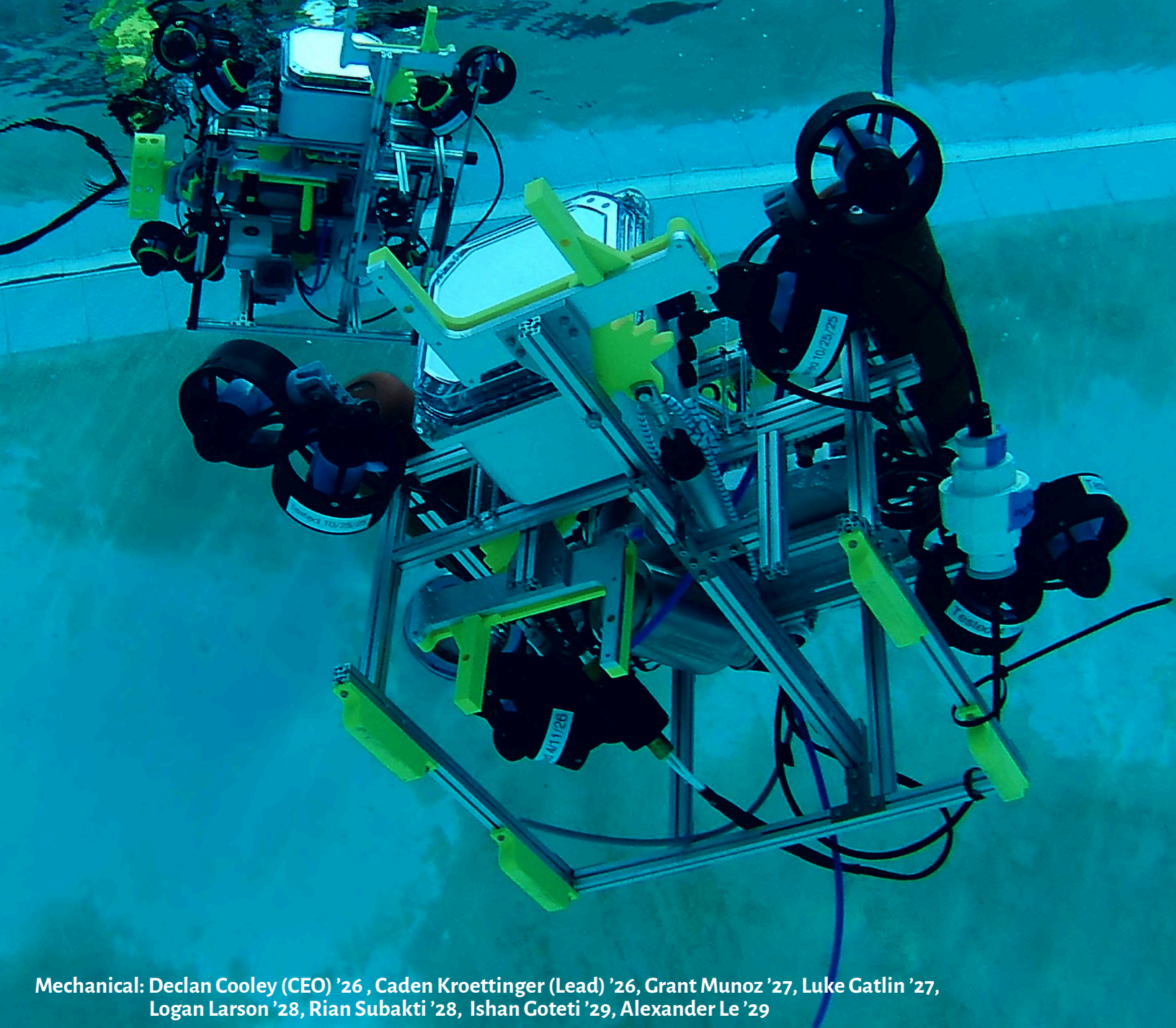


ROVOTICS TECHNICAL REPORT

2026 Company ID: 0247A



Mechanical: Declan Cooley (CEO) '26 , Caden Kroettinger (Lead) '26, Grant Munoz '27, Luke Gatlin '27,
Logan Larson '28, Rian Subakti '28, Ishan Goteti '29, Alexander Le '29

Electrical: Harry O'Hagin (Lead) '26, Oscar Pereira '28

Software: Jack Frings '26 (Lead), Ian Kim '27, Jonah Mayer '28, David Janssen '28

Mentors: Jay Isaacs, Cheryl Kiyama, Steve Kiyama, Michael Sharp , Virginia Clemmens

*All photos included in this report were taken by ROVOTICS.

