

Technical Documentation

Triton Tech ROV 2026

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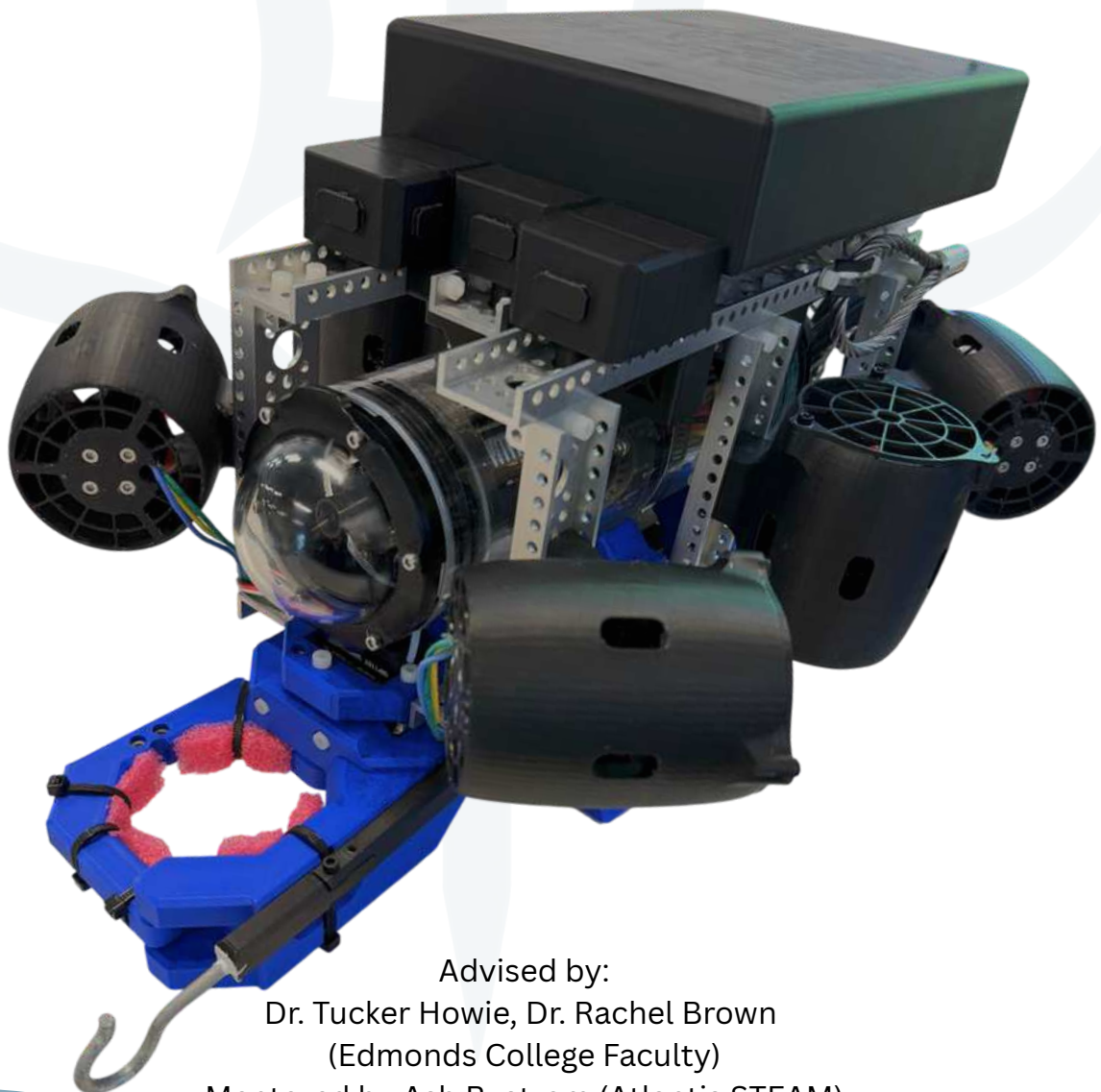
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Underwater Robotics

PIONEER Class



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Triton Tech ROV from Edmonds College is an underwater robotics organization which designs and builds Remotely Operated Vehicles (ROVs). In response to MATE's 2026 Request for Proposals, which highlights scientific monitoring, ecosystem protection, and environmental awareness, we present Razorbill. Razorbill is a remotely operated vehicle designed with modularity and reliability to operate in challenging ocean environments. Razorbill's systems allow it to be efficient and safe, both in operation and maintenance, and is designed to competitively pursue MATE's requested tasks and align with their Decade of Action for Cryospheric Science Goals. This document details the design, integration, and development of Razorbill to support the 2026 MATE mission tasks.

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Company & Personnel Overview

The Triton Tech ROV company is organized into technical and administrative departments. Leadership roles are established to provide support across technical departments and manage project plans.

Project Management

Triton Tech ROV utilized GitHub and Google Suite (Calendar and Sheets) as scheduling resources. The schedule was made with team feedback and possible manufacturing delays in mind.

Phase	Time Period
Recruitment & Training	Oct. 10 - Dec. 19
Planning & Design	Jan. 19 - Feb. 26
Building & Manufacturing	Feb. 28 - Apr. 15
Testing & Documentation	Apr. 16 - May 20
Final Testing	May 21 - June 19

Fig. 1 Triton Tech ROV 2026 Project Timeline

Protocols & Resources

To assure successful project development, Triton Tech ROV follows an adaptive project management protocol. With clear goals established about system expectations from mission task overview, team members clearly communicate and adapt to troubleshooting and design changes. As each department works on separate parts of the ROV, department meetings are established, with weekly team meetings to communicate progress. This also enables departments to gain feedback and discuss design revisions. Department choices may also require administrative input, such as safety oversight and budget discussion. We chose resources for their operating system (OS) compatibility and affordability, ensuring successful team communication and operation. As such, Google Suite was utilized for general file management and project management. GitHub was used for software management, alongside Canva for graphics and documentation. Onshape CAD was chosen for mechanical and electrical system modelling, and KiCad 9 was used for electrical circuit board design.

Leadership Department Roles

- CEO:** Establishes team goals, project management, and public relations.
- COO:** Manage daily operations, internal systems, and resource allocation.
- Department Lead(s):** Lead corresponding departments with project timelines, assignments, and troubleshooting.
- Safety Officer:** Ensure safety protocols are followed regarding ROV operation, workshop use, and team communication.

Department	Responsibilities
Chassis	Design and build the mechanical components of the body and frame of the ROV.
Electrical & Controls (Software)	Build the electrical systems and software integration for controls and operation of the ROV.
Manipulator	Design and build the manipulator (claw) of the ROV with mission tasks in mind.
Budget & Marketing	Record and manage finances and marketing efforts of Triton Tech ROV. Also includes management of Corporate Social Responsibility (CSR) efforts.
Float	Design and build mechanical, electrical, and software systems of the vertical profiling float.

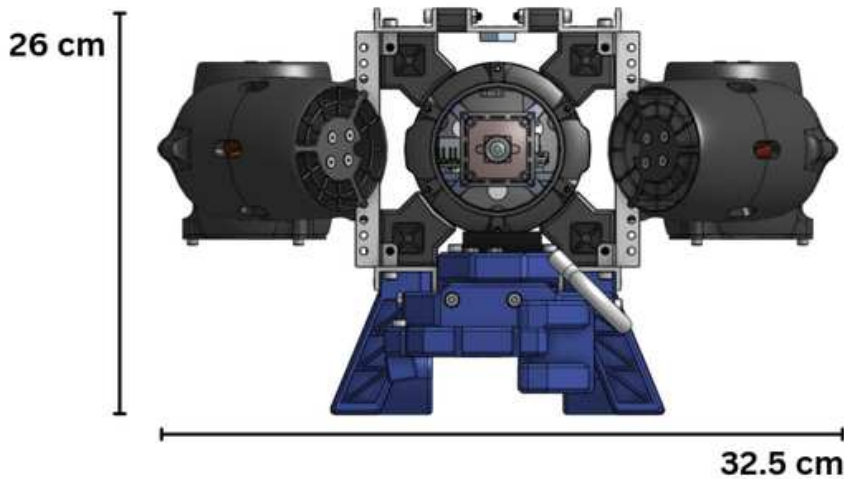
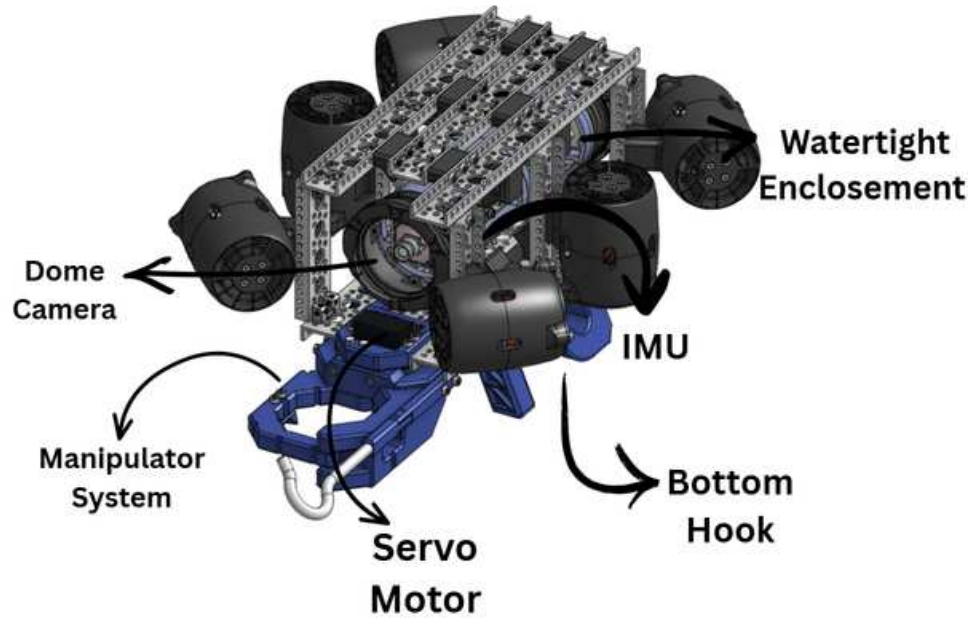
Fig. 2 Table of Triton Tech ROV Subteams and Responsibilities

