the microcontroller to switch high-current devices safely.

I²C Converter (re-used)

- Ensures compatibility between sensors and the controller (voltage shifting or protocol bridging).

E: EHS MATE Worlds 2026 Budget

Worlds Budget	Headings	Total Est (\$)
	ROV Total	\$3,061.32
	Float Total	\$503.20
	Props Total	\$336.50
	Travel Total	\$29483.05
	Other Parts Total	\$570.61
	Overall Total	\$33,955.05

F: Decision Trade-Off Table

Question	Option / Choice	+ Pros / - Cons: Trade Offs	Question	Option / Choice	+ Pros / - Cons: Trade Offs
What cameras did you choose for use?	<u>ExploreHD cameras</u>	+ Rated for deeper water	Why use the brand of claw that you chose?	<u>Blue robotics</u>	+ Wider voltage range 8-18V
		- Lower frame rate			- Uneven clamping strength from base to tip
		+ Aerospace grade aluminum			+ Operation cable and Control Box compatible
Why use the cameras you chose?	GoPro cameras	- Rated for shallow waters		Qysea Robotics	- Smaller voltage range 9-13V
		+ Higher frame rate			+ More even clamping strength 100N
		- Plastic and Glass			

Question	Option / Choice	+ Pros / - Cons: Trade Offs
Why choose the board you used for the float?	Arduino Portenta C33	+ Built-in Bluetooth that fits our antenna
	Arduino Uno R4	- Larger board with unnecessary components

Question	Option	+ Pros / - Cons: Trade Offs
Why use the platform you chose to stream the camera feed?	DWEOS	+ Compatible with Raspberry Pi
		+ Well-documented and secure software
		- Poor Interaction with school firewalls
	Custom OS	- Limited resources and programmers
		- Less secure, no documentation
		+ Tailored to our needs

Question	Decision	Reasoning
Why choose the modifications you chose to make? What modifications did you decide to make?	Buoyancy engine (Syringe Engine)	+ Syringe drive is more efficient and controllable
		- Less precise adjustments
	Change in casing (smaller tube)	+ More user friendly
		- Re-design of buoyancy engine
	New Control Boards (Arduino Portenta C33)	+ Smaller and works well with the antenna
		- Fewer ground pins requiring new wiring
What parts did you choose to re-use and why?	Claw (Blue Robotics Newton Gripper)	+ Worked well in the past and had success
		+ Solid force and easy to control
	Thrusters (Blue Robotics T200)	+ Low thrust but easy to control
		+ Worked perfectly in the past
What components did you choose to purchase brand new?	Cameras (ExploreHD Cameras)	+ Better Visual
		+ Deep water camera
	Blue Robotics Waterproof Enclosure	+ More Market Applicable
		+ Lighter
		+ More Waterproof
		+ Small

G: 2026 Job Safety and Environmental Analysis for Deck Ops/Launch and Recovery

Cyclone Robotics

Job Safety and Environment Analysis (JSEA)

By: Nathan Edwards and Gavin Rodeback

ENTERING/EXITING THE POOL DECK AREA

TASK	HAZARD	PROTOCOL	TASK PERSONNEL	INITIAL SIGN OFF
Carrying ROV and ROV Supplies	-Heavy lifting -Crushing of fingers -Dropping a heavy object -Awkward positioning -Tripping or falling when carrying an object	-Lift the ROV with a lifting partner -Lift with knees -Use handholds when available -Keep the load closed to one's body -Communicate with the lifting partner -Communicate with the lifting partner -Keep the load closed to one's body -Refrain from running and watch where you're going	-Anna Blackwell (Captain) -Xander Jones (Captain) -Bryson Roland	

SYSTEM SET UP

TASK	HAZARD	PROTOCOL	TASK PERSONNEL	INITIAL SIGN OFF
Setting up the control station	-Electronics shorting after being exposed to water	-Keep distance from the pool to avoid electrical shock -Keep wires out of damp areas	-Xander Jones (Captain) -Lucas Gillenwater	
Setting up the tether	-Tripping/Falling -Electrical Shock	-Keep the tether's location known -Safely plug the tether into the control box and ROV	-Anna Blackwell (Captain)	

