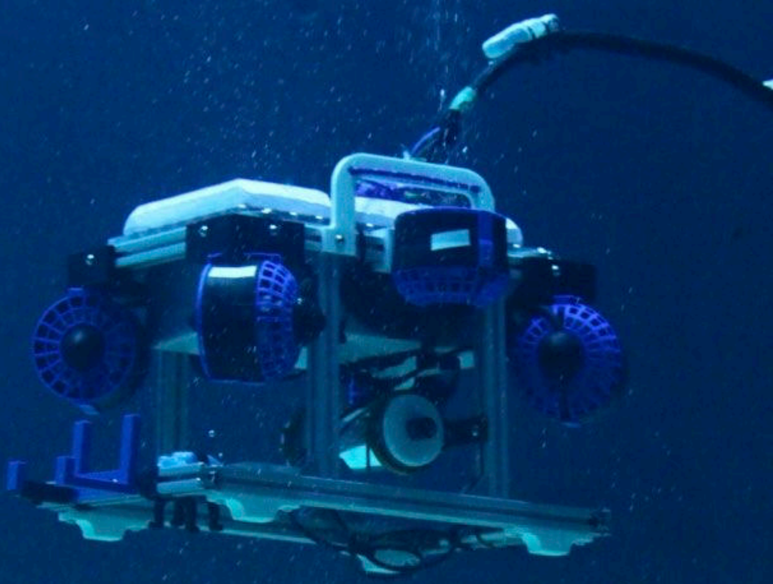
Technical Documentation

Eastern Edge Robotics

Memorial University of Newfoundland

St. John’s, Newfoundland and Labrador, Canada

Name	Title	Mentors
Martha Snelgrove	CEO	Dr. Paul Brett
Russell Corbett	COO	Joe Singleton, P. Eng
Jadzia Penney	CMO, Deck Manager	Michaela Barnes, B. Tech
Kristin Lahey	CSO, Lead Tether Manager	Anthony Randell, P. Eng
Mark Johnson	Mechanical Lead	Shawn Pendergast, B.Sc, M.Ed
Eric Goulding	Payload Lead	David Drover, B.Eng
Evan Vokey	Electrical Lead, Science Officer	Calvin Gregory, M.Eng
Zaid Duraid	Software Co-Lead	John Walsh, B. Eng
Evan Whelan	Software Co-Lead, Co-Pilot	
Sarthak Srivastava	Mechanical	
Colin Murphy	Mechanical	
Tyler Hanna	Mechanical	
Kaitlin Healey	Payload, Pilot	
Ty Freda	Payload	
Mohammad Kibria	Payload	
Brendan Booth	Payload, Tether Manager	
Ash Peddle	Payload	
Em Penney	Payload	
James Cole	Payload	
Morgan Heath-Domingues	Payload	
Julia Butt	Payload	
Aubrey Beaver	Payload	
Shane Tetford	Electrical	
Joseph Petten	Electrical	
Amelia Somers	Electrical	
Alexander Kennedy	Electrical	
Wilson Mogbo	Electrical	
Logan Janes	Software	
Allan Budgell	Software	
Oluwanifemi Olaiya	Software	



Contents

1 Abstract

In response to the Marine Advanced Technology Education (**MATE**) Center's request for proposals (**RFP**) [1], Eastern Edge Robotics (**EER**) (Figure 1) is proud to introduce its newest Remotely Operated Vehicle (**ROV**), ***Waterwitch***, named to commemorate the 150th year of a schooner sinking off the coast of Pouch Cove, Newfoundland. EER created *Waterwitch* through the collaboration of 30 employees over ten months to tackle ocean observation, protection, and restoration. Throughout this process, EER maintained a user-centered design philosophy, creating an ROV that is adaptable, reliable, and easy to pilot and maintain. EER designed *Waterwitch* to be smaller and more maneuverable than its predecessors, allowing it to navigate hard-to-reach or delicate areas, like shipwrecks or jellyfish habitats, without causing environmental disruptions. *Waterwitch* was manufactured with aluminum for the T-slot frame and rectangular electronics enclosure, maintaining sturdiness despite its size. Its compact electronics system was assembled in-house, and components were rigorously tested together and in isolation to ensure maximum reliability. An intuitive piloting interface was developed alongside *Waterwitch* and tested in a tailored ROV simulation environment to verify features such as directional power sliders and custom control profiles. *Waterwitch* is equipped with many safety features that protect those flying the ROV and the environment, such as thruster guards and a software inactivity kill switch. With its custom tooling system, *Waterwitch* is designed to complete all tasks outlined in the RFP quickly and efficiently, making it the ideal ROV for investigating shipwrecks, monitoring marine species, performing maintenance on machinery, and deploying floats.

Figure 1: Eastern Edge Company Photo

Back Row: Tyler Hanna, James Cole, Mark Johnson, Evan Whelan, Colin Murphy, Eric Goulding, Russell Corbett, Kristin Lahey, Ty Freda, Alexander Kennedy, Mohammed Kibra, Wilson Mogbo

Front Row: Ash Peddle, Em Penney, Kaitlin Healey, Martha Snelgrove, Evan Vokey, Jadzia Penney, Zaid Duraid, Sarthak Srivastava, Amelia Somers

Not Pictured: Brendan Booth, Morgan Heath-Domingues, Julia Butt, Aubrey Beaver, Shane Tetford, Joseph Petten, Logan Janes, Allan Budgell, Oluwanifemi Olaiya

Credit: Joe Singleton, 2025

2 Teamwork

2.1 Project Management

2.1.1 Company Overview

EER comprises 30 employees from various backgrounds, including Engineering, Computer Science, Nautical Science, Chemistry, Underwater Vehicles, and the Arts. The company is organized into five Sub-teams: Administration, Mechanical, Payload, Electrical, and Software. The Administration team includes:

- The Chief Executive Officer (**CEO**), who manages inter-team communication, sets schedules, and leads company meetings.
- The Chief Operating Officer (**COO**), who handles daily operations and finances.
- The Chief Marketing Officer (**CMO**), who leads marketing, outreach, and sponsorship efforts.
- The Chief Safety Officer (**CSO**), who oversees safety across all operations, from building the ROV to tank testing.

The technical Sub-teams, Mechanical, Payload, Electrical, and Software, all have respective team-leads or co-team-leads that manage task allocation and design execution in their area. The Sub-team leads also focus on training new employees and ensuring that everyone can take ownership of an aspect of the ROV or its tools. Each Sub-team is responsible for a different aspect of the ROV design:

- The Mechanical Sub-team designs the chassis and electronics enclosure, ensures proper buoyancy, configures thrusters, and designs the camera system.
- The Payload Sub-team creates custom tools based on tasks outlined in the RFP. The Payload Sub-team also works on the design for the vertical profiling float.
- The Electrical Sub-team oversees the design, testing, and assembly of the ROV's onboard electrical system.
- The Software Sub-team is responsible for the ROV's control software and user interface.

The organizational structure is shown in Figure 2 below.

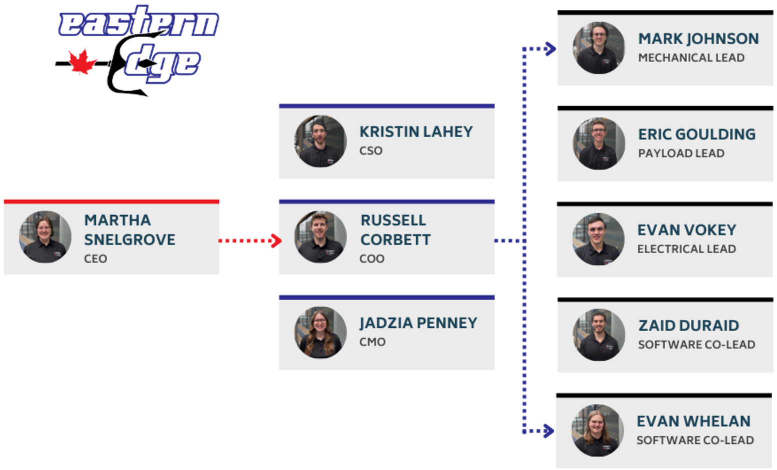


Figure 2: EER Organization Chart, Credit: Jadzia Penney, 2025

2.1.2 Management of Operations

With a wide variety of Sub-teams and many employees, communication is key in ensuring that everyone works together to build one cohesive design. Various platforms ensure a proper flow of information and strong communication throughout the company. EER uses:

- Discord to maintain organized communication via dedicated channels.
- Google Drive is used to store documentation, schedules, and meeting agendas.
- GitHub (used by Electrical and Software Sub-teams) for collaborative coding and Printed Circuit Board (**PCB**) design with version control.
- Onshape (used by the Mechanical and Payload Sub-teams) for collaborative Computer Aided Design (**CAD**) with version control.

EER identified during the previous RFP that it was difficult for employees to find company protocols, procedures, and other documentation that was required for day-to-day operations. To address this, the COO developed the "Eastern Edge Robotics Constitution." This document outlines the responsibilities of all administrative roles, Sub-team leads/co-leads, and standard procedures such as purchase requests and new member training. In addition to this, Sub-team leads/co-leads and other EER employees have created documentation for safe ROV handling, task tracking, new employee onboarding, code documentation, and more. For on-deck operations, the CSO and pilot developed flight checklists, as seen in Appendix A, that ensure the safety of the deck crew. For opening and closing *Waterwitch's* electronics enclosure, a documented procedure was created by the Mechanical Sub-team lead to prevent stripped screws and ensure a watertight seal. By combining communication and documentation storage platforms with custom employee documentation, EER ensures that all day-to-day operations and management are handled safely and efficiently.