RAZORBILL

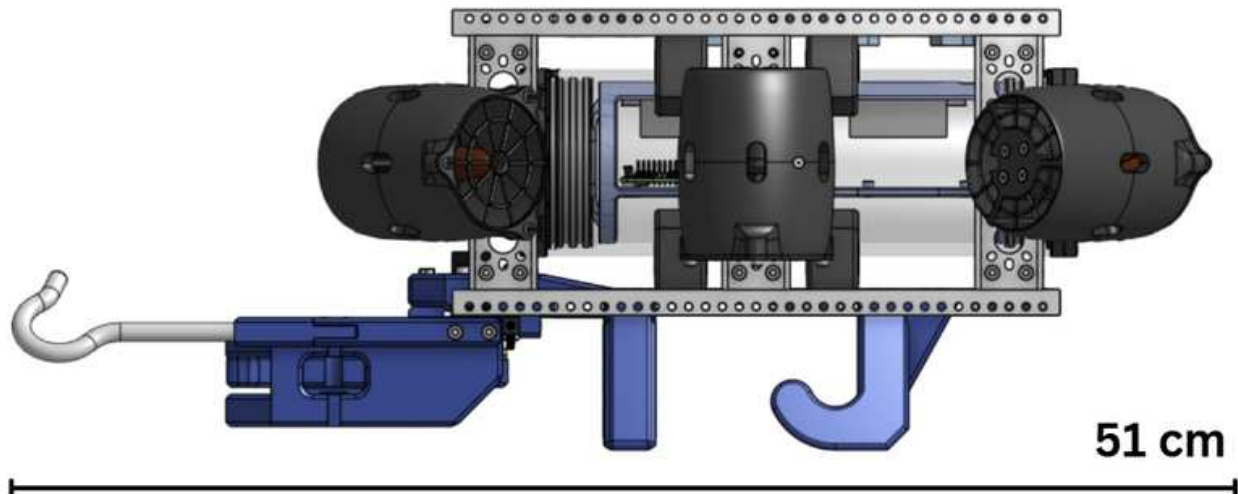
Triton Tech ROV 2026

Design Overview

In this 2026 request for proposal from MATE ROV, we present Razorbill. Designed to prioritize reliability, adaptability, and maneuverability. Six underwater brushless motor thrusters are configured to achieve movement in the x, y, and z directions, as well as yaw, and roll. The presence of an onboard IMU aids in the navigation and stabilization of the ROV in the presence of current, or while navigating various underwater terrains.



A watertight enclosure provides a consistent waterproof seal to protect our electronics. This confidence allowed us to focus on implementing robust manipulator systems and swift maneuverability while achieving mission tasks. The servo-driven claw is able to manipulate mission objects consistently and the combined thrust of each motor is able to provide enough power to carry items to and from the surface.



Design Rationale

Watertight Enclosure Tube

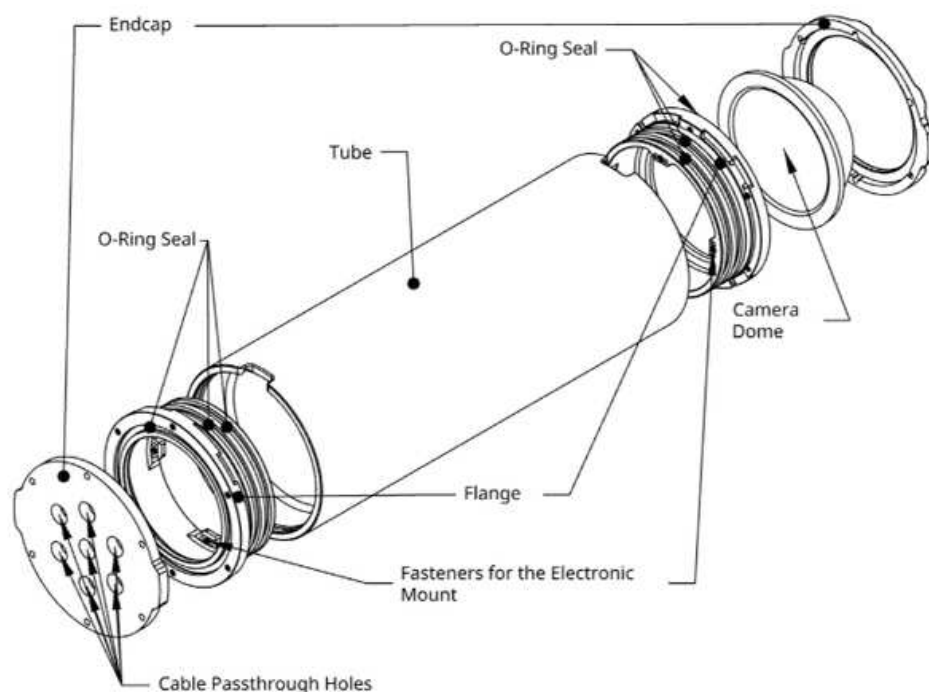


Figure 1: Exploded view of the watertight enclosure

The Blue Robotics watertight enclosure [1] is specifically designed for subsea usage. We designed, manufactured, and fastened the tray that holds the ROV's electrical components inside the enclosure. The tube had an internal diameter of 75 mm and is 240 mm long between the flanges. The tube and the dome are made out of cast acrylic which allows us to be able to see into electrical systems, while the flanges and the end caps are made out of anodized aluminum. This type of aluminum is ideal for withstanding a fair amount of force prior to deformation, and the anodized treatment increases its corrosion resistance [2].

Each flange has two O-rings that sit between the flange and the tube when inserted, and there is a third O-ring between the flange and the endcap. Marine grease is spread over the o-rings, or any place where two components are being fastened together, in order to provide another added layer of prevention of leak protection.

Chassis

The chassis was designed to meet MATE's RFP requirements. Before any decisions were made, we reviewed all mission tasks and designed subsystems required to complete mission requirements. It was determined in this exercise that the ROV's maneuverability would be far more important than its straight-line speed, which informed many of our decisions about the ROV's chassis and thruster orientation.

The initial design of the chassis was centered around addressing the waterproofing challenges we had faced in previous years. Knowing that a failure could damage electronics, we opted to design our ROV's frame around a 75 mm cylindrical water-tight enclosure from Blue Robotics. While it was at a high price point, we decided that its benefits heavily outweighed the cost and that we could make up for the impact on our budget by utilizing more affordable components elsewhere. With the decision to prioritize maneuverability over speed, we chose to design a rectangular chassis around our water-tight enclosure, as it provides a modular mounting system for exterior ROV components. The size of our ROV being well below the preferred maximum weight listed in the RFP allowed us to choose a denser material to use in our chassis that afforded us more rust resistance. While aluminum isn't as corrosion-resistant as PVC, aluminum provides sufficient environmental resistance against galvanic corrosion if marine grease and nylon barriers between metals are used.

One of our main considerations for the chassis design was that it makes subsystem mounting straightforward, allowing for fast disassembly and reassembly. Additionally, it provides easy access to electronics that could be crucial to its operation.

The 1143 Series Mini Low-Side U-Channels from GoBilda [5] are durable, corrosion-resistant, have thru-holes for easy mounting, and can be disassembled quickly with just a screwdriver and M3, M4, and Torx bits. Dual Block Mounts [6] and fasteners from GoBilda were used to fix the U-Channels together to form the chassis around the watertight enclosure. To hold the enclosure firmly in place, we used 3D printed blocks with rounded edges, named “corner buffers,” within which the enclosure rests. We installed heat-set inserts that align with the thru-holes of the U-Channels in each buffer, then fastened them to the top and bottom U-Channels to create a cradle for the watertight enclosure as seen in figure 2. The smallest U-channel available on GoBilda [5] is 48 mm long; using them to connect lengthwise channels would make the frame at least 192 mm wide, which would be over twice the diameter of the watertight enclosure. As an alternative, we 3D printed rounded blocks (figure 2) with holes that aligned with the holes in the lengthwise U-channels. Notice in Figure 2 that the middle U-Channel on the top and bottom is shorter than the U-Channels on the sides, which leaves a space to attach the manipulator arm at the bottom side of the front ROV. In previous years, cable potting was the chosen method for Triton Tech ROV’s