Jesuit High School | Carmichael, CA, USA

Abstract

ROVOTICS, a 14-member student robotics company from Jesuit High School developed its latest ROV, **Hydra**, to address the missions challenges of the 2026 MATE RFP. Engineered for operation in harsh ocean environments, *Hydra* features a modular frame and a reliable electronics system, along with a versatile set of tools designed to meet MATE mission requirements with high reliability and ease of operation. Throughout the design, build, and testing of the ROV, ROVOTICS prioritized the safety of the crew and the environment as its top priority.

Supporting the United Nations Decade of Ocean Science goals, *Hydra* uses an eight-thruster configuration for precise maneuvering during Holyrood Subsea Observatory servicing and coral bed seabed mapping. A key technical innovation is the magnetically coupled motor, housed in a resin-printed watertight housing that utilizes neodymium magnets to eliminate the risk of shaft leaks or corrosion. This system provides the reliability needed to remove camera biofouling using swappable, mission-specific attachments. Additionally, a stereovision system enables accurate 3D modeling of delicate habitats. All systems, including coral collector tools and protected thrusters, were developed to ensure the operational safety of personnel and the protection of the marine environment.

Included with the ROV is **Triton**, a GO-BGC-inspired profiling float designed to monitor freezing ocean conditions while maintaining specific depths. This report details the design rationale, systems integration, and testing methods used to ensure *Hydra* and *Triton* address the 2026 MATE theme: Pushing Performance: Science, Technology, & Discovery in Harsh Environments.



Figure 1 - ROVOTICS Team

Table of Contents

Abstract	2	Payload/Tools	13
Teamwork	3	Critical Analysis	16
Design Rationale	4	Safety	17
Vehicle Systems	6	Accounting	19
Mechanical	6	Acknowledgments	20
Electrical	7	Appendix	20
Software	11		

Teamwork

Company Structure

ROVOTICS is led by its Chief Executive Officer (CEO) for organizing the team and Chief Operating Officer (COO) responsible for managing operations and finances. The company is organized into three specialized departments: Mechanical, Electrical, and Software with each department managed by a lead who reports directly to the CEO. The company also appointed a Safety Officer to ensure safety, supporting mission reliability and following company safety practices as a top priority. A full breakdown of the company's roles is documented on the cover page of this report.

To maintain team expertise, ROVOTICS utilizes a formal succession plan centered on technical mentorship. This was implemented through a twin-ROV strategy. Experienced leads constructed the primary vehicle while underclassmen built an identical training ROV using lead-developed build guides. All projects and deadlines are managed via Basecamp and Github to ensure standardized safe practices and key technical skills are retained each year.

Project Schedule

ROVOTICS uses a structured development timeline divided into Pre-RFP and Post-RFP phases to ensure vehicle reliability and mission readiness. The schedule is managed through Basecamp, where milestones are broken down and managed using Kanban cards to assign tasks to department team leads.

Phase 1: CORE ROV Development (Aug-Dec): Focused on achieving a basic functioning ROV that can “Drive & See” by December. This phase involves reviewing previous systems and prototyping a modular frame and electronics control and power systems before the

MATE mission RFP is released.

Phase 2: Mission Tools Development (Jan-May): Following the RFP release, development efforts shift to mission tools and the profiling float. Each system follows a standard design process: Plan, Prototype, Iterate, and Test, that results in a “Mission Ready Release” in May.

Phase 3: Operations Training (May-June): After final systems integration, the company mandates 40 hours of mission practice. This phase focuses on deck crew training, operations checklist execution, and pilot training to ensure operations are conducted safely and efficiently.

Project Management

To manage employees' day-to-day project work, ROVOTICS used several key resources and protocols to ensure the overall team stays on track with achieving project objectives.