EER spent ten months building *Waterwitch*. During such long-term projects, goal management becomes crucial. In light of this, EER created a Gantt Chart (Appendix B) in a collaborative, company-wide meeting to plan and track objectives. First, EER collectively outlined the requirements to complete the RFP. Then, starting at the desired completion date and moving backward, EER created deadlines for each element of the design, taking into account employee availability along with manufacturing and shipping times. This ensured that the outlined goals were met and that solutions could be found when problems arose, EER held quarterly "Edge Days" to check in on employee progress. During "Edge Day," each employee would give a small presentation to the company outlining what they had been working on, what progress had been made, or if any roadblocks had been encountered. The schedule and "Edge Days", combined with the outlined documentation and procedures, allowed the company to smoothly manage both day-to-day operations and long-term goals. The result is a simple, adaptable, and reliable ROV that is a competitive option for this RFP.

2.2 Problem Solving

EER begins the problem-solving process with brainstorming, which is a critical step in collaborative projects. At EER, brainstorming is a group activity where, in a round-robin process, ideas and plans are commented on and edited by all employees. When brainstorming, the company attempts to think of many alternative solutions and then compares data from published research or company testing; this is further outlined in Section 3, Design Rationale. While many smaller brainstorming sessions occurred throughout the year, one major session (Figure 3) covered payload plans once the RFP tasks were released.

Figure 3: Tooling Brainstorming Session, Credit: Michaela Barnes, 2025

In this meeting, the tasks and props were reviewed, and different possible tools and approaches were discussed. At the end of the meeting, several ideas were assigned to interested employees to move forward in the prototyping, testing, and manufacturing processes.

3 Design Rationale

EER has a 22-year-long history of successfully developing ROVs for various underwater missions. For the 2025 RFP, EER adopted a user-centered design philosophy focused on simplicity, adaptability, and reliability. Past design challenges, such as long maintenance times and non-specific tooling, guided key innovations in the new ROV, *Waterwitch* (Figure 4).

For the 2025 RFP, EER moved away from a cylindrical electronics enclosure to a custom rectangular electronics enclosure in a significant design shift. This solution improved packing volume and reduced both maintenance times and the cost for the user. The chassis was built entirely with aluminum extrusions and off-the-shelf fasteners, enabling quick integration of new components and simplifying construction. While this new design sacrificed hydrodynamics due to its flat shape, it resulted in an 8.3 kg lighter, 28.3% smaller ROV, ideal for entering small spaces like shipwrecks.

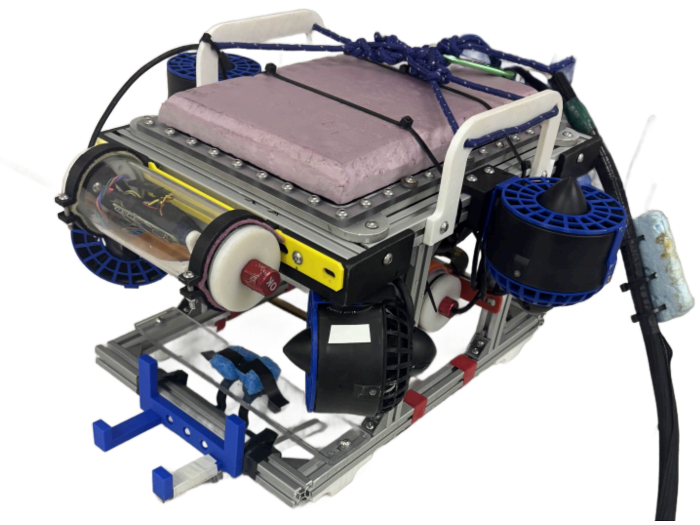


Figure 4: Waterwitch, Credit: Jadzia Penney, 2025

To continue to improve from previous designs, new tooling and cameras were developed to enhance the user experience during operation. In the previous RFP, EER created a multi-purpose gripper that could be used for various applications. However, this solution was not always effective because it was not designed with a specific task in mind. For the 2025 RFP, EER switched to a static (i.e., not powered) and task-specific tooling system, reducing the risk of failure during missions. Passive designs simplified integration and enabled the team to focus more time on pilot training and testing. Each tool is optimized for its specific task, making them significantly more effective than a general-purpose tool. EER also developed a new active (i.e., powered) camera system housed in custom enclosures, allowing the user to control the camera's viewing angle with a servo motor, significantly improving task precision and situational awareness.

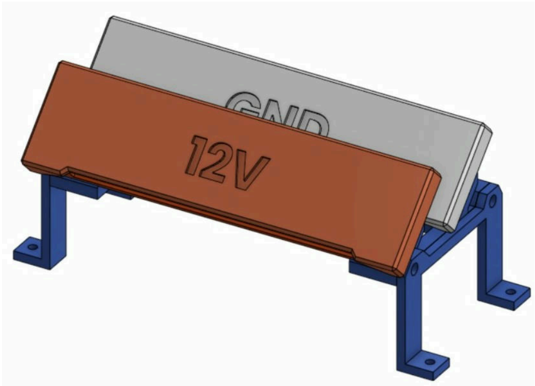


Figure 5: Custom Busbars, Credit: Eric Goulding, 2025

To pilot *Waterwitch*, six thrusters interface with the topside control station through the onboard electronics and Ethernet tether. To emphasize simplicity and maintain low costs for the user, a simpler electronics system was developed for the 2025 RFP than in previous years. This involves an off-the-shelf microcontroller development board for direct control of the Propulsion Subsystem and custom busbars (Figure 5) for power distribution. For intuitive control of the ROV, a frontend user interface designed specifically for *Waterwitch* combines cameras, directional power controls, configuration, calibration, and pilot input in one place. This design allows for any computer to serve as the topside control system for *Waterwitch*, provided that it has an Ethernet connection.

The company follows a step-by-step design process that involves brainstorming, designing, testing, iterating, and integration. As described in Section 2.2, Problem Solving, the company begins the process of tackling a design challenge by having employees brainstorm ideas and outcomes for a design. For this RFP, these outcomes were specifically focused on pain points from the previous RFP as well as design trade-offs such as hydrodynamics in exchange for higher packing volume. These ideas are then turned into one or multiple designs that can be tested and iterated upon. Once the desired design has been reached and it meets the outcomes outlined, the design is then integrated with the system, which will typically involve further testing to ensure that the new design contributes to the system as a whole.

3.1 Systems Design Approach

EER takes a holistic approach to vehicle design by integrating mechanical, electrical, software, and user experience considerations throughout the development process. To achieve this, EER makes design decisions with the whole ROV and the end-user in mind rather than trying to optimize elements of the ROV in isolation. For example, when designing the electronics enclosure, there was a collaboration between the mechanical and electrical Sub-teams to ensure that the electronics could fit inside the enclosure easily without sacrificing the enclosure's small size or organizing it in a way that would make it hard to perform maintenance. There was also collaboration between the tooling and mechanical Sub-teams to ensure that the chassis could accommodate all tools and cameras without sacrificing the lightweight chassis design or obstructing the pilot's view.

3.2 Vehicle Structure

3.2.1 Chassis

Waterwitch's (Figure 6) structure comprises 20 x 20 mm aluminum T-slot extrusion, allowing for a lightweight and compact design. This material allowed the team to reduce the overall size of the ROV to 480 x 460 x 305 mm with a total weight of 7.95 kg. This size makes *Waterwitch* small enough to fit in a Pelican™ case without disassembly for easy transport.

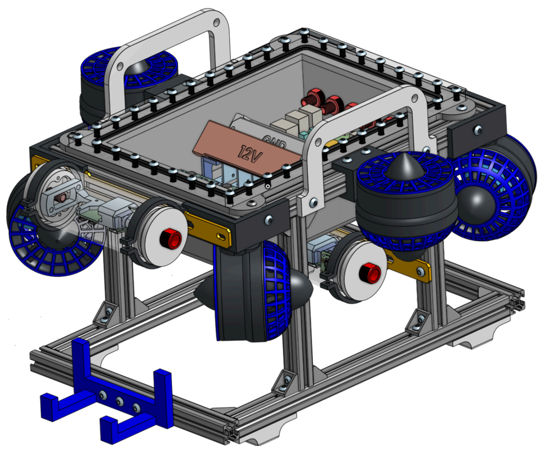


Figure 6: Waterwitch Model, Credit: Tyler Hanna, 2025

Compared to the 30 x 30 mm extrusion used in previous years, the 20 mm profile offered similar structural integrity while reducing size and weight. This downsizing improved maneuverability, allowing the ROV to navigate confined or delicate areas easily. A trade-off for this was the higher cost of the smaller extrusion, but the increase in maneuverability and transportability justified this change. High-Density Polyethylene (**HDPE**) had been used for the tooling skid in the past and was changed to aluminum in the current RFP. This saved on weight, as the HDPE sheet was heavier than the aluminum T-slot bars and has proven to be more adaptable by eliminating the need for threaded inserts to attach tools. Using aluminum T-slot extrusion, tools were added more efficiently by utilizing self-aligning T-nuts to easily attach elements, such as tools and cameras, to the frame. These T-nuts were more expensive but allowed for more efficient assembly and a simpler design. All extrusion cutting was done in-house, reducing fabrication costs and minimizing material waste. Overall, these design decisions created an ROV that the end-user can easily transport and maneuver.

3.2.2 Electronics Enclosure

At the center of the chassis lies the brand-new watertight electronics enclosure (Figure 7), custom-made to protect the onboard electronics of *Waterwitch* at great depths for long periods.

Figure 7: Electronics Enclosure, Credit: Mark Johnson, 2025

The enclosure was manufactured by MUN Tech Services using aluminum 5052 sheets, which were bent and welded to create a usable volume of 260 x 170 x 84 mm. The watertight seal was accomplished by a custom-size ⅛ Buna-N O-ring and a transparent acrylic sheet with a machined O-ring groove.