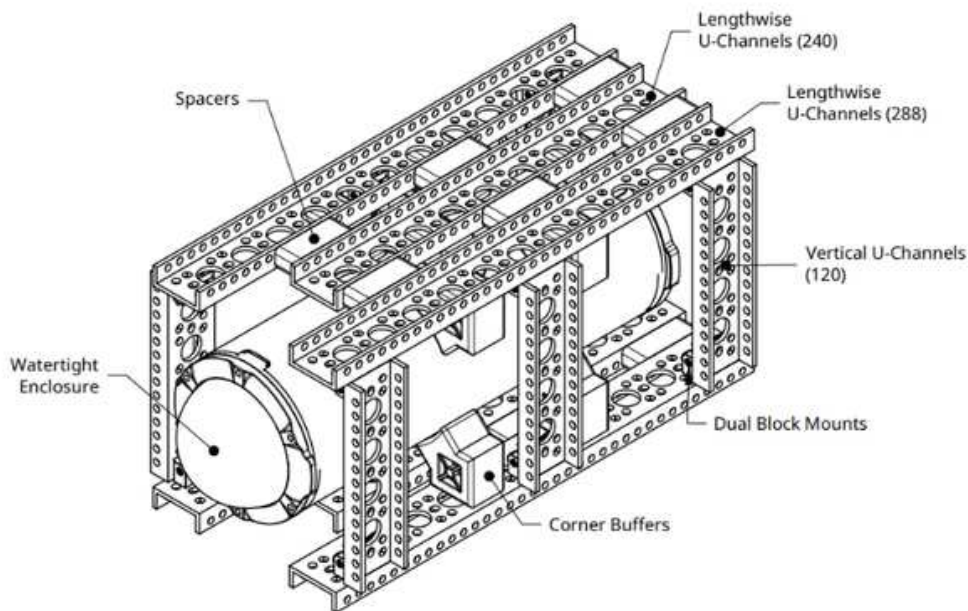


Figure 2: Isometric view of ROV chassis

cable management and waterproofing using silicone caulk in order to create a seal around holes cables passed through to the inside of the enclosure. We found that this often resulted in leaks due to microcracks in the caulk. Therefore, we sought out a fully waterproof solution that would guarantee our equipment safety. This led to us choosing the Blue Robotics WetLink Penetrators for our waterproofing method [3]. However, the number of wires required for

our thrusters far exceeded the number of holes we had available. We were unable to run two wires through a single hole as the penetrators require a circular cable jacket for a secure, watertight fit. We then decided to splice two thruster wires together, each containing a power, ground, and signal wire. In order to make this work we surmised a cable that contained 6 conductor wires each 16 American Wire Gauge (AWG) were needed and had to be less than 8.5 mm in order to fit in the largest penetrator. This meant that we could use three 8.5 mm in diameter 16AWG/6c (this notation

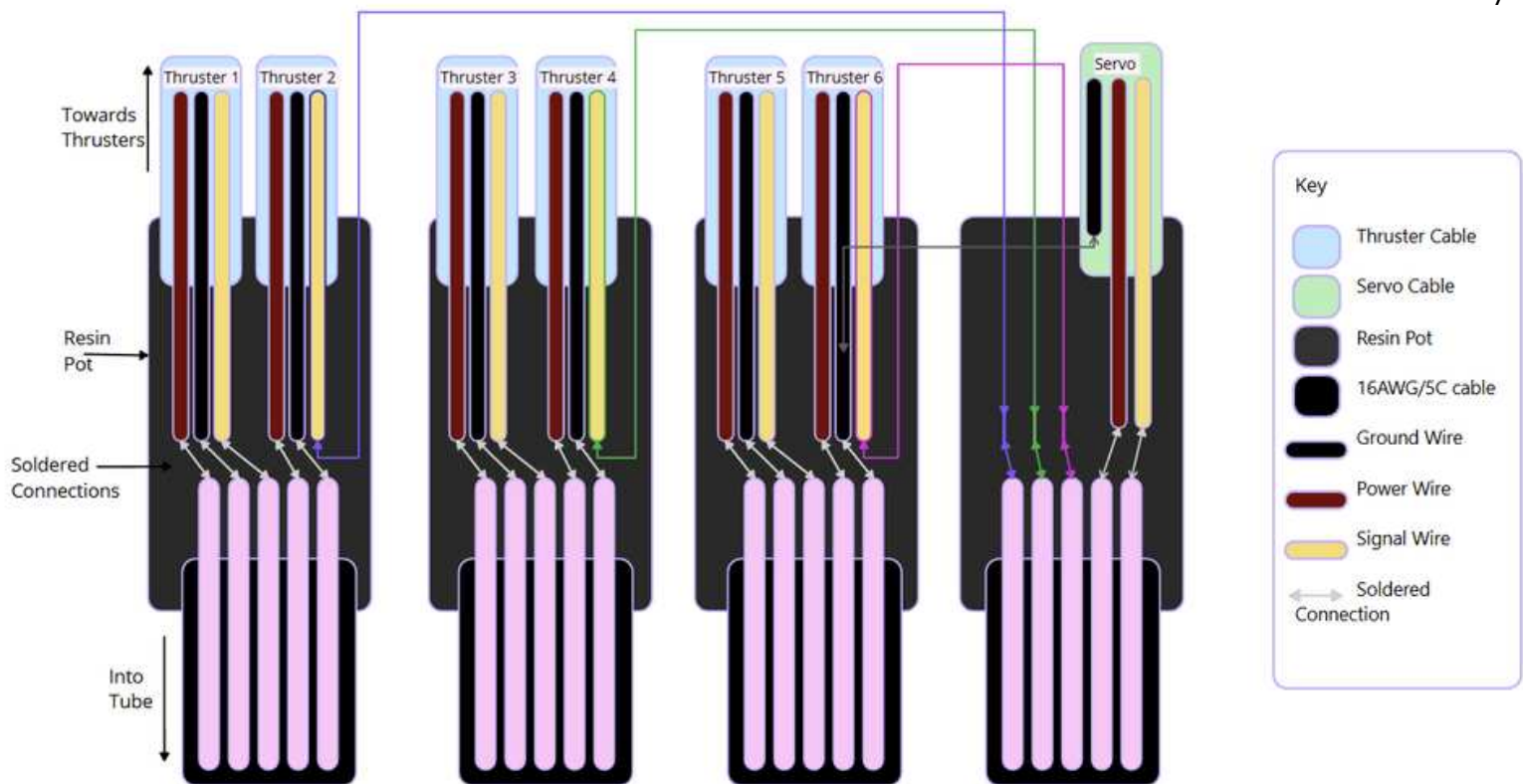


Figure 3: Cable splicing and resin pot diagram

means that in this cable contains 6 conductor wires each 16 AWG) cables for thrusters and servo-motor, one 8.5 mm 14 AWG/2c cable for power, and one 5.5 mm signal cable.

Although a wire meeting these requirements was found to splice the thruster wires together, the cable penetrator was unable to support all 6 conductor wires, as they were unable to pass through of the smallest diameter of the bulkhead without damaging the conductors, even though the outer jacket did fit in the outer diameter of the bulkhead. Since the penetrators that we had selected for the thruster splicing were the largest size that would fit into the back of the tube, we were unable to change to a larger diameter, nor were we able to decrease AWG of the conductors since that would affect the performance of the thrusters.

Our solution was then to use 16AWG/5c cables to splice our thrusters together (figure 5). Any soldered connection outside of the tube needed to be contained in resin pots in order to prevent any water from entering the wires. In addition to a slim heat shrink placed over the individual wire connections, we also placed a large heat shrink such that it contained the thruster wires entering, and the single 16AWG/5c wire exiting. The slim heat shrinks were scoured in order to allow the epoxy to flood the conductor wires. One end of the heat shrink is sealed such that enclosed around the 16AWG/5c cable jacket, and then resin was poured into heat shrink and allowed to surround the v split where the two thruster wires met and up to the jackets of the thruster wire. Instead of making 3 resin pots each containing 6 wires to account for all of the thrusters, we instead ran one of the signal wires out of each pot to make a fourth pot. The fourth pot also contained the power and signal wires of the servo-motor motor, and since we had run out of wire space we combined the servo-motor's ground wire with one of the thruster's ground.

Manipulator Overview

The design of our manipulator system seeks to simplify and optimize functionality for the 2026 mission tasks, while also remaining cost-efficient by reusing components from our 2025 ROV and iterating on the success of our previous designs. To meet MATE's RFP, we introduced an upgraded suite of manipulation systems to meet mission parameters and ensure effective integration into the chassis.