RESOURCES

ROVOTICS uses industry standard tools for design and code management. We use Autodesk Fusion 360 for mechanical design, enabling real-time collaboration and version control of physical components of *Hydra* and *Triton*. Our electronics team relies on KiCad for reproducible circuit board designs. Finally, we manage our software through GitHub, allowing team members to track changes, review code, and collaborate efficiently. By using these resources, technical errors are avoided, ensuring ROV development stays organized and on schedule.

PROCEDURE

When proposing and implementing designs, ROVOTICS utilizes both design change requests and bills of materials (BOMs) to manage projects. Our design change requests are technical writeups that

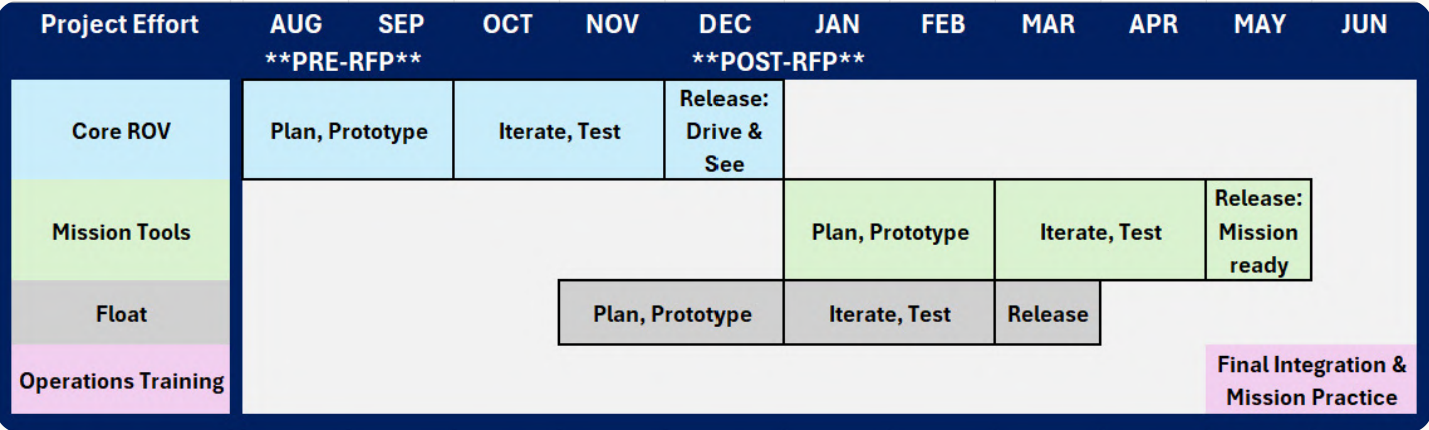


Figure 2 - Rovotics Project Schedule

that detail the motivation behind a change and plans for implementation. After ROVOTICS approves a given change request, we then use a BOM to track the necessary components and ensure that purchases align with the planned budget. This procedure improves interdepartmental coordination and maintains clear technical documentation, resulting in quality, cost-effective, and reliable engineering.

PROTOCOL

To manage operational challenges and maintain project schedules, ROVOTICS follows a structured communication protocol. Weekly virtual meetings allow departments to coordinate progress, align goals, and proactively address resource and material needs. Additionally, eight hour Saturday workdays include an opening and closing stand-up meetings to ensure development stays on track and technical challenges are being addressed. Team members also track progress and document issues through Basecamp Kan-Ban boards, while Discord is used for immediate communication and coordination of day to day issues. This overall approach ensures that project issues are identified early on and addressed quickly, keeping projects on schedule.