Equation 1 was used to validate the uniformity of pressure across the enclosure's O-ring seal. In addition, the Finite Element Analysis (**FEA**) (Figure 8) was used to obtain the maximum pressure the enclosure could endure at around 70,000 Pa. This ensured that *Waterwitch* was capable of performing tasks at depths exceeding the 5 m required for the 2025 RFP. The transparent acrylic sheet lets the user view potential onboard electrical issues and enables the pilot to use an upward-facing camera during operation.

$$3 \leq \frac{\pi \cdot D_{\text{bolt diameter}}}{N_{\#\text{ of bolts}} \cdot d_{\text{bolt circle diameter}}} \leq 6$$

Equation 1: Uniformity of pressure [2]

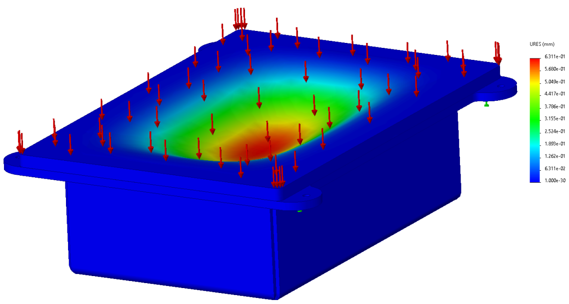


Figure 8: FEA screenshot, Credit: Mark Johnson, 2025

In three previous ROV designs, EER opted to buy pre-built cylindrical electronics enclosures from Blue Robotics due to their accessibility. However, during the brainstorming phase this year, the company performed a comparison analysis between the reuse of a cylindrical enclosure and the design of a new custom-made rectangular enclosure. The pros and cons listed during this process can be seen in Table 1.

Table 1: Rectangular vs. Cylindrical Enclosure, Credit: Mark Johnson, 2025

Consideration	Rectangular	Cylindrical
Integration Into Chassis	Easier (screw holes)	Harder (round shape)
Packing Volume	More optimal (rectangular)	Less optimal (Circular)
Hydrodynamics	Reduced	Increased
Development Time and Cost	Longer and more expensive	Shorter, already on hand
Maintenance	Easier (sealing mechanism simple)	Harder (unique seals)

The cylindrical enclosure showed key downsides during the comparison, including difficult integration into the ROV, reducing packing volume due to its shape, increased maintenance times due to its seals, and having a large weight/size. As a result, the company spent months designing a custom rectangular electronics enclosure to solve these issues for the user. The final electronics enclosure design is easily integrated into *Waterwitch's* custom chassis with pre-built slide-in fasteners. The rectangular shape helped to optimize electronics packing volume and significantly simplify maintenance with easy-to-access screws for the seal. In addition, the decreased weight and size greatly improved *Waterwitch's* on-ground portability and underwater maneuverability for the user. All of these improvements resulted in a much simpler and more compact ROV that can use its new enclosure as a starting point for future development.

Inside the main electronics enclosure sits the drop-in plate. The drop-in plate (Figure 9) serves as the central mounting point for the most important electrical devices of *Waterwitch*. The drop-in plate was designed by the Mechanical Sub-team in collaboration with the Electrical Sub-team to hold the onboard electronics, ensuring they are secured when the ROV operates. The drop-in plate was created using 5052 aluminum to act as a thermal heat sink from the Power Conversion Subsystem.

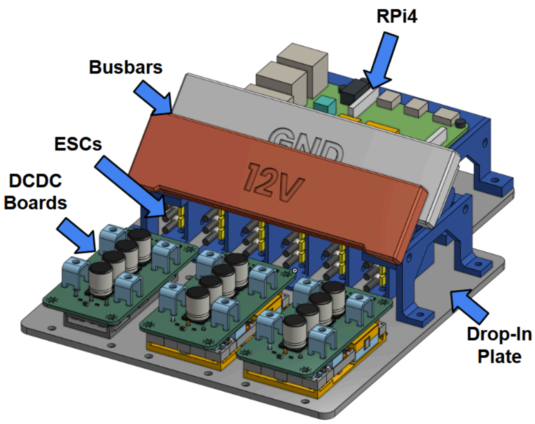


Figure 9: Drop-In Plate,
Credit: Mark Johnson, 2025

The initial design had a Raspberry Pi 4 (**RPi4**) attached to the center of the drop-in plate and one PCB on the back of the plate, with a series of Electronic Speed Controllers (**ESCs**) mounted in front of the RPi4 to control the speed of the motors. Following further discussions with the Electrical Sub-team regarding the design of the electronics, the initial design was iterated. The PCB was split from a singular board to three separate Direct Current to Direct Current Converter (**DCDC**) boards, the RPi4 was moved to the front section of the drop-in plate, and the ESCs remained in the center. The Mechanical Sub-team also added a pair of busbars (Figure 5) that would attach to the drop-in plate, which held connections for the 12 V power and ground over the ESCs in the center. The busbar holders are 3D-printed, which provides electrical insulation by preventing short circuits with other components.

3.3 Control and Electrical System

3.3.1 Tether

Reused from the company's previous ROV, the tether comprises two 12 AWG wires to carry 48 V, an Ethernet cable for data transmission, a 3.175 mm tube for collecting water samples, and a mesh sleeve for exterior protection (Figure 10).

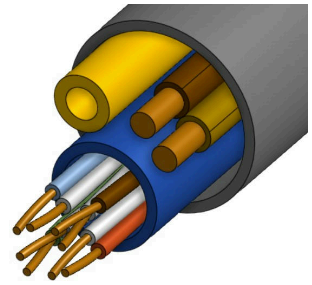


Figure 10: Tether cross-section,
Credit: Mark Johnson, 2025

EER had both 12 and 16 AWG wires available that could have been chosen for the tether. Using a thinner wire would make the tether more flexible, easier to manage, and interfere less with piloting. However, in previous RFPs, EER had issues with voltage drop over the tether, causing the 12 V DCDC converters to cut out and temporarily disable the thrusters. Since the DCDCs cut out when the input voltage reached ~35 V, the company tested both 12 and 16 AWG wires to compare the voltage drop. Figure 11 shows the results of the test. For the 16 AWG wires, the voltage drops below 35 V when using five thrusters at max load, causing the DCDCs to cut out shortly after. Using 12 AWG wires, up to eight thrusters can operate at max load. Since the company had decided to use six thrusters onboard *Waterwitch*, 12 AWG wire was chosen.

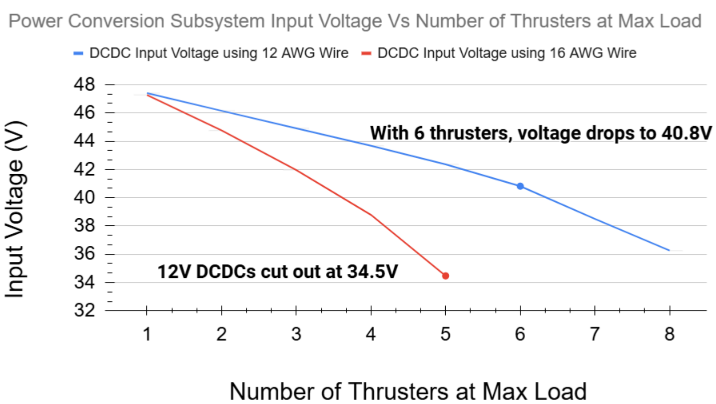


Figure 11: Thruster Testing Comparison, Credit: Martha Snelgrove, 2025

The main trade-off of tether reuse is reliability, as extensive use may wear down internal wires and potentially incur damage to the waterproof seals. However, because the tether has only been used in one previous RFP, this was not considered to be an issue. The tether adequately covered the requirements of *Waterwitch's* design, including transferring power and communication to the ROV, covering a larger distance than the RFP mission area at 18 m, and exhibiting neutral buoyancy thanks to the addition of closed-cell foam blocks throughout its length. Reusing the tether from the previous RFP also aligns with UN Sustainability Goal #12, "Responsible Consumption and Production" [3].

Two members of the deck crew, the "Tether Managers", control the tether during operations. The Lead Tether Manager provides and removes extra length as needed for the pilot. The Secondary Tether Manager places excess in a "figure-eight" formation to reduce strain and keep the surrounding area tidy. The tether management protocol can also be seen in Appendix A.

3.3.2 Electrical Systems

For the 2025 RFP, the electrical architecture was designed with simplicity and field serviceability in mind. This architecture consists of the Power Conversion Subsystem and the Control Subsystem. Each of these subsystems is made up of easily replaceable components; they are organized in the electrical enclosure so that they can be conveniently replaced in the event of an electrical failure. The architecture was designed holistically by considering not only the way these subsystems would function together but also how they would fit into the enclosure and interact with the tooling and cameras used on the ROV.

3.3.2.1 Power Conversion Subsystem

EER's Power Conversion Subsystem is responsible for converting the 48 V supplied from the surface to the 12 V used for the Propulsion Subsystem and the 5 V used for the Control Subsystem. The 12 V for the Propulsion Subsystem is provided by two 600 W 48 V-to-12 V Murata DCDC conversion modules in parallel, supplying a total of 1200 W. The 5 V for the Control Subsystem is provided by a single 75 W 48 V-to-5 V Murata DCDC module.

For the 2025 RFP, EER ensured that the Control Subsystem was powered entirely from 5 V instead of 12 V. In addition to this, the company selected a 48 V-to-5 V converter that can handle a lower input voltage than the 48 V-to-12 V converters. In effect, if the Power Conversion Subsystem's input voltage drops due to the Propulsion Subsystem drawing too much current, the 48 V-to-12 V converters will shut down while the 48 V-to-5 V converter remains operational. The result is that *Waterwitch* can recover from an "over-current" scenario in a matter of seconds rather than minutes, decreasing downtime and providing the pilot with a better operating experience.

In the 2024 RFP, EER utilized multiple Murata DCDC modules soldered to a single PCB. In the event that one of these modules were to fail, a complex repair process was necessary. This year, EER has designed a new PCB featuring sockets, which allow the Murata DCDC module to be installed and removed from the board without soldering, as seen in Figure 12.