POWER UP CHECKS

TASK	HAZARD	PROTOCOL	TASK PERSONNEL	INITIAL SIGN OFF
Product Demo	-Exposing electrical system	-Perform a test run to ensure proper operation -Ensure water proofing on electronics	-Xander Jones (Captain)	
Pre-run Check	-Injuring one’s hands -Electrical Shock	-Test ROV for proper claw operation -Check thrusters to make they are working properly and not a danger -Check electrical connections while the ROV is dry -Make sure the waterproof seals are intact	-Xander Jones (Captain)	
Troubleshooting Control System	-Electrical Shock	-Ensure the power is off before working on the electronics	-Xander Jones (Captain)	

POOL SIDE OPERATIONS

TASK	HAZARD	PROTOCOL	TASK PERSONNEL	INITIAL SIGN OFF
ROV Operation	-Personal Injury -Claw and Hand injury -Tripping -Electrical Shock -Falling into Water -Environmental Damage	-Always wear close toed shoes -Alert the pilot while near the claw or working on the ROV -Manage tether position -Keep passageways clear of objects -Always walk, never run -Maintain clear communication with all employees -Follow all checklists -Keep the extension cord dry -Kneel on deck when placing ROV in the water -Do not overreach into the water -Make sure no items are close to the edge of the pool	-Bryson Roland -Abigail Watson	

Wave Tank Operations

TASK	HAZARD	PROTOCOL	TASK PERSONNEL	INITIAL SIGN OFF
Safe Operation of ROV	-ROV Damage from wave movements -Losing Control of Equipment in the pool -Falling into the pool	-Maintain sight of the ROV -Proper management of the tether -Stay supervised near the pool's edge -Wear non-slip shoes for safety	-Bryson Roland -Abigail Watson	

Flume Tank Operations

TASK	HAZARD	PROTOCOL	TASK PERSONNEL	INITIAL SIGN OFF
Safe Operation of ROV	-Strong Currents overpowering the ROV -The Tether being dragged, pulling operators or equipment -Hand/Finger related injuries while managing the tether due to resisting the current	-Have the ROV maintain a minimum safe distance from the walls to avoid collision -Maintain constant communication about the tether's location -Maintain clear walkways to avoid hazards -Never place hands near active thrusters in the water -Confirm with the pilot about whether the ROV is shut down before retrieval	-Bryson Roland -Abigail Watson	

Ice Tank Operations

TASK	HAZARD	PROTOCOL	TASK PERSONNEL	INITIAL SIGN OFF
Safe Operation for the Float	-Abrasions to the float due to contact with ice -Reduced operator dexterity due to prolonged exposure to cold environments -Icy environments causing slipping hazards -Hypothermia	-Inspect the ice before deployment of the float -Employ proper PPE when reaching into the water -Limit operator time reaching into the water -Rotate operators reaching into the water -Employ slow and controlled movement near the edge of the ice -Monitor physical conditions of operators to avoid hypothermia	-Bryson Roland -Abigail Watson	

H: List of Tables and Figures

Figure Number	<u>Name of Figure</u>	<u>Page Number</u>
Photo 1	EHS Cyclones	Title page
Photo 2	EHS Cyclone Team	3
Photo 3	<i>Otter 1</i>	5
Photo 4	Brain Box	5
Photo 5	Blue Robotics Camera	5
Photo 6	ROV Claw	6
Photo 7	T200 Thruster	6
Photo 8	Tether	6
Photo 9	Brain Box	7
Photo 10	Mussel	8
Photo 11	Sensor and Antenna	8
Photo 12	Custom Claw Expansion	9
Photo 13	Float with Previous Iteration	9
Figure 1	Scheduling Flow Chart	4
Figure 2	CAD Diagram of ROV	4
Figure 3	Mussel CAD	8
Figure 4	SID for Float	10
Figure 5	SID for ROV	10
Table 1	Otter 1 Budget Estimation	13
Table 2	Budget Breakdown	13-15
Appendix A	Sub Team Structure	16
Appendix B	Project Schedule	16-17

Appendix C	Otter 1 Custom Fabricated Parts	18
Appendix D	Build Vs. Buy, New Vs. Old	18-19
Appendix E	EHS Otter 1 2026	19
Appendix F	Budget Decision Trade-Off	19-20
Appendix G	JSEA	21-23
Appendix H	List of Tables and Figures	24-25

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COMPETITION

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