Design Rationale

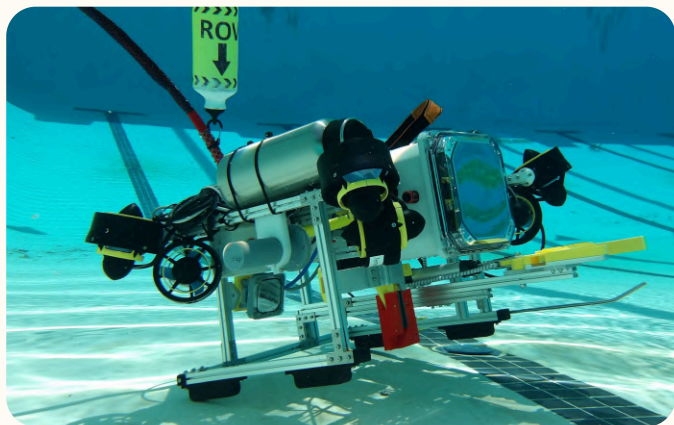


Figure 3 - Hydra ROV

When planning *Hydra's* fundamental design, our first consideration was the environment we would be operating in: Memorial University in Newfoundland, which includes harsh environments such as the flume tank, engineering basin, and salinity tank. To address the MATE mission theme and specific mission tasks, Pushing Performance: Science, Technology, & Discovery in Harsh Environments, ROVOTICS designed *Hydra* to be adaptable, reliable, and highly controllable under demanding operating conditions. Our goal was

to ensure *Hydra* could successfully support scientific discovery and mission operations across all MATE environments.

We pursued this goal through three primary strategies, which dictated all design decisions:

1. Improved pilotability
2. Greater reliability
3. Enhanced modularity

Brainstorming

When brainstorming *Hydra's* design, ROVOTICS first evaluated prior systems to determine how effectively they supported our core engineering strategies of pilotability, reliability, and modularity. Using lessons learned from previous competition seasons, team members developed formal Change Requests (CRs) that proposed improvements through technical analyses, CAD models, prototypes, and weighted design matrices.

Each Change Request was reviewed collaboratively by the full team to validate the proposed solution and ensure it aligned with mission objectives and operational needs in harsh environments. When weighing changes, we always took into account how each proposed change would affect the various mission tasks. For example, the transition to an eight-thruster configuration was driven by the need for rotation on all angular axes (pitch control). In addition to a greater control over movement, pitch control made it easier to install the new eDNA sensor (Task 2.5) and collect coral species by the substrate (Task 1.1). During these reviews, ROVOTICS also carefully considered engineering tradeoffs such as performance gains, reliability, manufacturability, cost, and development time before approving modifications.

This structured and data-driven design review process allowed ROVOTICS to efficiently identify which systems should be retained, refined, or redesigned. As a result, *Hydra* was engineered into an adaptable and mission-focused ROV optimized for the demanding conditions of the MATE competition environments.

Systems Approach

Following the change request process, we designed our mechanical, electrical, and software systems with compatibility in mind. Each design underwent cross-department input to ensure proper integration among all systems. For example, when designing our eight-thruster system, we considered the mechanical and electrical implications. Due to the Power8Board

larger, a larger Power System Enclosure (PSE) was chosen to enclose the board. We considered adjustments in the frame and buoyancy to ensure that mechanical performance wasn't compromised. Additionally, the higher power systems necessitated a thermal redesign. To manage this, the electrical department coordinated with the mechanical team on developing a heat sink that is custom to the power converters' dimensions on the Power8Board. This cross-department collaboration is also present among electrical and software departments as well. Sensors on the Power8Board were specifically chosen for their python software library support, ensuring easy integration into our software stack. ROVOTICS' focus on subsystem integration makes *Hydra* very reliable.

Re-Used Design Decisions

Our focus on reliability led us to keep the systems that performed well. This meant manufacturing our frame from 15x15 mm aluminum extrusion due to its low weight and high durability compared to other options on the market. Our grippers were also reused due to their ability to be actuated via the joystick, optimizing pilot ergonomics, as well as their ability to be fitted with a variety of gripper fingers suited for collecting basket stars (Task 1.1), retrieving coral species (Task 1.1), moving edna sensors (2.5), and plugging power connectors (Task 3.2). Finally, we opted to continue utilizing ROS 2 as the basis of our software stack, allowing for a modular, package-based organization (discussed further in Software).

Innovations

Our systems approach also led us to significantly improving prior systems. For example, when considering Memorial University's harsh environments, we recognized a need for improved maneuverability.