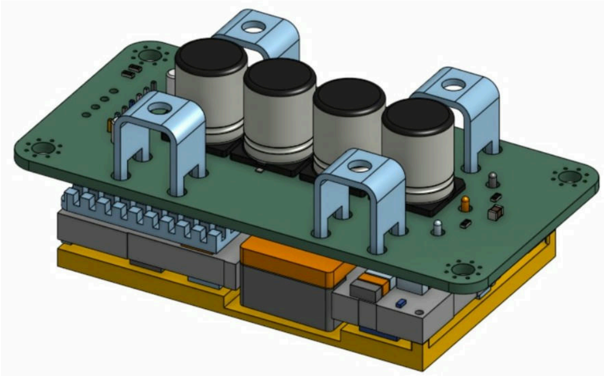


Figure 12: DCDC Board featuring sockets, Credit: Eric Goulding, 2025

This socketed design allows for quick replacement of DCDC modules and permits DCDC modules to be reused across future PCB designs. Being able to reuse DCDCs from previous RFPs in the future also aligns with UN Sustainability Goal #12, "Responsible Consumption and Production" [3].

3.3.2.2 Control Subsystem

Waterwitch's Control Subsystem software was adapted from the 2024 RFP, once again making use of the Robotics Operating System 2 (**ROS 2**), which is an open-source robotics framework popular in academia and industry [4]. Figure 13 shows an overview of the top-level software architecture. As shown in Figure 13, the main enclosure RPi4 was configured to act similarly to an Ethernet switch, placing all devices on the same network. This configuration saved around 65 cm^3 of volume for a dedicated Ethernet switch as compared to the 2024 RFP. Also, Universal Serial Bus (**USB**) gadget mode is used for the Raspberry Pi Zeros (**RPi Zeros**), with associated advantages discussed in Section 3.5.

Figure 13 also shows how *Waterwitch's* control software is split between a frontend on the topside computer, a backend on an RPi4 in the main enclosure, and additional components on RPi Zeros for camera streaming and servo control. Ultimately, control signals are sent from the RPi4 to a Raspberry Pi Pico microcontroller over I2C. The Pico, in turn, provides 16 Pulse-Width Modulation (**PWM**) channels, which are used to control *Waterwitch's* six thrusters along with room for any future active tools. To minimize wiring, the Pico is atop the RPi4 using a custom-made HAT (Hardware Attached on Top), which also contains connectors for the ESCs, power, and tooling.

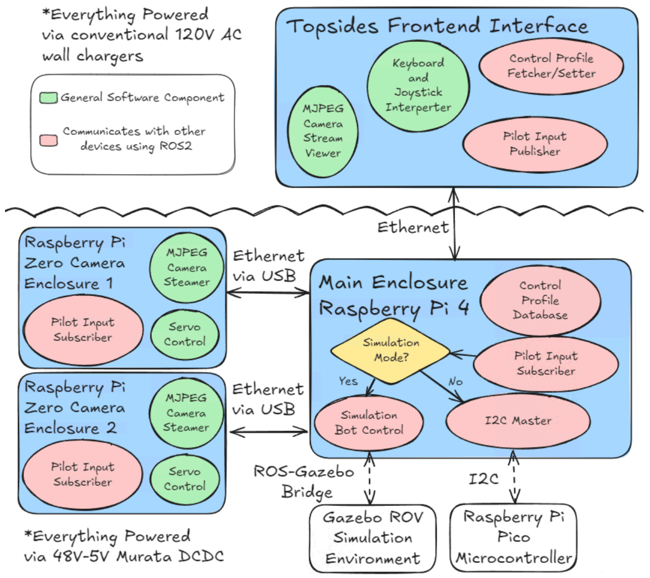


Figure 13: Overview of the Control Subsystem Software Architecture, Credit: Zaid Duraid, 2025

For the 2025 RFP, the company decided to develop a frontend application in addition to the 2024 RFP's web-based frontend, which relied upon weakly supported external dependencies that resulted in latency issues. The new frontend application, pictured in Figure 14, used a minimum number of reliable external dependencies. Features present in the old frontend application were adapted to the new one, including support for both keyboard mode and a wide range of controllers, as well as the ability for the pilot to save custom control profiles in a database onboard Waterwitch itself.

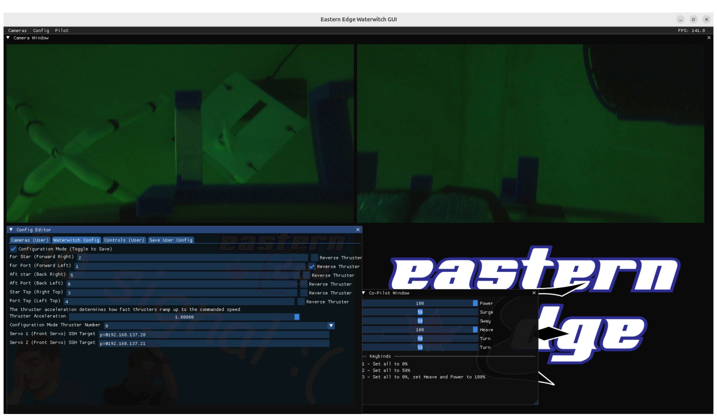


Figure 14: Topsides Frontend Interface, Credit: Zaid Duraid, 2025

3.3.3 Propulsion

Waterwitch's propulsion subsystem consists of six Blue Robotics T200 thrusters oriented to provide five degrees of freedom to the ROV. This is achieved by two vertical thrusters located on the right and left sides of the chassis, along with four horizontal thrusters positioned at 45° (Figure 15). This makes it possible to perform heave, surge, sway, roll, and yaw movement underwater, enabling *Waterwitch* to complete all mission tasks listed in the RFP. For example, the ROV will require the yaw direction for twisting the sacrificial anode and the heave direction for lifting objects through the moon pool. While a common sixth degree of freedom, pitch, is lost with the chosen configuration, it is not necessary for the completion of the mission tasks. Also, more thrusters would increase the size, power consumption, cost, and weight while decreasing the tool mounting space of *Waterwitch*.

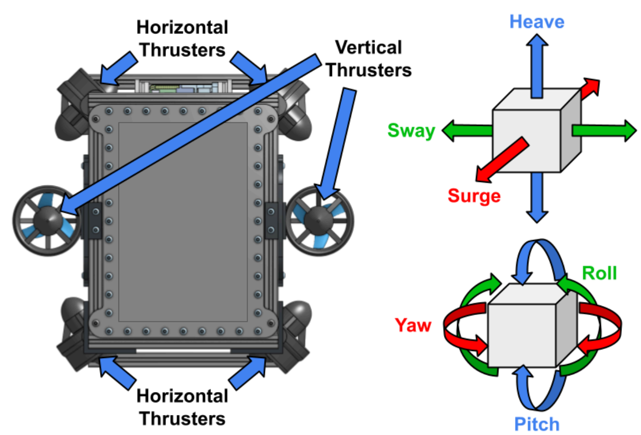


Figure 15: Thruster Diagram, Credit: Mark Johnson, 2025

While brainstorming the Propulsion Subsystem, the company decided to conduct market research (Table 2) into new underwater thrusters and compare their attributes to find an optimal choice. The Blue Robotics T200 thrusters were selected because of their relatively small diameter and high thrust-to-weight ratio when operating at 12 V. High cost was the main downside of the T200 thrusters, but they greatly outperformed cheaper thrusters with respect to their thrust-to-weight ratio.

Table 2: Market Research for Thrusters, Credit: Mark Johnson, 2025

Parameter	**Apisqueen U2 Mini** 	**Blue Robotics T200** 	**Blue Robotics T500** 	**Diamond Dynamics TD1.2** 
Thrust @ 12V	0.9 kgf	3.71 kgf	16.1 kgf	0.9 kgf
Mass	0.21 kg	0.427 kg	1.157 kg	0.2 kg
Outer Diameter	72.21 mm	97.3 mm	141.2 mm	78 mm
Price	$32 USD	$220 USD	$750 USD	$73 USD

3.3.4 Buoyancy and Ballast

Waterwitch's buoyancy and ballast system uses static foam and modular metal plates mounted to appropriate locations on its aluminum extrusion frame. Without added buoyancy or ballast, the ROV is negatively buoyant and unstable in the water due to a lack of counteracting buoyant and gravitational forces. To remedy this, Archimedes' buoyant force principle [5] was used to calculate the amount of upward force the ROV's components create underwater. Then, the gravitational force [6] of the ROV components was subtracted from the buoyant force to calculate the net buoyancy. Based on the obtained value, a foam volume was calculated and added to the ROV to create positive buoyancy. Finally, metal plates were attached to achieve neutral buoyancy and counteract imbalances that created instability. Equation 2, Equation 3, Figure 16, and Table 3 show how the buoyancy calculations were completed.

$$F_{\text{buoyant}} = V_{\text{object}} \cdot \rho_{\text{water}} \cdot g_{\text{earth}}$$

Equation 2: Archimedes Principle [5]

$$F_{\text{gravity}} = -M_{\text{object}} \cdot g_{\text{earth}}$$

Equation 3: Force Due to Gravity Equation [6]

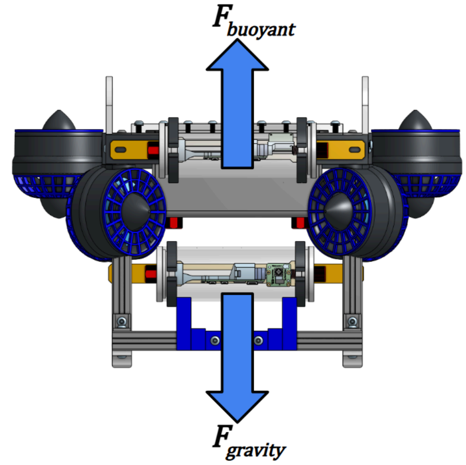


Figure 16: Buoyancy Diagram, Credit: Mark Johnson, 2025

Table 3: Buoyancy Calculation Table, Credit: Mark Johnson, 2025

Component	Quantity	Buoyant Force (N)	Mass (kg)	Weight (N)	Net Force (N)
Frame	1	5.28E+00	1.45E+00	1.43E+01	-8.98E+00
T-200 Thrusters	6	1.15E+01	2.56E+00	2.51E+01	-1.37E+01
Corner Mounts	24	4.74E-01	2.26E-01	2.21E+00	-1.74E+00
Drop-In Plate	1	9.01E-01	2.50E-01	2.45E+00	-1.55E+00
Electonics	1	1.96E+00	3.70E-01	3.63E+00	-1.66E+00
Enclosure Metal	1	5.19E+00	1.44E+00	1.41E+01	-8.93E+00
Enclosure Cover	1	4.21E+00	5.10E-01	5.01E+00	-7.99E-01
Enclosure Air	1	3.37E+01	4.44E-06	4.36E-05	3.37E+01
Penetrators	18	7.08E-01	1.96E-01	1.93E+00	-1.22E+00
Camera Enclosure	2	3.24E+00	4.04E-01	3.97E+00	-7.31E-01
Camera Enclosure Air	2	4.92E+00	6.49E-07	6.36E-06	4.92E+00
M5 Screws	110	3.42E-01	2.79E-01	2.74E+00	-2.40E+00
Drop in nuts	70	1.84E-01	2.80E-01	2.75E+00	-2.56E+00
Total	238	7.26E+01	7.97E+00	7.82E+01	-5.59E+00