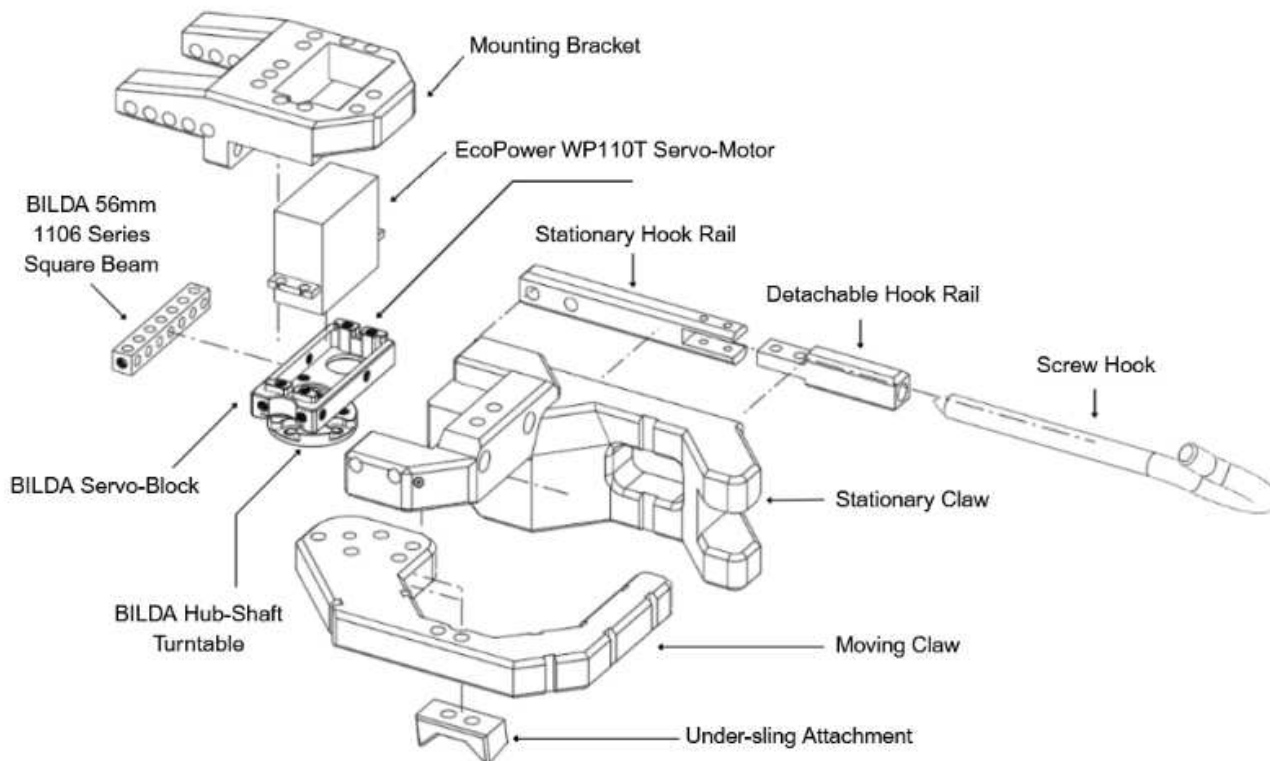


Figure 4: Isometric Exploded View of the Manipulator Claw

Mounting Bracket

The mounting bracket serves as the attachment point for the manipulator system. This component is secured to the frame's horizontal U-channel using M4 nylon fasteners on both the horizontal and vertical axes, securing the servo motor, front hook, and the stationary claw. The servo motor, GoBILDA Servo Block, and stationary claw are fastened to the mounting bracket using M4 nylon screws; the servo motor is safely nested between the mounting bracket and Servo Block while also being accessible for removal and replacement.

Moving Claw and Under-sling Attachment

The moving claw serves as the articulated component of the manipulator system. Initially, our claw was designed to be able to pivot and rotate 90° at the base of its attachment to the frame,

allowing it to dynamically switch between horizontal and vertical orientations. However, it became apparent that an additional servo motor would introduce more front-end weight and unnecessary risk involving waterproofing the servo and wiring the electrical. As such, our team moved to develop a static claw system that features a single point of actuation. Having only one moving finger driven by one servo motor greatly simplifies the design and streamlined our development timeline without sacrificing any relevant capabilities. The geometry of the moving claw was designed to avoid interference with any adjacent components during operation.

Stationary Claw

In addition to the moving claw, the manipulator system features a larger stationary claw component that nestles the moving claw when closed, producing a fully enclosed octagonal perimeter inside the claw, and preventing any objects from coming loose or escaping. The stationary claw is a singular static 3D printed PLA unit. The large surface area along the inside perimeter of the component allows for a firm grip of mission task items. To further reinforce the grasp of the claw, several slivers of pool noodle were cut and secured to the inner faces of both the moving and stationary claw, allowing for greater pressure on and complete control over task items (figure 5).

Front Hook

The front hook was developed and implemented as a peripheral to the manipulator system, allowing the ROV to carry multiple mission task items simultaneously. The front hook consists of a single metal fish-eye screw hook epoxied to the 3D printed PLA Detachable Hook Rail, with the entire assembly being fastened to the side of the stationary claw. During the design process, we solidified that the manipulator claw must be able to grab items with a vertical profile that have significant thickness (such as the diameter of the coral substrate or eDNA sensor). However, the claw is not well-suited for all tasks, such as task 3.1c (table 4), and the claw cannot pick up multiple items simultaneously. To address this discontinuity, the hook was designed to pick up items the claw may have trouble grabbing onto (table 4). The front hook also allows for precise alignment, accurate sensing, and careful control with smaller objects. The detachable feature of the hook is meant for safer handling during travel. The design allows for the hook to conveniently detach while also being rigid enough not to yield to the weight of any objects obtained.

Bottom Hooks

Initially, the bottom hook was a standalone front-facing hook mounted under the middle bottom c-channel, resting between four legs. We realized the space constraints would make it hard to align with objects and potentially create imbalance when holding objects, risking the ROV tipping sideways. For these reasons, we decided to integrate the hook into the front of our rear legs and added an upper cantilever shape to the back side of the hook/leg for increased stability. With two spread-out hooks on the rear undersides of the ROV, the lobster pot handle will remain level while the ROV lifts it up, reducing risks of tipping and dropping. (Table 4)

Physical and Mechanical Considerations

An aspect of consideration during the design process of the manipulator was ensuring its strength. PLA strength depends highly upon its infill percentage, pattern, and printing orientation. We intentionally took precautions to have print parts print with layer lines that would run perpendicular to any applied load carried by the ROV. This decreases the risk of parts shearing. When designing the bottom hooks, we included a cantilever arm that would aid in stabilizing the hooks when lifting the lobster pot by distributing the moment caused by the load.

Any item picked up by the claw has the potential to create imbalance and tip the ROV. Therefore, we designed the mounting module to distribute the load more efficiently and evenly. These design decisions were influenced by underwater weight estimates of mission task items; the bottom hook needing to lift no more than 20N (lobster pot), and the claw needing to handle just over half a newton (coral substrate assembly).

As a contingent payload-handling option, a lift bag system was included to work in conjunction with the bottom hooks. In case of scenarios where the ROV's vertical lifting threshold is approached, the lift bag will assist and provide supplemental buoyancy forces. The lift bag serves as a reliable back up option, increasing the reliability and safety of manipulator systems and the overall ROV's functionality.

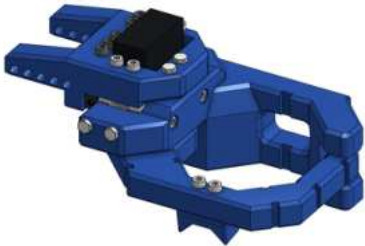
Articulation Systems

A significant amount of our modeling was derived from the fixed dimensions of our chosen EcoPower WP110T servo-motor and the BILDA Servo-Block and hub shaft turntable (figure 4). When developing the manipulator system, we heavily considered the torque requirements and load that would be placed on the servo motor, and subsequently, the moving claw. The servo-motor is capable of delivering 1.97 Nm of torque from the servo-motor spline, but only if the spline gear is properly supported by surrounding infrastructure. The use of the Servo-Block and hub shaft allowed the stress and load from the weight of the mission task items to be relieved from the spline onto these BILDA components, enabling the servo-motor to deliver smooth rotation to the moving finger component.

Manufacturing Design

The manipulator system's design is centered around task performance and optimization. As such, we greatly considered the manufacturing and development costs and timeline of these features, as well as preparing for future potential revisions. To minimize material costs and allow for rapid prototyping, we frequently utilized 3D printing technology provided by our facilities, selecting PLA filament at a minimal infill for each printed component. We reused the 2025 ROV's servo-motor for ease of electrical and control integration. We also understood the troubleshooting processes of this servo motor, providing us with a reliable foundation for claw articulation.

Table 4: Itemized manipulator systems and associated mission tasks

CAD Model	Description for Completing Mission Tasks
Stationary Claw and Moving Claw 	Task 1.1a: Collect two coral samples by substrate • Can obtain 1x sample at a time. Task 1.1b: Collect two basket stars • Can obtain 1x sample at a time. Task 2.3a: Turn handle to release retrieval buoy • Primary manipulator system can push handle forward to release the retrieval buoy. Task 2.5a: Recover the old eDNA biodiversity sensor • Can obtain 1x sensor via 50cm rope. Task 2.5b: Install the new eDNA sensor connector • Can obtain and install 1x new eDNA sensor connector into the Holyrood subsea observatory. Task 3.1a: Bubble Curtain and Micropile Installation • Can obtain and place the bubble curtain over the micropile. Task 3.2a: Retrieve the power connector • Can obtain 1x power connector from the wind farm subsea station. Task 3.2b: Guide Power Connector through the Waypoint • Can transport 1x power connector via the screw hook. Task 3.2c: Remove oil platform port cover • Can obtain and transport 1x cover via 40cm rope.
Front Hook 	Task 1.1a: Collect coral sample by substrate • Can obtain 1x coral sample (via substrate) at a time. Task 1.1b: Collect two basket stars • Can obtain 1x sample at a time. Task 2.5a: Recover the old eDNA biodiversity sensor • Can obtain 1x sensor via 50cm rope. Task 3.1c: Micropile Installation and removing pin • Can secure and pull 1x pin to release the micropile. Task 3.2c: Remove oil platform port cover • Can obtain and transport 1x cover via 40cm rope.
Bottom Hooks 	Task 2.3b: Recover Lobster Pot Unit • Can obtain and lift/transport 1x lobster pot via handlebar.