As a result, we upgraded our existing six-thruster Blue Robotics T100 configuration to an eight-thruster T200 design. This upgrade greatly improved *Hydra*'s pilotability by enabling rotation on all angular axes while also improving *Hydra*'s thruster efficiency and net thrust. One tradeoff, however, is the increased cost. Upgrading the thrusters and adding two more not only increased costs, but it lengthened the time needed to build and service the ROV. Ultimately, we decided that the increase in maneuverability for missions was worth the cost of two additional thrusters.

This year, we also converted our camera system from a prior silicone-sealed, ethernet design to a O-ring

sealed, USB solution. This choice eliminated prior issues with cameras dropping off the network, increased system reliability and performance, and improved our cameras' modularity and serviceability thanks to their o-ring design. These improvements were critical for the image recognition of invasive European Green crabs (Task 2.1) and the photogrammetry used to autonomously model the coral garden ridge (Task 1.2).

Mission Tool Integration

After completing our Core-ROV, ROVOTICS moved forward to developing ROV tools to accomplish specific missions that our core systems could not solve. When initially designing tools, we follow a similar process to the Core ROV via design proposals and company review. ROVOTICS' tools also embrace the importance of adaptability, as seen in our gripper fingers designed to transport objects like the eDNA sensor (Task 2.5) and our magnetically-coupled motor designed to remove biofouling from the Holyrood Subsea Observatory (Task 2.5). Both of these tools contain a base device designed to connect with a variety of 3D-printed attachments, embracing the importance of modularity and adaptability.

Testing and Final Product

Throughout the entire process of development, ROVOTICS embraces a strict testing procedure. Every feature, from Core ROV modifications to individual tools, must be verified individually and validated on the ROV for multiple hours to ensure design quality. Aside from individual testing, we also tested based on three primary ROV-milestones: Drive and See in which we tested *Hydra*'s core systems, Qualification Video in which we tested *Hydra* with MATE's assigned missions, and Mission Practice in which *Hydra* performed mission runs for 40+ hours ensuring *Hydra*'s functionality and adaptability.



Figure 4 - Stereovision Testing Before Final Integration

Vehicle Systems:

Mechanical

Frame

Hydra's frame provides an ideal foundation for the ROV's hardware. Built from aluminum extrusions with t-slots, the modular frame offers versatile mounting options for tools, cameras, and various components along its structure. The aluminum segments are secured with brackets, screws, and sliding nuts, all of which create secure joints and allow for easy adjustments. The team chose 15 mm x 15 mm aluminum extrusions because they provide ample strength without the cost, size, and subsequent drag that larger extrusions and polycarbonate sheet frame designs have in water. This year, ROVOTICS recycled most of the material from a previous frame into a new design, saving money and promoting sustainability. For safety, smooth end caps are placed on the ends of the extrusion, eliminating sharp edges and thus ensuring operator safety.

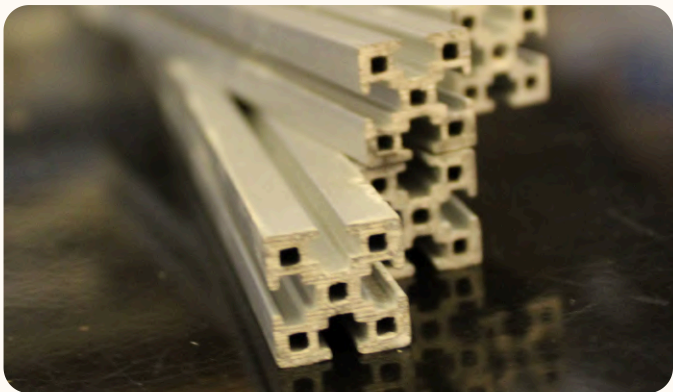


Figure 5 - Aluminum T-slot Extrusions Used for ROV Frame

Buoyancy and Ballast

Hydra's buoyancy system is divided into static and dynamic components. The static component is made of two electronics housings and two water bottles,

which serve as the primary buoyancy components. Water bottles are positioned to provide stability and maintain easy serviceability for the electronic compartments. Dynamic buoyancy is modular and consists of two adjustable stacks of hydrostatic foam squares. Foam squares secured with quick release pins allow for rapid buoyancy adjustment.