3.4 Tooling and Sensors

In recent years, EER has focused on developing a single dynamic tool onboard the ROV capable of completing the majority of the mission requirements. However, this single tool breaking down made it difficult to complete any missions, which decreased the ROV's overall reliability due to the higher likelihood of failure. Moreover, this single tool was often active, requiring a complex design that directly involved several or all Subteams. To remedy this problem, EER has developed a larger array of onboard tools that are designed with specific missions in mind. These tools are static, which makes them easier to integrate into the system. This allowed the team to do more prototyping, testing, and driving practice, as tools could be removed, adjusted, and reattached quickly.

3.4.1 Photosphere Camera

EER designed an independent sensor capable of capturing its entire surroundings to photograph shipwrecks and the environment (Figure 17). The camera is an independent sensor, so it can be operated by another member of the deck crew while the pilot is completing other missions. Both the waterproof camera and the waterproof DC motors were reused from a previous RFP, saving funds and development time. This tool aligns with Ocean Decade Challenge 8, “Create a digital representation of the ocean” [7].

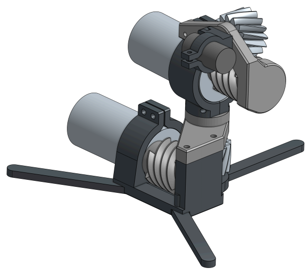


Figure 17: Photosphere Camera, Credit: Eric Goulding, 2025

3.4.2 Water Collection Tool

To collect water samples for eDNA analysis, EER uses a peristaltic pump located on deck (Figure 18). A hydraulic tube runs along the tether from *Waterwitch* to the deck pump, allowing samples to be retrieved without the need to surface and thus saving a considerable amount of time. Having the pump on the surface also saves space on the tool skid, as only a small piece of plastic must be attached to puncture the membrane covering the sample.

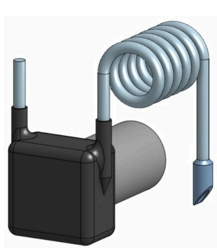


Figure 18: Water Collection Tool, Credit: Eric Goulding, 2025

3.4.3 Sacrificial Anode Tool

This tool (Figure 19) was designed specifically to disconnect and replace sacrificial anodes. This aligns with UN Ocean Decade Challenge #5, “unlock ocean-based solutions to climate change” [7], as the sacrificial anode is attached to the base of an offshore wind farm. Performing maintenance on it aids in the production of renewable energy, which is an important step in fighting climate change. The two 3D-printed clips are secured to the underside of the ROV. Instead of powering the tool, the ROV does the required rotation and uses the elasticity of the clips to secure and release the anode.

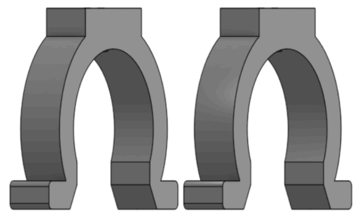


Figure 19: Sacrificial Anode Tool, Credit: Ash Peddle, 2025

3.4.4 Forklift Tool

Although task-specific tools are central to EER’s tooling plans, having a single tool that can complete multiple tasks where applicable helps save space. This versatile tool (Figure 20), comprising two hooks, is capable of removing/replacing the lid from cargo containers, deploying hydrophones, and removing covers from solar panel array connection ports. A neodymium magnet is also attached to the tool, allowing it to securely hold metal hydrophone pins.

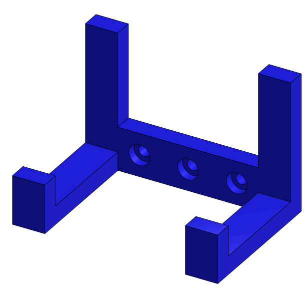


Figure 20: Fork Lift Model, Credit: Julia Butt, 2025

3.4.5 Polyp Jelly Collector Tool

This single-piece tool (Figure 21) reliably collects polyp stage jellyfish that have attached themselves to the underside of solar panel arrays. This protects biodiversity and ocean life, as indicated by UN Ocean Decade Challenge #2 [7]. The tool protrudes at a 30° angle, making it easy for the pilot to reach any jellyfish on the water's surface. Taking inspiration from the extended nose of a sawfish, this tool features barbs to ensure the jellyfish do not slide off once they have been retrieved.

Figure 21: Polyp Jelly Collector, Credit: Julia Butt, 2025

3.4.6 Vertical Profiler

When designing the newest vertical profiling float, EER's biggest priorities were improving reliability and user-friendliness as compared to the 2024 RFP. This was achieved by purchasing a strong, robust motor to drive the buoyancy engine, adding inline connectors to wires for easier disassembly, and installing an external on/off switch to preserve battery life, as outlined in Figure 22.

To meet the mission requirement of hovering midwater, a linear potentiometer and depth sensor were added to the profiler. This allows the profiler to know its depth and adjust its buoyancy engine accordingly to precisely control its position in the water column.

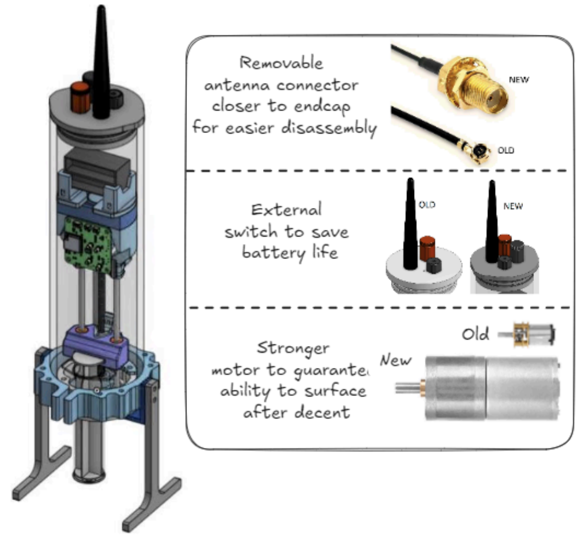


Figure 22: Vertical Profiler, Credit: Brendan Booth, 2025

3.5 Cameras

EER's user-centric design philosophy was the highest priority for this year's camera design. This year's camera modules include an RPi Zero, a Raspberry Pi Camera Module 3 Wide [8], and a small servo motor. Last year, the commercially available enclosures that were used had poor optical clarity, leading to blurry camera feeds. Custom camera enclosures (Figure 23) were fabricated in-house using clear acrylic tubes to improve the image quality, significantly improving the pilot's view.

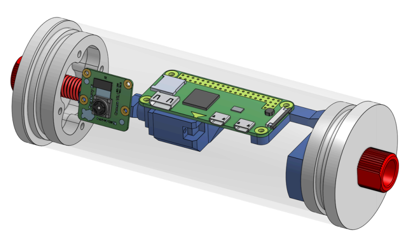


Figure 23: Custom Camera Enclosure, Credit: Mark Johnson, 2025

In addition to improving image quality, EER also wanted to increase the pilot's field of view by rotating the camera module. Two options were considered, which were waterproofing a motor to externally rotate the camera enclosure or fitting a motor inside the camera enclosure to rotate just the camera. Due to concerns with the reliability of waterproofing motors, EER chose the latter option. A servo motor was chosen as it was small and provided precise position control. For the 2024 RFP, EER used an Ethernet cable to connect the camera modules to the control subsystem. This required an Ethernet hat to be added to the RPi Zero. To fit a servo in, the Ethernet hat needed to be removed. After brainstorming and testing efforts involving various Sub-teams, a solution was achieved using the RPi Zero's USB gadget mode, which allows power and data to be transmitted over a single USB cable. By removing the Ethernet hat, space was created for the servo, allowing the camera to rotate 180°, greatly increasing the ROV's field of view (Figure 24).

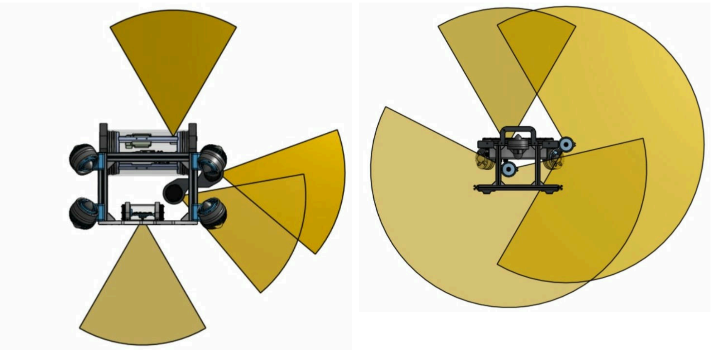


Figure 24: Camera Field of Vision (Left: 2024 Right: 2025), Credit: Eric Goulding, 2025

Once the servo was added to the camera module, they were ready to attach to the ROV. *Waterwitch* features two rotating cameras, one on the front and one on the back. These two cameras can rotate to see both the front and back payload braces, giving the pilot depth perception and making it easier to perform precise operations. Additionally, there is a third camera in the main electronics enclosure, which faces directly upwards. This camera allows the pilot to see the moonpool when ascending to the surface, and it assists in the retrieval of fish samples from the solar panels below.