The closer the ROV is to neutrally buoyant, the less we need to employ minor thruster corrections in order to stay static, especially when moving vertically. The ROV and all its system was weighed at 5.3 kg, and its total volume can be estimated around 0.003683 cubic meters using Onshape's section properties feature. Using those values, we get a weight of 51.993 N and a buoyant force of 36.13 N, so the ROV itself is negatively buoyant. After adding a large, hollow, 3D rectangular prism, we can bring the overall buoyancy closer to neutral. The rectangular prism weighs another 0.3 kg and displaces a volume of 0.00198 cubic meters, allowing it to act as a buoyancy module. Adding the buoyancy module adds 2.93 N of weight and 19.45 N of buoyancy force. Adding those values to the weight of the buoyant force of the ROV itself results in a total weight of 54.93 N and a buoyant force of 55.89 N, which means that after adding the buoyancy module, the ROV has positive buoyancy.

Electrical Controls System

Main Power

The ROV uses 12V main power from the MATE ROV power supply and is sent down to the ROV with 14AWG stranded wire, maximizing flexibility while also carrying up to 15A of continuous current. While the official power supply used by MATE ROV is labeled as 12V, it provides 14.1V, meaning with our 100ft tether and a max load of 14 amps, we have a potential voltage drop of about 6 volts. While this is a large difference, this is above what we need to maintain required power to all parts of the ROV without resulting in uncontrollable thrust.

The first step in the ROV's power chain is the main 15A fuse located within 30 cm of the power supply in order to protect the electrical systems in the event of over draw of current. This is immediately followed by a power switch. After which, the cable enters the water and leads into the ROV via a cable penetrator, it is terminated with a ferrule and inserted into a WAGO lever-action connector. All 12V ROV power is distributed with WAGO power connectors with ferrule-terminated wire ends, ensuring robust connections that are easy to maintain.

After connecting to the WAGO connectors, power is distributed in parallel to three different destinations. The first is Electronic Speed Controllers (ESCs). Each Thruster ESC requires Voltage input, Ground, and PWM inputs, and translates these inputs into PWM outputs for the brushless thruster motors. The 12V power and Ground from the main power supply are distributed in parallel to each ESC input. The second destination is the Raspberry Pi's 5V buck converter, which supplies power to the Raspberry Pi via the USB-C port. We chose the USB-C port as it is more protected than GPIO, which can sometimes be more convenient space-wise, but increases the risk of accidental electrical damage. The third destination is the 5V buck converter for the Servo, which just outputs power to the servo for manipulator control. The reason for having independent buck converters for the servo and Raspberry Pi is because they are both rated for 5V 5A max output. The Raspberry Pi can potentially use 5A on its own, so adding a second buck converter for the servo introduces a safety factor and protects from inductive voltage spikes.

Signal Wiring

The ROV electrical system was created to maximize simplicity and robustness, making things easy to repair, while also reducing the amount of repairs needed. This was achieved by evenly distributing processing power based on the needs of each part of the ROV. Table 5 illustrates the purpose of each computer controlling the ROV.

The reason we chose to distribute the load this way is due to maximize efficiency of each subsystem. The Control Station Computer is where all control input originates, and where all outputs are final. The Control Station Computer also requires only minimal processing power with only simple signals being sent into the ROV. Keeping the role of the Control Station Computer simple helps to prevent any potential electrical interference, limiting the tether to only power and an ethernet cable.

Table 5: Summary of software control station systems

Control Station Computer	Raspberry Pi 5	ESP32
• Translates controller inputs and sends commands to the Raspberry Pi for processing. • Displays the ROV camera feed for the Pilot. • Provides a control panel for the Pilot to configure ROV characteristics.	• Receives controller inputs from the Control Station Computer and transforms them into thruster and servo commands. Then sends these commands to the ESP32 via UART. • Connects to the primary camera and performs OpenCV processing for target recognition • Sends camera feed data to the Control Station computer.	• Collects thruster and servo commands and transmits PWM signals to all thrusters and Servos for processing. • Collects IMU data and sends this to the Raspberry Pi via UART.

The Raspberry Pi acts as the main brain of the ROV, taking inputs, transforming them into control signals, and sending data from sensors up to the Control Station after translating it into understandable information. However, because of the high processing load being placed in the Raspberry Pi, it would be difficult to balance high processor load with PWM outputs for thrusters and servos, as the Raspberry Pi runs a general-purpose operating system (Linux) and is negatively impacted by OS-level thread scheduling. Due to this fact, we decided to offload the PWM processing to a dedicated microcontroller, the ESP32. We chose the ESP32 because of its wide availability and ease of use. By using Serial communication with the Raspberry Pi, it can control the thrusters with strict, uninterrupted hardware timing.

Dashboard

Regarding our server, we use a Raspberry Pi 5 for our hardware with the Debian operating system as both are well supported, documented, and well known among those who work with robotic systems. On the Raspberry Pi, we use Python 3 with the Flask library to orchestrate our Web Dashboard communication pipeline. Python Flask hosts the website interface that acts as our dashboard for ROV control, which is the first component of our pipeline. The dashboard allows the user of the ROV to monitor the main and secondary cameras and the orientation of the ROV using the IMU. Connecting to the ROV is extremely straightforward, the user plugs a laptop into the tether, opens a website in a browser, and they instantly have access to the dashboard. This simple setup process ensures that all potential users of the ROV are able to control and configure it without prior knowledge of control systems.

Dashboard - Controller

We utilized a Logitech controller which allowed seamless connection to any laptop, and communication with a Raspberry Pi found within the device via Ethernet. The Raspberry Pi receives control input from the web dashboard and translates this into “commands” that are sent via serial to the ESP32 which then acts as a dedicated PWM controller for our thrusters and servo-motor. The primary camera, found within the front dome of the ROV, is connected to the Raspberry Pi with USB. The secondary camera is connected with a ribbon cable to the Raspberry Pi and is used to give visibility below the ROV’s frame.

We set out to use the logitech controller for Razorbill operations since many people already know how to use game controllers, which will make control of the ROV much more intuitive for the handler. Additionally, there are a wide range of tools available to work with game controllers. They are structured to make inputs easily accessible and fast, and they simplify the control requirements to just a laptop.

Controller & Socket Communication

Using the javascript gamepad API library, we input controller signals from the dashboard, over to our server. We then use C++ with Arduino libraries for code which we will push to our microcontrollers. Our main method of communication between the dashboard and the Pi is with sockets. In short, they act as a persistent and secure two-way connection medium.

While the websocket implementation of sockets is more widespread and known, socketIO has libraries that integrate well with flask. SocketIO also goes well with the Flask server we set up to ensure uniformity.

After control inputs are sent to the Raspberry Pi, the controls are transformed by a matrix corresponding to the thruster orientation, simplifying the math to just a combination of linear transformations without an abundance of hard-coded functions to balance movement on different axis.

$$\begin{bmatrix} 1 & 1 & 0 & 0 & -1 \\ -1 & 1 & 0 & 0 & 1 \\ 0 & 0 & 1 & 1 & 0 \\ 0 & 0 & 1 & -1 & 0 \\ -1 & 1 & 0 & 0 & -1 \\ 1 & 1 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \\ roll \\ yaw \end{bmatrix}$$

Figure 6 : Controller input transform into thruster outputs

The ESP 32 is connected to mechanical devices on the ROV. In the ESP 32 code, we decided to write looped code that would read data from Serial. These control commands, sent from the Raspberry Pi, contain a simple structure of “set [device] [speed value between -1.0 and 1.0]”, such as “set t1 0.5”, which instructs the ESP32 to spin thruster 1 (“t1”) at 50% speed in the positive direction. This is directly translated to a PWM output between 1000 and 2000 microseconds of pulse width.

ROV Controller PCB

Although the ROV’s current control system works, its simplicity does lack some minor electrical protections that can potentially improve robustness. Because of this, we decided to design a custom PCB prototype that solves these issues, and we aim to install it in the ROV before the final product demonstration. Images of this PCB and its schematics can be found in figure 7. The issues that the PCB aims to solve are as follows:

- Reverse polarity and inrush current protection on the main 12V power line, preventing accidental component damage if wires are incorrectly connected or when the power is turned on.
- TVS Diodes on each thruster channel to clamp high-voltage spikes during thruster movement.
- PWM noise shunting and treatment to prevent impedance mismatch and ringing.
- Electrostatic Discharge protection on all critical components.
- Addressable RGB LEDs for status signals and debug messages.
- Integrated STM32 for PWM output and reading from sensors.
- 6 Thruster channels, each with current sensing, allowing the STM32 to read and control the maximum current output reactively to prevent going over 15A max current.
- 6V buck converter for the servo, saving space and removing the need for an external buck converter.
- BNO055 9-axis IMU for ROV orientation and acceleration sensing.
- Mini blade fuse slot for main power, adding additional protection within the ROV.
- Probe plugin for leak sensors, allowing the STM32 to sense and send alerts to the Raspberry Pi, LEDs, and the integrated magnetic buzzer.
- USB-C connection for the Raspberry Pi to communicate via UART Serial.

Propulsion

APISQUEEN U1 underwater brushless thrusters were selected for their cost efficiency and predictable controls implementation. Custom shrouds were designed and 3D printed, as the original shrouds that the thrusters came with did not satisfy IP 20 standards, and mounting holes did not align with our chassis’s U-Channels.