To calculate *Hydra's* buoyancy, the team measured the displacements and densities of its components by referencing the CAD model. Using Archimedes' principle, we calculated the ROV's weight in water and then adjusted the buoyancy as such. Performance tests were then conducted with each payload configuration adjusted for neutral buoyancy. Also, tools are placed below the center of buoyancy, adding to the stability of the ROV.

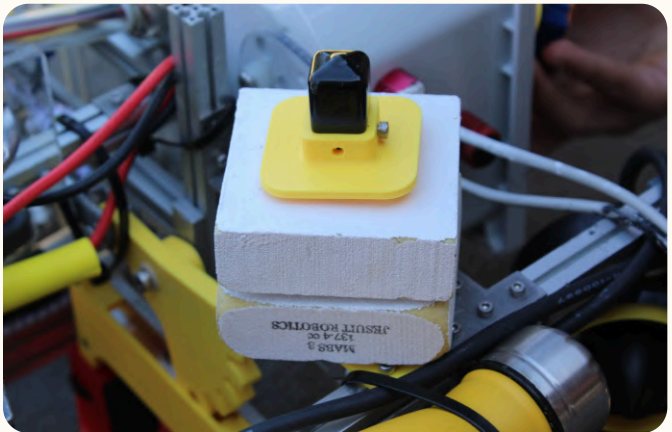


Figure 6 - Modular Adjustable Buoyancy (MAB) on Hydra ROV



Figure 7 - Hydra Static Buoyancy

Item	Quantity	Mass (g)	Volume (cm3)	Net (g)	Net Force (N)
Core ROV	1	-13465	8920	-4545	-45
Static Buoyancy	1	-1,950	5,270	3,320	33
Modular Buoyancy	8	-42	1150	1109	11
Total		-15,457	15,340	-117	-1

Figure 8 - Buoyancy Calculations

Thrusters

For enhanced motion, *Hydra* is now propelled by eight Blue Robotics T200 thrusters, marking a significant improvement from our previous six-thruster ROVs. This configuration consists of four vertical thrusters and four 45-degree horizontally mounted thrusters, which add pitch control to the ROV. Pitch control is critical, opening up a completely new axis of rotation we were never able to access before. For example, during the eDNA task, pitch control allows the sensor

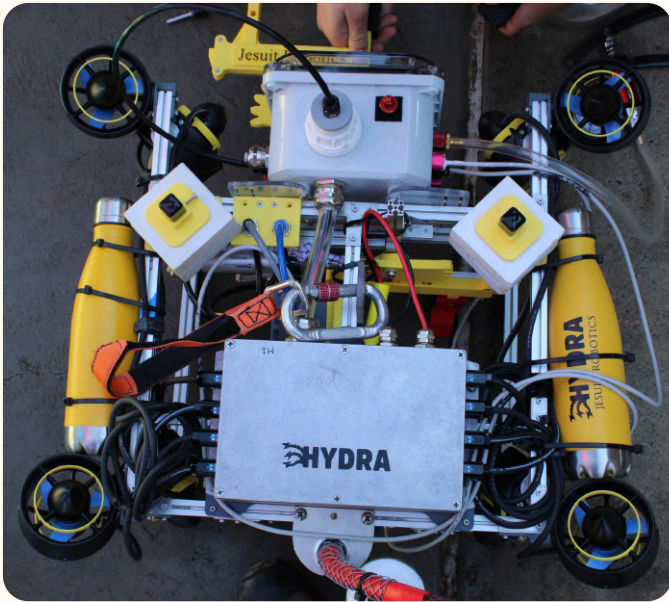


Figure 9 - New Eight Thruster Configuration

to be inserted. The new system also offers increased roll power and higher vertical thrust, making it easier to maneuver in adverse conditions, such as in the new wave pool at this year's competition location. For horizontal movement, we decided to reuse previous year's vectored thruster configuration as it provided substantial lateral and forward thrust while providing agile angular movement.

The transition from T100 to T200 thrusters addresses end-of-life concerns with T100s, ensuring that ROVOTICS will have a reliable thruster option for future years. The higher power of the T200s grants much higher thrust, which is especially vital for turbulent settings. It also provides superior efficiency, as less time is wasted in transit between tasks and the deck. All thrusters are equipped with guards, preventing people and wildlife from coming into contact with the propellers.