4 Safety

At EER, safety is of the utmost priority. It impacts every aspect of work, from the employees and equipment to the end user and the environment. A strong safety culture creates a workspace where employees can be productive, happy, and comfortable. Throughout the development of *Waterwitch*, safety was considered at every stage, with procedures designed to handle a wide range of situations.

4.1 Safety Procedures

To create a strong safety culture, EER implements structured training, procedures, and systems. During onboarding, employees are introduced to workshop safety rules (Appendix D), with emphasis on proper Personal Protective Equipment (**PPE**) (see Figure 25) and that work should not be done alone. Next, junior employees are introduced to the tools used in the workshop through safety demos from senior employees. These junior employees initially perform tasks in pairs with senior employees to ensure proper training through peer mentorship. As the year progresses, they gradually transition to working independently alongside peers. In addition to EER's internal training procedures, all new employees are required to complete a workshop safety training course created by MUN to ensure that all topics are thoroughly covered. Beyond training, maintaining detailed records of work and incidents is critical for assessing the organization's safety fallbacks. To maintain these records, EER uses three Google Workspace-based forms.

The first is the Job Safety and Environment Analysis (**JSEA**) form, which documents the nature of the task, personnel involved, location, potential risks, and mitigation strategies. It enables review and planning to ensure a safe work environment while tracking ongoing activities.

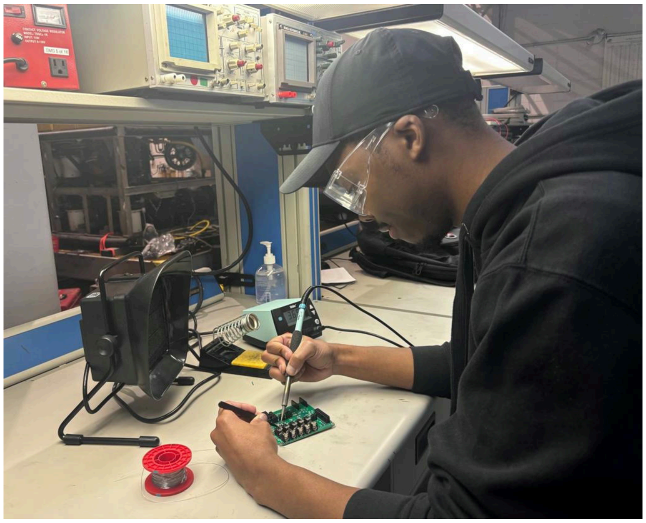


Figure 25: Employee using PPE,
Credit: Jadzia Penney, 2025

If an incident or near-miss occurs, involved employees fill out an associated second form to document the safety procedures that fell short. This information guides updates to safety protocols to prevent recurrence.

The third form, the Unsafe Work Refusal form, provides a formal channel for employees to decline tasks they deem unsafe. Though never used at EER, it reinforces the right to refuse unsafe work, aligned with the Government of Canada's occupational health and safety mandate [9], and supports post-incident investigation when needed.

Safety procedures also extend to ROV operations. Operational checklists (Appendix A) guide pre-deployment and deployment steps, including watertight integrity checks, pilot–tether manager communication protocols, and contingency actions for communication loss. These procedures ensure safety throughout *Waterwitch*'s use.

4.2 Safety Features

Waterwitch includes several features designed to protect the environment, the end user, and employees. Each thruster is equipped with a 3D-printed guard shrouded and protected to IP-20 standards to prevent injury and avoid harming nearby marine life. All components are carefully filed to remove sharp edges, enhancing safety for both users and the surrounding environment. To prevent uncontrolled behavior, the Control Subsystem contains a kill switch that automatically stops the thrusters if communication with topsides is lost for a set period. The ROV has a 30 A Littelfuse within 30 cm of the power supply that will blow in overload conditions. There is also over-current protection on the DCDCs so that they will stop powering the 12V bus if the current exceeds the rating. All thrusters have danger labels to indicate that there are moving parts. Finally, *Waterwitch*'s compact size minimizes the risk of collisions with the shipwreck at the bottom of the mission area. *Waterwitch* also has strain relief for the tether so that if in the event the tether needed to be tugged the company can do so safely without worry of damaging the ROV.

5 Critical Analysis

5.1 Testing

While developing *Waterwitch*, EER used a three-step testing methodology applicable to all elements of the ROV. The process begins with unit testing, where components are tested in isolation to identify issues early. This is followed by integration testing, in which components are combined with other subsystems. Finally, water testing is conducted by evaluating the components on *Waterwitch*. No component is considered complete until it functions reliably during water testing.

This methodology is exemplified in the development of the new camera modules and their custom enclosures (see Section 3.5).

1. **Unit Testing**: The camera electronics, mechanical assembly, and waterproof enclosure

were all tested individually. The mechanical assembly, in particular, underwent several prototypes to evaluate which arrangement would allow the camera's servo to rotate a full 180° without pinching wires. Once all components were tested and early issues were resolved, testing proceeded to the next step.

2. **Integration Testing**: Integrating the cameras into *Waterwitch*'s Control Subsystem required communicating with the RPi4 in the main electronics enclosure over USB rather than Ethernet. This was not something EER had experience doing, so great care was taken to ensure reliable communication, including the ability to recover from disconnects or reboots. Successful integration with the Control Subsystem allowed testing to proceed to the next step.

3. **Water Testing**: For water testing, the camera enclosures needed to be attached to *Waterwitch*'s chassis. A key consideration was preventing scratches on the enclosures, as any damage could impair the pilot's view. The first mount prototype achieved this by holding onto the enclosure endcaps, but it pulled the endcaps off the enclosure. Several prototypes were developed and tested to solve these issues. Once this design had passed water testing, it was deemed finished.

5.1.1 Static Tool Testing

Static tool testing at EER follows a unique process that aligns with the broader three-step testing methodology. It is comprised of the following two phases:

1. **Pole Test** (Unit Testing): Tool prototypes are first attached to a 2 m PVC pipe and tested on land to simulate in-situ use. This allows the team to evaluate metrics such as handling and general usability without involving the ROV. This allows for rapid iteration and alleviates the requirement for in-water testing time.
2. ***Waterwitch* Test** (Integration + Water Testing): Static tools do not require integration testing with other subsystems. Therefore, they proceed to full underwater testing directly after the pole test.

The benefits of this methodology are evident in the development of the Forklift tool. The initial prototype performed well during the Pole Test. However, once mounted on *Waterwitch*, it blocked the cameras' field of view, prompting a redesign. The new version was modified to be smaller, and a magnet was added to easily pick up ferrous objects.

Although the Pole Test could not replicate underwater conditions, it accelerated the prototyping process by confirming the tool's core functionality early. This enabled the team to focus on refinements rather than starting from scratch, making tool development more efficient.

5.1.2 Software Testing

One of the advantages of *Waterwitch*'s Control Subsystem Software, inherited from the 2024 RFP, is seamless integration with EER's ROV simulation environment. Developed by the Software Sub-team using the Gazebo open-source robotics simulator [10], the simulation environment contains a model of *Waterwitch* featuring custom-written plugins for thrusters, buoyancy, and servos, as well as MJPEG camera streamers [11]. Crucially, the simulated *Waterwitch* is driven by the same software, enabling unit, integration, and even water testing to be performed without real hardware. Features such as thruster math, directional power sliders, runtime thruster calibration, custom control profiles, and more were all developed and verified in simulation and later smoothly integrated into the physical ROV. Figure 26 shows the *Waterwitch* simulation model.

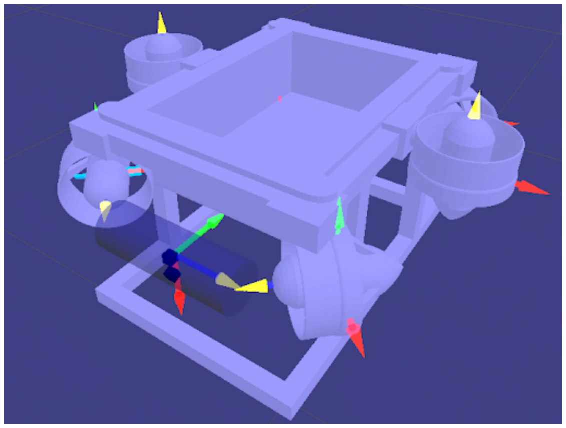


Figure 26: Simulated Waterwitch Model, Credit: Zaid Duraid, 2025

5.2 Troubleshooting

There is no such thing as a perfect ROV, and EER experienced its fair share of obstacles while completing the 2025 RFP. EER takes a systematic approach to troubleshooting. When a problem is encountered, employees start the process of finding the solution by clearly identifying the problem and gathering the data required to understand the full scope of the issue encountered. Then solutions will be implemented and tested until there is verification that the problem has been solved.

When preparing for the 2025 RFP, EER encountered an issue where the over-voltage protection mechanism on the surface power supply was tripping when the vehicle's thrusters were commanded to make a quick deceleration. Employees began troubleshooting and initially assumed this issue to be a failure of the power supply's ability to regulate its output for large changes in current. However, by using an oscilloscope and current clamp probe, the employees noticed current flowing in the reverse direction when the thrusters were commanded to decelerate. This behavior is consistent with the back Electromagnetic Field (**EMF**) from the thrusters traveling up the tether and into the power supply. To mitigate this issue, a transistor was added to prevent current from flowing in the incorrect direction into the power supply. By following the systematic approach to troubleshooting as listed above, the problem encountered was solved.

6 Accounting

The EER budget for the 2025 RFP cycle was developed based on previous RFP budgets, historical operating costs, and expected contributions from recurring sponsors. Major expenses included the development of *Waterwitch*, travel to the MATE World Championships, and the implementation of a new inventory and organizational system for the workspace. At the beginning of the year, multiple budget meetings were held with admin, Sub-team leads, and company mentors. Regular follow-up meetings were held to ensure the budget stayed on track and adapted as problems arose.