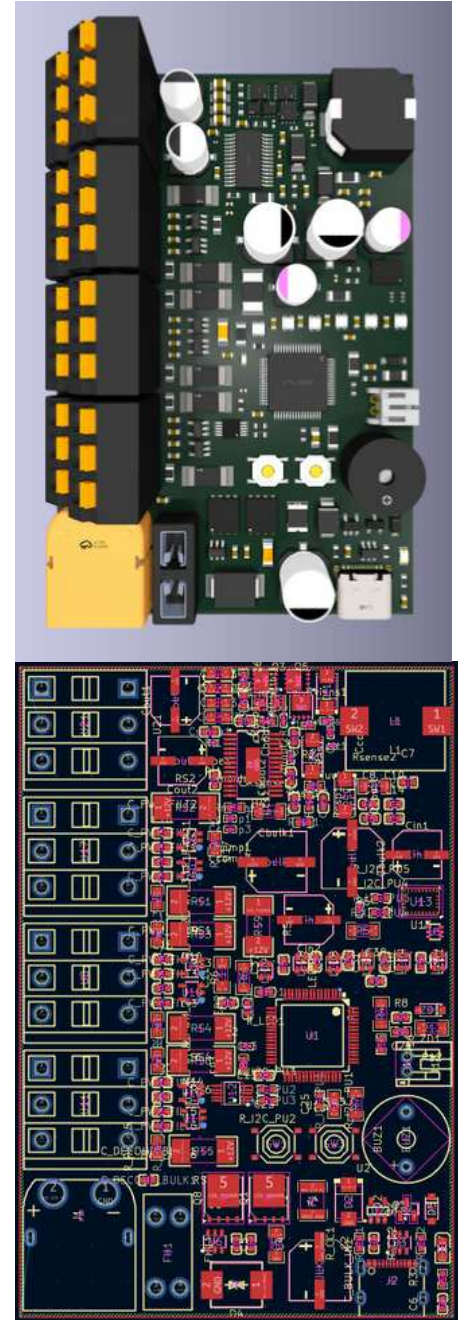


Figure 7: The PCB design and model

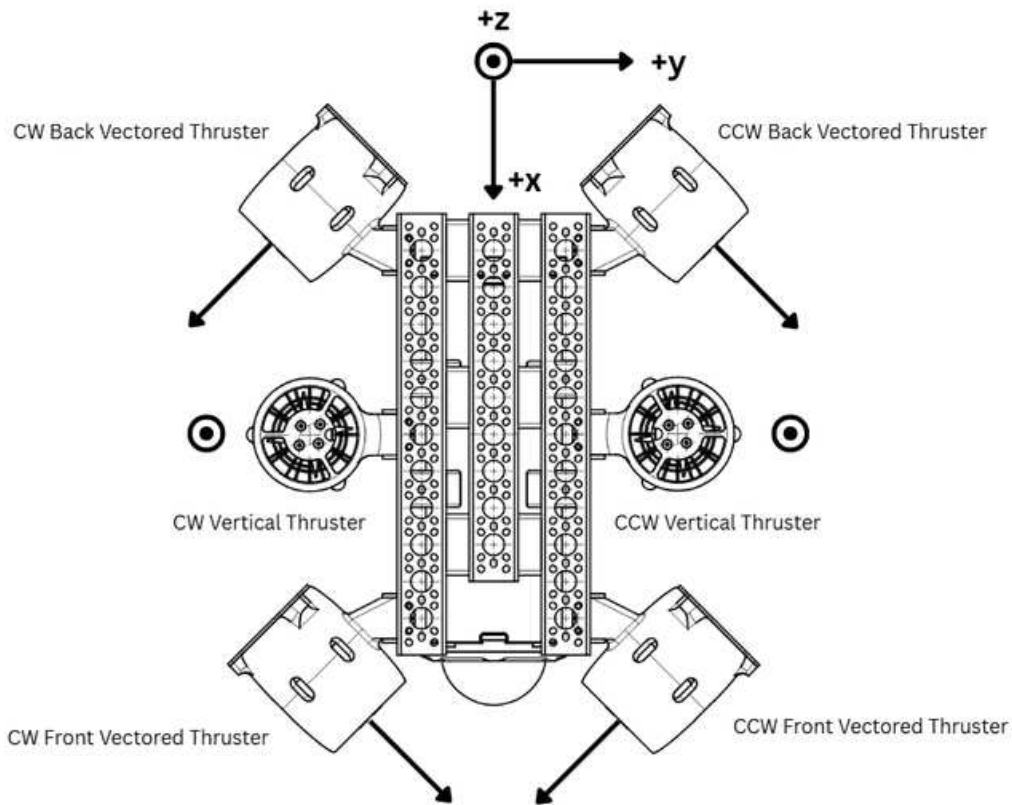


Figure 8: Thruster orientation and coordinate system

Our ROV utilizes a 6 thruster layout;

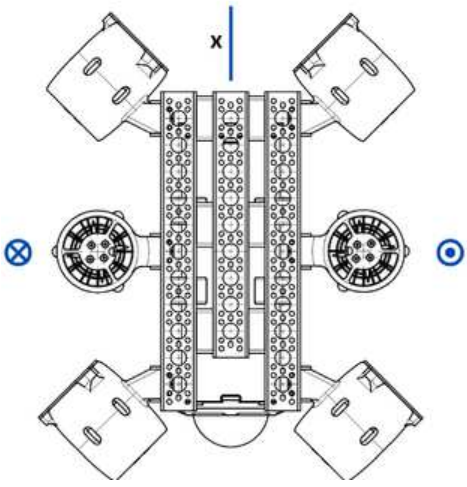
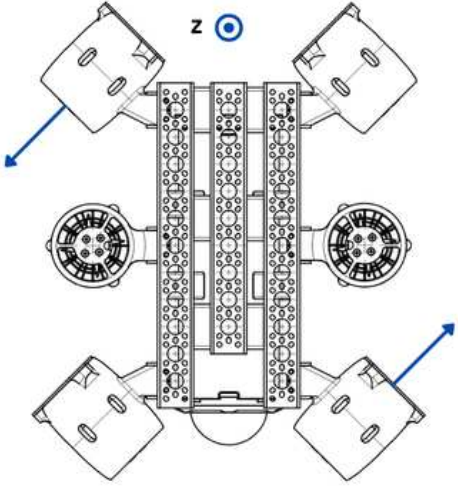
- 4 vectored thrusters in xy plane
- 2 vertical thrusters in z plane

The vectored thrusters are symmetrical which leads to components of the thrust getting cancelled out by the opposite thruster so motion only occurs along or around desired axis. The red lines in the X and Y Translation in Table 6 represent the components of the thrust that is cancelled out. The green lines represent

Table 6 : Thruster translation

Z Translation	X Translation	Y Translation

Table 7: Thruster rotation

X Rotation	Z Rotation
	

Cameras

The ROV contains two cameras within the tube. The primary camera has an Arducam IMX219 sensor with a wide-angle lense, providing full-color, and high-speed image feeds. The secondary camera is a 5MP Arducam sensor facing the bottom of the ROV's frame to provide strong visibilty when picking up objects with the bottom hooks, and viewing the transect. The secondary camera is purely used as a tool for the pilot's control, while the primary camera is used for the main camera feed, picking up objects with the claw, and autonomous mission task completion.

The primary camera has high-speed image encoding for the pilot's feed, sent via the Flask server to the Control Station laptop where it is decoded. During tasks, the pilot can take images of mission task objects for processing and autonomous CAD on the Raspberry Pi.

First, the camera was calibrated using the ChArUco algorithm, giving high-accuracy camera FOV and lens-shift measurements. These measurements are incorporated into the measurement of mission task items. When a snapshot is taken of a game object, it is processed with the OpenCV library. Using the OpenCV library, we mark contours for specific colors, such as the pink hue found on the Coral Garden markers, and then places bounding boxes around these contours. Using the dimensions of these bounding boxes, their offsets relative to each other, and the FOV and lens-shift measurements collected by the ChArUco calibration, we are able to accurately estimate the Coral Garden dimensions without any human input. The Coral Garden model is then forwarded to the web dashboard and displayed using the ThreeJS library, accurately modeling it in an interactive view that displays all measurements.

Tether Construction

Our tether consisted of our power and Ethernet cable. With the 14 AWG chosen, we were able to safely operate at a limit of 15 Amps. When initially finding our Full Load Amp Calculations (FLA), a single one of our thrusters at maximum drew about 7 Amps in water, and we calculated that our entire system would draw 50 Amps at full power. We implemented software limits on our thrusters that would keep their maximum amperage under 14 amps. Our underwater FLA with these limits was 14 Amps, which led us to choose a 15 Amp fuse. We used a CAT6 Ethernet cable connected to the surface control laptop to make sure constant connection is established with the Raspberry Pi and ESP32 to control ROV systems. Both tether cables used WetLink Penetrators in order to pass through the water-tight enclosure. Both cables were chosen to be approximately 30 meters, to provide sufficient distance for ROV operation and navigation underwater. The tether was made by covering our cables in a braided mesh sheathing. Floatation aids were secured around the tether at spaced intervals to provide buoyancy during underwater ROV navigation. These pool noodles were set up to provide the ROV with sufficient room to navigate freely, but not to a point where the tether would be dragging on the pool floor. We also didn't place the pool noodles too close to the ROV as that provided too much buoyancy and pulled the ROV up, preventing successful manipulation and movement.

Tether Management Protocol

Tether management is crucial for ROV operation and for personnel safety. Team members must refer to the Jobsite Safety and Environmental Analysis (JSEA) when working around the ROV. This ensures tether hazards, such as tripping, are communicated and prevented. The tether manager and safety officer work in tandem to ensure safety and protection of the ROV and personnel during operation.

Safety Checklist

- ☐ Closed-toe shoes
 - ☐ Safety goggles during workshop sessions and tool handling.
 - ☐ Secured hair, jewelry, loose clothing.
 - ☐ Dry hands before handling power/electrical and moving components.
 - ☐ Communicate 'POWER ON' when power is connected. All present team members MUST repeat this command, and the same for 'POWER OFF'.
 - ☐ No running by pool side. Mind your surroundings and footing.
- 

Float Design

Triton Tech ROV introduces our first non-ROV device, Eureka, an autonomous vertical profiling float that changes position through a volume displacement buoyancy engine while recording time and pressure. Eureka utilizes an original design and autonomous electrical and controls system to operate its syringe buoyancy engine.