This system redesign required fundamental changes to both the electrical and software components. Electrically, we designed a new PCB called the

Power8Board to incorporate eight slots for Electronics Speed Controllers (ESC). Software takes advantage of new sensors that are actively monitoring current and voltage to each of the thrusters. To mitigate the risk of brownouts, new features ensure thrusters will not consume too much power at any given moment, protecting both the ROV and its operators from potential hazards.



Figure 10 - T200 Thruster with Thruster Guards

Electrical

Hydra's electrical system consists of two subsystems: topside and bottomside. These interface with each other via the tether for data transmission and power delivery. Topside comprises all electronics above the surface and is responsible for powering and controlling the ROV via a simple pilot interface. Bottomside includes all submerged electronics, including the ROV's control electronics, power system, and onboard sensors.

Topside

The Topside Control Unit (TCU) consists of the hardware that controls and powers the ROV. All the components easily fit within a Pelican Case, which was chosen for its durability and portable design. To improve serviceability, the team color-coded wires according to their corresponding components and implemented a cable raceway to reduce clutter and ensure easy access to internal parts without interference from loose wires.

The monitor is mounted into the lid, while the TCU's organized bottom compartment contains hardware that can be easily accessed by lifting the hinged control panel. An Ethernet connection reliably transmits data to the bottomside electronics, and there are solenoids and bulkhead connectors for pneumatics. To maintain reliable power, ROVOTICS designates two distinct

formats of high-current Anderson Powerpole connectors, one for the 48V MATE-supplied power and another for the 48V tether power. This prevents the potential swapping of input and output power lines. On deck, the co-pilot uses a laptop to launch and control *Hydra's* software. This approach allows any laptop to control unique software setups, improving adaptability. The laptop integrates with several devices to provide a quality piloting experience, connecting to a joystick and monitor to enable pilot control over the thrusters and grippers. To adjust ROV settings and run mission-critical programs, the laptop itself also displays a Graphical User Interface (GUI).



Figure 11 - Topside Setup

Tether

To connect the ROV to surface controls, the tether reliably delivers power, data, and compressed air while maintaining the ROV's full maneuverability. Connecting the TCU and ROV, a braided strain relief evenly distributes tension across the tether's durable polyester sheathing, protecting vital cabling from sudden movements. Additionally, this strain relief

allows the ROV to be safely lifted by the tether without damaging connections. Incompressible buoyancy nacelles can be configured along the tether to create custom curve profiles, preventing the tether from disturbing the environment or obstructing operation. To fine-tune buoyancy, the deck crew can easily alter the amount of water in these nacelles. For an optimal design, ROVOTICS determined the tether length by analyzing the aquatic operating environment. Power is transmitted to the ROV through a pair of 12 AWG wires, which were selected due to their optimal balance between flexibility, weight, and low-resistance electrical properties. This ensures that our power electronics receive the appropriate voltage while the tether remains easily operable. A Cat6A Ethernet cable is used to transmit data due to its high transmission speed, allowing us to stream multiple USB cameras at a high frame rate and resolution. Two flexible pneumatics lines control the horizontal and vertical gripper. The lines are color coded to eliminate the possibility of flipped connections and are rated to 6.89 bar (100 PSI), meeting MATE safety specifications.