In line with EER's objective to optimize spending and make strategic build-versus-buy and new-versus-reuse decisions driven by performance and reliability, EER strongly emphasized reusing in-stock components before issuing new purchase orders. All purchases were logged in real-time into EER's upgraded inventory management system, including both physical storage and software tracking, which enhanced visibility and traceability across the organization. This systematic approach to procurement helped reduce unnecessary expenditures and streamline future builds.

A key focus of this year's budget was the evaluation and potential replacement of propulsion hardware. EER operates two alternating sets of Blue Robotics T200 thrusters, one for even years and one for odd, to ensure an ROV remains active for continuous tool testing and pilot training during the new ROV development. The thrusters originally procured for the 2019 RFP and slated for reuse in 2025 were found to be operating at below 70% efficiency based on internal performance metrics, including power draw, thrust output, and wear. With the increased depth of this RFP's mission, the need for speed and reliability justified the purchase of seven (6+1 spare) new T200 thrusters for *Waterwitch* at a cost of $1 516.

The new electronics enclosure for *Waterwitch* was fabricated by MUN Tech Services, who generously donated labor and only billed for raw materials, yielding an estimated savings of $600. Further cost reductions were achieved by reusing the tether from the 2024 RFP following UN Sustainability Goal #12, "Responsible Consumption and Production" [3], simplifying the electrical system, and designing tooling with minimal reliance on costly actuators and tubing.

With the 2026 MATE World Championship set to be held in Newfoundland, EER chose to expand travel to this year's competition in Alpena, Michigan, as a strategic opportunity for professional development and networking. The number of traveling employees increased from 15 to 20, resulting in a travel cost overrun of $3,195. This deficit will be absorbed in the 2026 cycle when no major travel is anticipated.

Funding for the 2025 RFP was primarily sourced from long-standing sponsors, with additional support secured through employee-led outreach, public engagement, and institutional partnerships. These efforts yielded an additional $1,230 in new funding. The Fisheries and Marine Institute also contributed $368 specifically toward the improved inventory system.

Overall, as shown in Table 4, the total budget for the 2025 RFP amounted to $26,956, with expenditures of $29,001. Of this, $4,324 was allocated to new components, $21,694 to travel, and the remainder for other miscellaneous costs, including administration, taxes, and shipping.

Table 4: Purchase Budget, Credit: Russell Corbett, 2025

Eastern Edge Robotics Budget 2025 (Purchases/New)			
Description		Budgeted USD	Expenses USD
Electrical Expenses	DCDCs	$316.85	$891.15
	Boards	$444.68	$28.90
	Components	$592.91	$181.19
	Thrusters and ESCs	$1,643.55	$1,516.38
	Electrical Budget+Contingecy & Expenses Total :	**$3,297.79**	**$2,617.63**
Mechanical Expenses	Chassis	$112.50	$263.65
	Enclosure	$578.92	$532.93
	Camera Tubes	$111.27	$87.83
	Mechanical Budget+Contingecy & Expenses Total :	**$882.95**	**$884.40**
Software Expenses	Camera Equipment	$325.66	$273.37
	Raspberry Pi	$131.29	$152.30
	SD-Cards	$28.16	$28.16
	Cables	$41.49	$58.68
	Misc	$0.00	$0.00
	Software Budget+Contingency & Expenses Total :	**$526.59**	**$512.51**
Payload Expenses	Props	$185.29	$11.12
	Vertical Profiler	$96.33	$214.06
	Camera Tubes	$29.65	$0.00
	Misc Parts	$185.29	$95.80
	Payload Budget+Contingecy & Expenses Total :	**$546.20**	**$320.97**
Administration Expenses	Competition Registration	$449.88	$708.18
	Fluid Power Quiz	$24.99	$27.66
	Shirts/Polos	$741.14	$718.91
	Website Fees	$14.49	$0.00
	Printing (Local)	$148.23	$48.30
	Printing (Competition)	$199.94	$0.00
	Shop Organization	$370.57	$319.31
	Orientation Day	$148.23	$136.92
	Office supplies, sharpies etc	$74.11	$52.27
	Administrative Budget+Contingecy & Expenses Total :	**$2,307.22**	**$1,959.27**
Travel Expenses	Flights	$5,500.00	$6,594.89
	Accommodations	$8,500.00	$12,600.00
	Vehicle Transports	$2,000.00	$2,500.00
	Misc Travel	$2,500.00	$0.00
	Travel Budget & Expenses Total:	**$18,500.00**	**$21,694.89**
Taxes and Shipping Expenses	**Shipping Costs Budgeted & Expensed**	**$305.93**	**$402.39**
	Taxes Budgeted & Expensed	**$589.54**	**$609.79**
Total Budgeted & Expensed:		**$26,956.22**	**$29,001.87**
Total ROV Budgeted+Contigency & Expenses (Not including props for testing):		**$5,068.25**	**$4,324.40**

The fair market value of *Waterwitch*, as shown in Table 5, was $3 422.

Table 5: Fair Market Value, Credit: Russell Corbett, 2025

Waterwitch ROV Fair Market Value			
		Price	New? Donate? Reuse?
Electronics	Thrusters	$1,320.00	New
	ESCs	$228.00	New
	Onboard Electronics	$396.35	New
	Cameras	$197.27	New
	Sensors	$99.38	Reused
	Tether	$100.00	Reused
	Connectors and Wire	$200.00	New
	Electronics Total	**$2,541.00**	
Mechanical	Enclosure Lid	$14.84	Donated
	Enclosure Structure	$91.57	Donated
	Chassis	$196.84	New
	Penetrators	$120.00	New
	Camera Tubes	$90.60	New
	Drop In Plate	$13.60	New
	Mechanical Total	**$527.45**	
Payload	Vertical Profiler	$205.88	Reused
	Tooling	$147.61	New
	Payload Total	**$353.49**	
	Total	**$3,421.94**	

7 Acknowledgements

Eastern Edge would like to thank the following organizations for their monetary support in the development of *Waterwitch*, travel expenditures to Alpena, Michigan, and the MATE ROV Competition, both regionally in Newfoundland and Labrador and internationally. ExxonMobil; Atlantic Canada Opportunities Agency; Department of Tourism, Culture, Industry and Innovation; Fugro GeoSurveys Inc; Hibernia Company Ltd; Crosbie Group Ltd; Husky Energy; Equinor; Marine Institute of Memorial University; Memorial University Faculties of Engineering, Humanities and Social Sciences and Science; Memorial University Technical Services; Memorial University of Newfoundland and Labrador Student Union; City of St. John's; RobotShop; Blue Robotics; CoLab Software; SubC Imaging; Subsea 7; InspectAR; Angler Solutions; Energy and Research Newfoundland and Labrador. Eastern Edge would also like to thank the following organizations for donating software or material resources: GitHub and Onshape. EER extends a heartfelt thank you to mentors Paul Brett, Joe Singleton, Anthony Randell, Shawn Pendergast, Chris Batten, Calvin Gregory, John Walsh, David Drover, and Michaela Barnes for their time, administrative support, and unwavering encouragement, as well as to the MATE Center for making this all possible.

8 References

[1] "MATE ROV Competition." [Online]. Available: https://materovcompetition.org/

[2] R. G. Budynas and J. K. Nisbett, *Shigley's Mechanical Engineering Design, Tenth Edition*. McGraw Hill Education, 2015, pp. 436–437.

[3] "The United Nations 17 Goals." [Online]. Available: https://sdgs.un.org/goals

[4] "ROS2." [Online]. Available: https://www.ros.org/

[5] "The Buoyant Force." [Online]. Available: https://physics.bu.edu/~duffy/sc527_notes01/buoyant.html

[6] "Weight Equation." [Online]. Available: https://www1.grc.nasa.gov/beginners-guide-to-aeronautics/weight-gravitational-force/

[7] "Decade of the Oceans Challenge." [Online]. Available: https://oceandecade.org/challenges/

[8] "Raspberry Pi Camera Module 3." [Online]. Available: https://www..com/products/camera-module-3/

[9] "Right to Refuse Dangerous Work." [Online]. Available: https://www.canada.ca/en/employment-social-development/services/health-safety/reports/right-refuse.html

[10] "Gazebo." [Online]. Available: https://gazebosim.org/

[11] "ROV Simulator Guide." [Online]. Available: https://www.zaidduraid.com/projects#rov-simulator

Appendix A Checklists

Pre-deployment Construction Checklist

- ☐ Area clear and safe
- ☐ Power supply is powered off
- ☐ Cables/ tether are undamaged
- ☐ Tether strain relief is attached
- ☐ Check to make sure the electronics are properly plugged in
- ☐ Grease and tighten penetrators
- ☐ Grease the enclosures O-ring
- ☐ Close the enclosure by tightening screws in an alternating pattern
- ☐ When the enclosure is closed, add the vent plug and tighten
- ☐ Visually inspect the ROV to check for any damage and to make sure the ROV is safe for water
- ☐ Leak test ROV for 15 minutes
- ☐ Check for water in the camera tube and in the enclosure
- ☐ If there are no leaks: the ROV is ready. Proceed to deployment
- ☐ Leaks: Disassemble and inspect ROV

Deployment (Power On)

- ☐ Pilot sets up topside
- ☐ Pilot ensures team is attentive
- ☐ Co-Pilot calls Power On
- ☐ ROV is connected to power supply
- ☐ Tether in coiled by deck crew to ensure easy use
- ☐ Tether managers place ROV in the water and check for bubbles going to the surface
- ☐ If bubbles are identified, take the ROV out of the water and check for leaks
- ☐ Pilot calls "Performing thruster test"
- ☐ Pilot ensures all thrusters are functioning properly
- ☐ Pilot checks cameras to ensure proper feed and positioning
- ☐ If all systems are okay, proceed to Launch Procedure

Launch Procedure (Deck Crew)

- ☐ Pilot calls power on, and power is turned on with disabled controls
- ☐ Deck crew calls hands-off
- ☐ Deck crew removes their hands from the ROV
- ☐ Piloting begins

Mid-Mission (Deck Crew)

- ☐ When the the ROV is visible in the moon pool, the deck crew calls surface
- ☐ Pilot calls safe when controls are disabled
- ☐ Hands-on is called by the deck crew when they have made contact with the ROV