The mechanical system is operated using a NEMA 17 DC Stepper Motor, that has an extending lead screw to provide linear actuation. A nut is integrated in the plunger mount connecting to the lead screw to provide the actuation mechanism. Three syringes provide redundancy in the case of syringe component failure. The syringe plungers are fastened with M3 screws into the plunger mount. A custom component, nicknamed the 'Dorito' for its triangular shape, fastens between the syringe plungers to provide bottom support during syringe actuation. The plunger mount also aligns with linear rods and bearings to provide structural support and prevent syringes from jamming during actuation. A rubber end cap with a U-bolt (for retrieval) is friction fitted at the top to provide a waterproof seal, and act as a pressure release valve in case of battery failure.

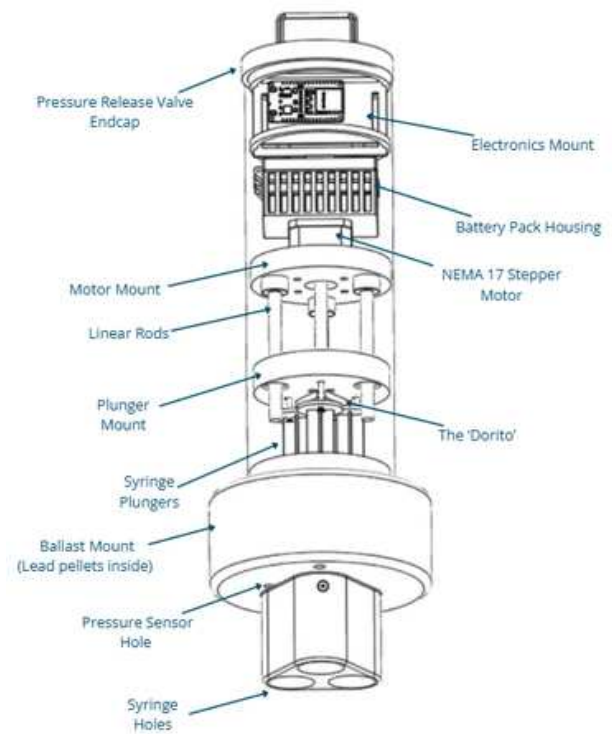


Figure 9: Labelled Diagram of Float

A ballast mount is secured to the bottom of the float to provide additional weight for buoyancy and balance adjustment. This component also supports the syringes extending through the ballast mount, and has a hole to accommodate the pressure sensor wires. The ballast mount is hollow to provide space for lead pellets for additional mass to fine tune center of gravity and buoyancy according to ocean salinity. The lead is then encased in epoxy resin to prevent harmful exposure and the pellets from shifting.

Electrical design safety regulations were considered to align with MATE's Request for Proposals. The float's autonomous power is provided by a 12V DC Nickel-Metal Hydride (NiMH) battery selected for wire gauge with a 2 Amp fuse selected based on full load amperage value. We selected a 12V NiMH battery pack to accommodate the stepper motor's high-torque actuation. The 18 AWG supports 16 Amps, which is adequate for the 2 Amp current draw. The battery pack is secured in a heat-resistant, durable PETG ventilated housing.

The float uses an ESP32 microcontroller for software development and data collection. A buck converter is used to step down to 5V for ESP32 power, while the stepper motor receives 12V. The stepper motor is controlled by a A9488 Stepper Motor Driver, to provide a logic power supply for motor actuation. A 1000 μ F capacitor is integrated into the PCB to prevent voltage spikes and damage to the motor driver. The ESP32 connects to the GY-MS5837 Pressure Sensor via I2C signal for data collection and retrieval using the ESP32's Wifi/Bluetooth features. The pressure sensor is placed at the bottom of the ballast mount and syringes to provide accurate readings of depth.

Triton Tech ROV 2026

Edmonds College, Lynnwood, WA

ROV SID

KEY

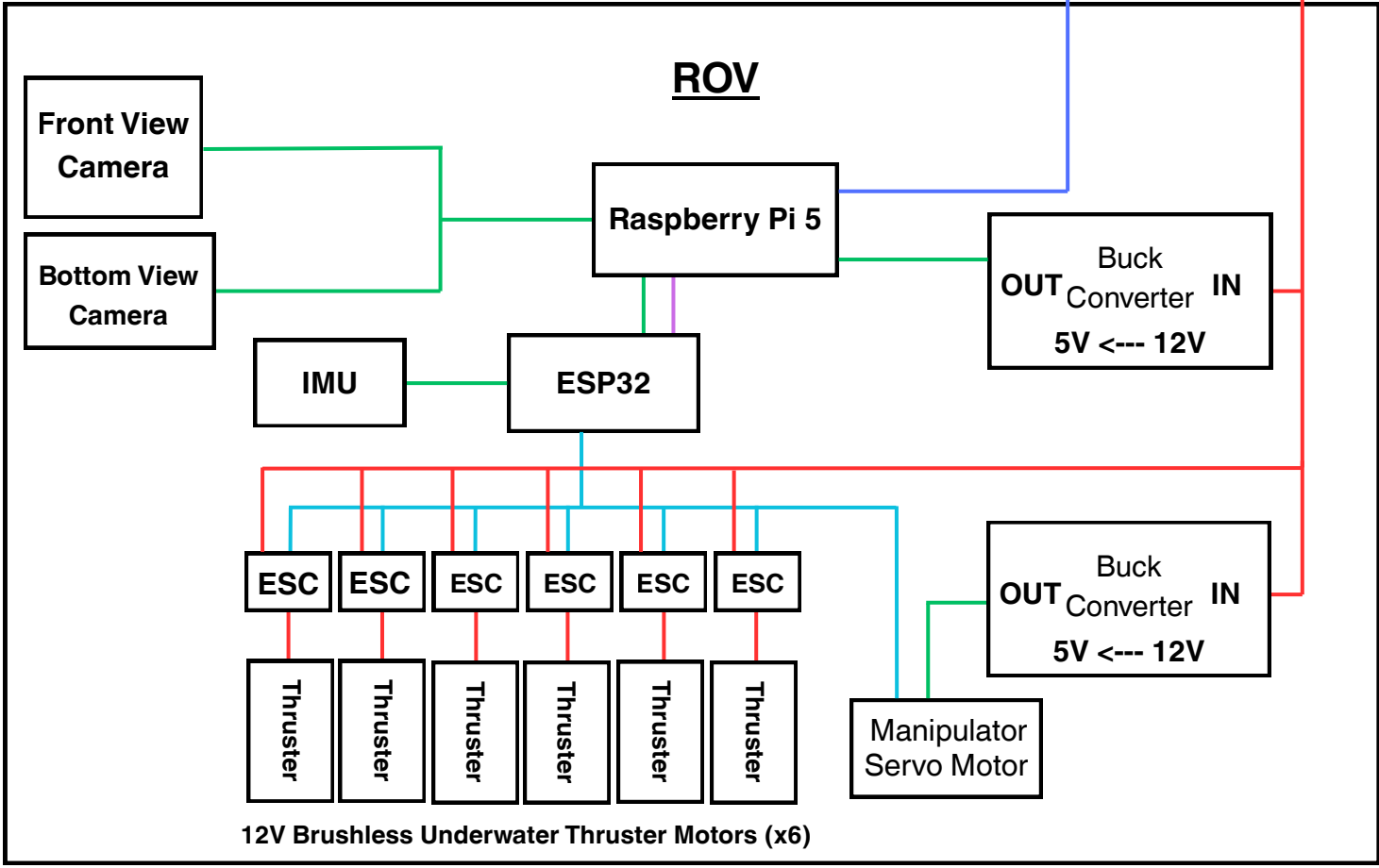
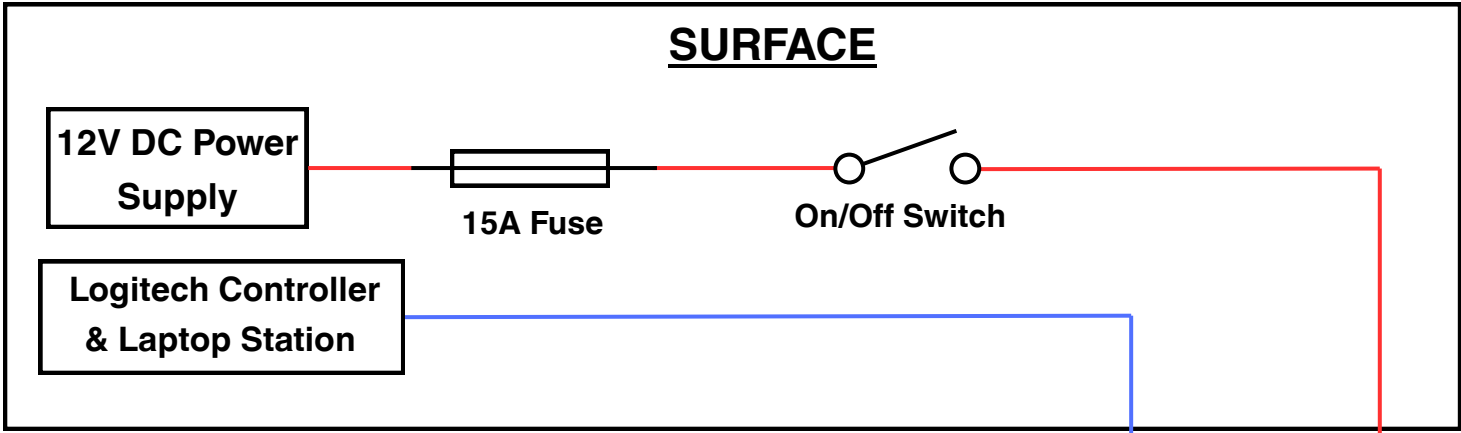
Power 12V