Loss of Communication

- ☐ Steps are attempted in order. If a step is successful, the mission resumes
- ☐ After 2.5 seconds without topside communication, thrusters turn off
- ☐ Co-Pilot inspects tether and surface connections to the laptop
- ☐ Pilot attempts rebooting the control system
- ☐ Co-Pilot attempts rebooting *Waterwitch* by cycling power supply
- ☐ Power down ROV, call Power Off
- ☐ Manual retrieval of ROV using tether
- ☐ Confirm no leaks and begin troubleshooting
- ☐ Isolate the cause and document

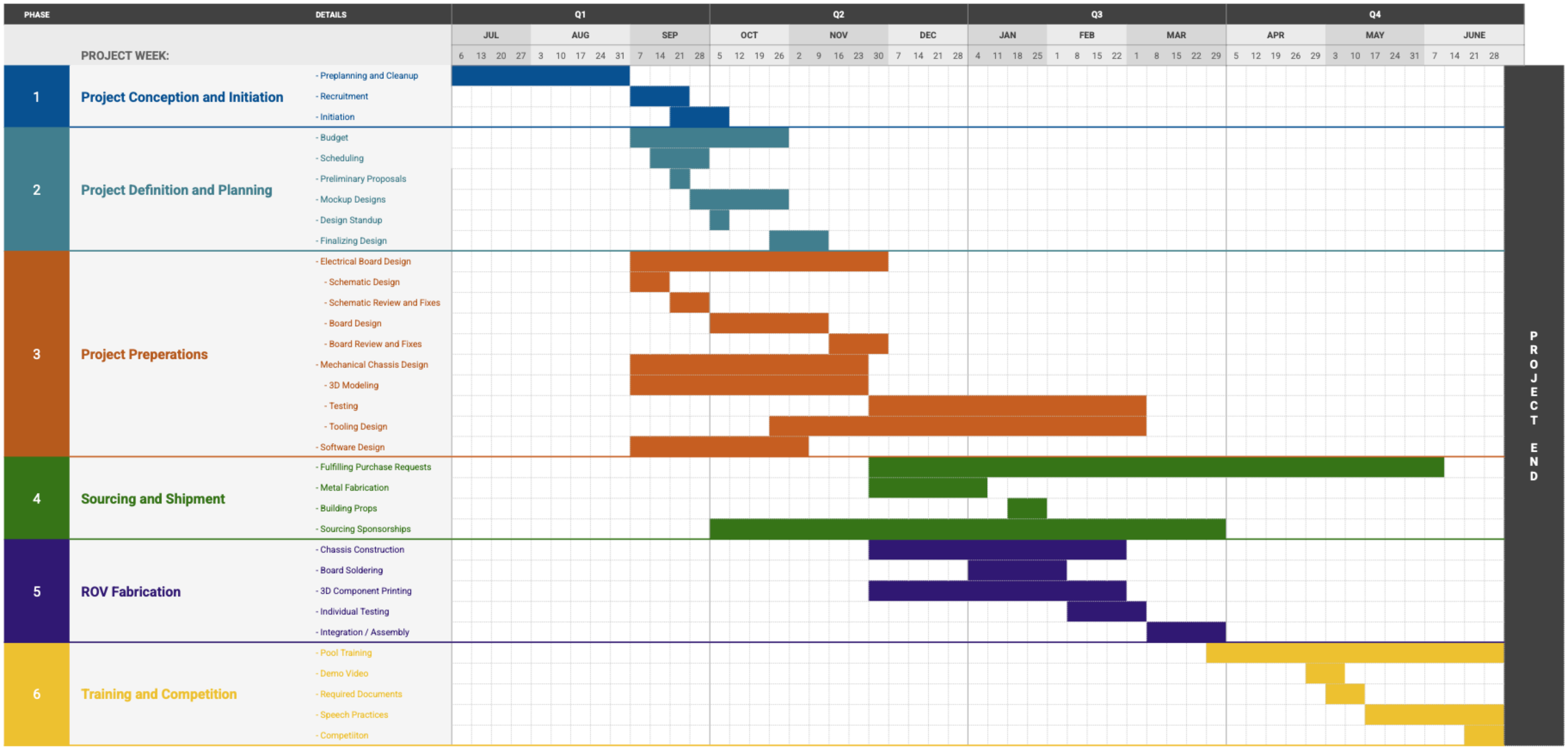
Tether Protocol

- ☐ Tether Manager conducts inspection of tether
- ☐ Tether is deployed carefully and monitored throughout the mission to make adjustments as needed
- ☐ Tether Manager retrieves the tether at the end of the mission and coils it into a figure-eight pattern for storage

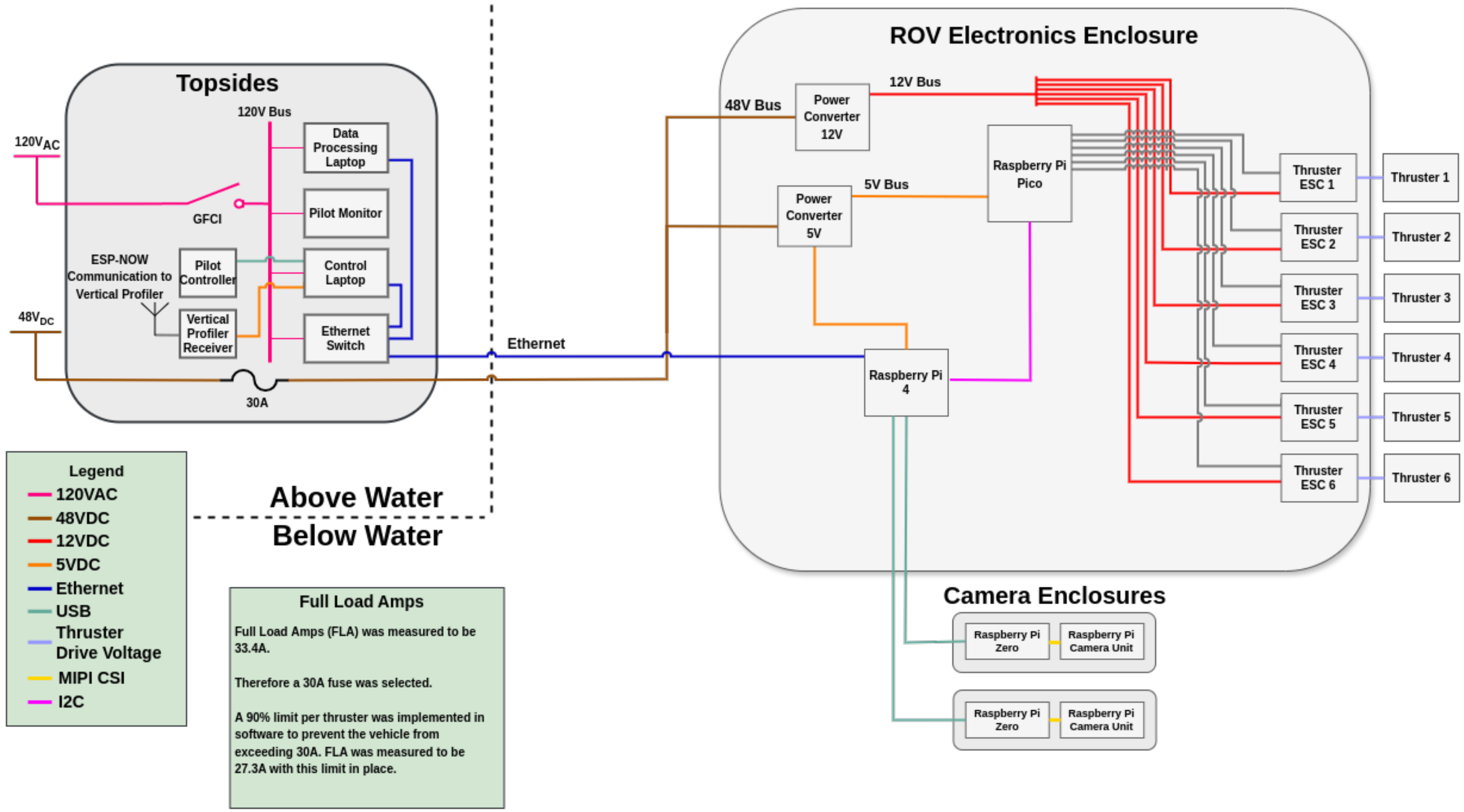
Appendix B *Waterwitch* Production Gantt Chart

Eastern Edge Waterwitch Production

PROJECT TITLE	Waterwitch	COMPANY NAME	Eastern Edge Robotics
PROJECT MANAGER	Russell Corbett	DATE	10/12/24



Appendix C *Waterwitch* SID



eastern Edge	Eastern Edge Robotics - Waterwitch **Electrical System Integration Diagram**	**Revision History** 2020-04-19 - Originally Drawn - DD 2021-09-15 - Concept for 2022 - SF 2022-04-28 - Updated for 2022 - SF 2023-05-17 - Updated for 2023 - SBP 2024-05-18 - Updated for 2024 - ZB 2025-05-12 - Updated for 2025 - EV

Appendix D Workshop Safety

SAFETY GUIDELINES

1. Wear proper PPE (closed-toed shoes, safety glasses, life jackets, etc.) when undertaking a task.
2. Ensure safe communication and team work in shared spaces; no horseplay!
3. Ensure you have been properly trained with a tool before attempting to use it.
4. Maintain the cleanliness of your workspace to avoid accidents.
5. Be cautious when testing in the acoustics tank.
6. Know your emergency exits, muster stations, and location of first-aid kit.
7. Store hazardous materials in designated locations and dispose of them properly. Always check the MSDS before using a hazardous material.
8. MOST IMPORTANTLY
   Always fill out a JSA before attempting a potentially hazardous task.

IF THERE'S AN INCIDENT:

Fill out an incident report.

IF THERE'S AN EMERGENCY:

CALL 911

Then fill out an incident report.