Power 5V

Ethernet

USB/Serial

PWM Signal



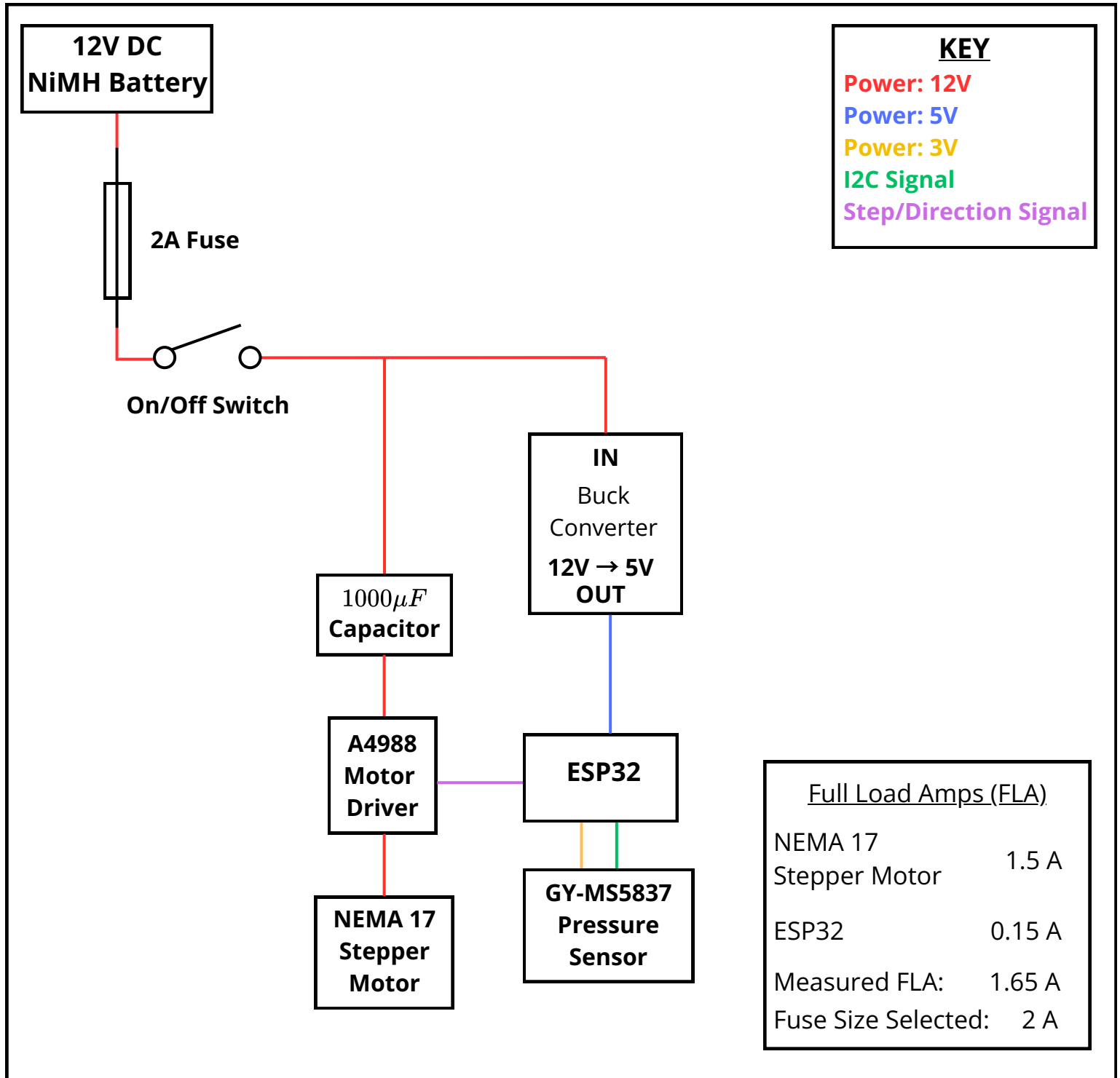
Measured Full Load Amps (FLA) Underwater: 13.9 A

Fuse Selected: 15 A

Triton Tech ROV 2026

Edmonds College, Lynnwood, WA

Float SID



At the beginning of the season, we developed a projected budget in creating the bid for proposal for the 2026 Project Demonstration. Our past data allowed for our team to optimize and adjust delegations of our expense categories by reviewing spending trends and allocation reports from 2024 and 2025 seasons. This in turn helped support the technical demands of this year’s ROV design. New emphasis was placed on Testing & Prototyping to support system validation, iterative improvements, and design reliability throughout development. Additional planning was also dedicated toward Demonstration. Logistic and travel coordination as the team prepared for increased operational responsibilities throughout the season.

Compared to previous projects, the overall project budget increased due to the purchase of new components, expanded testing efforts, and rising registration expenses. This year’s ROV required significant investment in updated electronics, structural materials, propulsion systems, and mechanical components to improve overall functionality and performance. While some tools and materials from previous years were still utilized when appropriate, much of the system was newly developed or replaced to better support the team’s engineering goals and RFP Demonstration requirements. MATE RFP travel and logistics expenses were largely supported through grants and external funding, allowing the team to focus more of its direct budget on technical development, testing, and system improvement throughout the season.

Table 8: 2026 travel budget estimate

Travel Estimate				
Category	Description	Cost (USD)	Qt.	Subtotal
Airfare	Round-trip flight for team members	\$1,000	6	\$6,000
Lodging	Hotel accommodations	\$200 / day	2	\$1,000
Car Rental	Local transportation and equipment transport	\$130 / day	1	\$650
Allowance	Meals and daily expenses	\$60 / day	6	\$360
			Total	\$12,425

Table 9: Budget allocation comparison by years

Budget Allocation				
Category	Description	Yearly Costs (USD)		
		2024	2025	2026
Materials & Structure	Frame materials, structural components, enclosure systems	\$347	\$687.90	\$605.69
Electronics & Control	Microcontrollers, sensors, cameras, wiring, power systems	\$1,107.85	\$362.06	\$394.02
Manipulator System	servo-motor systems, mechanical arm components,	\$208.84	\$240	\$83.37
Propulsion System	Thrusters and motor controllers		\$223.96	\$222.50
Hardware & Fasteners	Screws, mounts, adhesives, sealing components	\$63.83	\$92.32	\$104.12
Outreach & Operations	STEM outreach, events, engagement materials	\$200		
Testing & Prototyping	Experiment materials and testing components.			\$264.71
Buoyancy	Passive depth control (Pistons, floats, weights)	\$191.14		\$79.80
Logistics	Equipment transport, shipping, packing materials, and		\$200	\$200
Registration Fees	Team registration, participation, and event-related fees	\$25	\$550	\$550
Travel	Transportation, lodging, meals, and travel expenses for team	\$10,000	\$11,850.23	\$12,450
Total Project Value	Actual costs including reusable component savings, donations,	\$12,322.98	\$13,656.23	\$14,954.21
	Total Estimated Cost:	\$1,722.98	\$777.26	\$2,001.66

Table 10: Available funds for the 2026 year

Category	Name	Amount in USD
Sponsorship	Edmonds College Student Government	\$12,425
Fundraising	Through selling Brown Bear Car Wash Tickets and the Edmonds College Foundation	\$8,551
Club Funds	Triton Tech ROV operational reserve funds	\$2,000
	Total:	\$22,476

Table 11: Total cost of the ROV for the 2026 year

Budget Category	Type	Item(s)	Est. Value (USD)
ROV Surface Station	Purchased	Control system, monitor, tether interface, controllers, and wiring	\$850
	Reused	Tether	\$200
Manipulator System	Purchased	servo-motor motors, gripper assembly, mounting hardware	\$323
ROV Electronics	Purchased	Raspberry Pi, Pi camera, sensor, control boards, and power	\$394
ROV Structure	Purchased	Blue Robotics Tube, aluminum U-Channel, frame materials, waterproofing materials, screws, mounts adhesives, and sealing	\$710
Propulsion System	Purchased	Thrusters and motor controllers	\$223
Buoyancy System	Purchased	Floats, ballast, and buoyancy materials	\$80
3D Printing & Fabrication	In-kind	Filament, machine time, prototyping prints, iteration	\$150
		Total	\$2,930

References

- [1] <https://bluerobotics.com/store/watertight-enclosures/wte-vp/>
- [2] <https://www.gabrian.com/wp-content/uploads/2018/09/6061-Aluminum-Alloy-Properties-1.pdf>
- [3] <https://bluerobotics.com/store/cables-connectors/penetrators/wlp-vp/>
- [4] <https://www.underwaterthruster.com/products/u01-12v-16v-200w-2kg-thrust-brushless-underwater-subsea-thruster-propeller-propulsion-with-bi-directional-control-esc-for-rov-boat?variant=42640242639076>
- [5] <https://www.gobilda.com/1143-series-mini-low-side-u-channel>
- [6] <https://www.gobilda.com/1205-series-dual-block-mount-1-5-2-pack/>