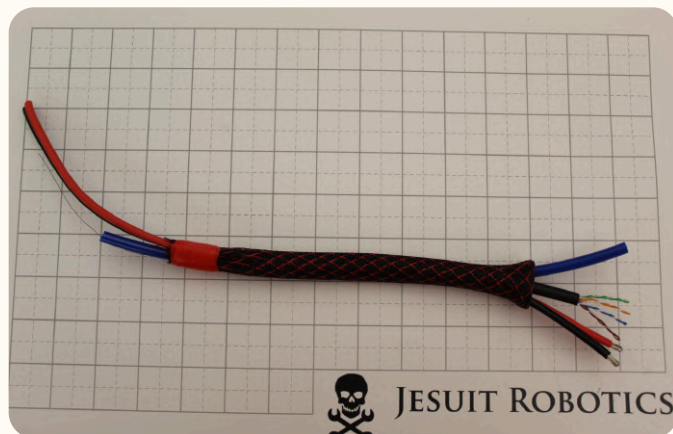


Figure 12 - Tether Construction

To address previous issues with the underwater Bulgin ethernet connector, which suffered from consistent leaks, the team transitioned to a threaded PVC union, which is far cheaper, more robust, and has better water resistance because it features a larger o-ring cross-section. Inside the union, an RJ45 coupler links the male connectors from the ROV and the tether. Before selecting this design, the team experimented with an 8-pin Subconn connector, but discarded it because its non-twisted wires limited data throughput to 100 Mbps. The current PVC threaded union RJ45 connection successfully achieves the 1 Gbps throughput necessary for high-definition camera streaming and responsive piloting.



Figure 13 - Hydra Tether

Tether Management

ROVOTICS established a Tether Management Protocol to standardize safe tether handling practices, minimizing risk to personnel and marine wildlife while maintaining reliable vehicle operations throughout every mission.

1. Inspect the tether for damage and uncoil before deployment.
2. Attach the strain relief, then connect the tether power, pneumatic, and signal lines in sequence.
3. Continuously monitor tether slack and adjust position to accommodate *Hydra's* movement throughout the mission.
4. After the ROV shutdown, disconnect the tether from the TCU and ROV.
5. Coil the tether using the underhand-overhand method to prevent twists and tangles during storage.
6. Verify connectors are clean and dry before installing protective covers on all connectors when not in use.
7. Store the tether on the cart for protection and ease of transportation.

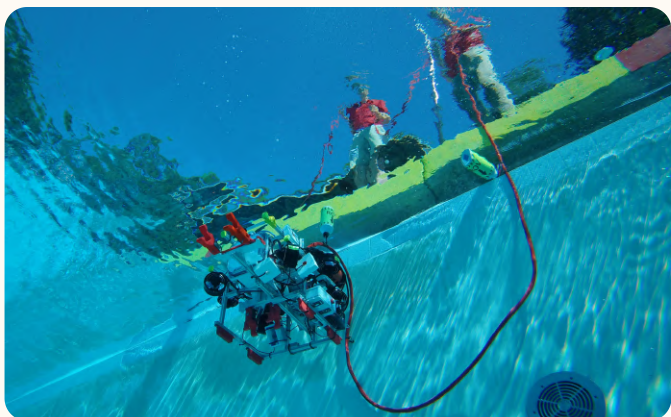


Figure 14 - Tether Management During ROV Operation

Bottomside Electronics

Hydra's electrical system is simple and modular. ROVOTICS chose to divide the bottomside electronics into two housings: the Main Electronics Housing (MEH) and the Power Systems Enclosure (PSE). This division capitalizes on the different properties of both housings. The MEH's clear lid offers operating and servicing advantages for control electronics, while the aluminum PSE dissipates heat from the power electronics. Additionally, dividing the electronics system allows the team to isolate variables when testing, simplify servicing, and balance buoyancy distribution across the ROV.

A clear, flexible tube connects the electronics within the PSE and MEH. Through this tube, the power electronics provide power to control electronics in the MEH, and control electronics communicate thruster data to power electronics in the PSE. This tube is especially beneficial for maintenance because it allows both housings to be vacuum tested simultaneously to confirm water seals, reducing complexity and improving the reliability of testing.

The tube is strategically positioned high enough on both enclosures to isolate each housing should a leak occur. After manufacturing, the housings are submerged and cycled in vertical profiles to stress test the seals and reveal faults that could cause leaks. This testing method simulates the mission environment where the ROV is profiling the area frequently. Before operating the ROV, ROVOTICS vacuum tests the enclosures to confirm they can hold a consistent pressure for at least 15 minutes, verifying the integrity of the watertight seals.

Power Electronics

Hydra's power electronics are housed within the Power Systems Enclosure (PSE), which was redesigned this year to support an expanded eight-thruster configuration. ROVOTICS selected a larger enclosure model, increasing the available internal volume by 67% to accommodate additional power hardware while maintaining accessibility and reliability. This change allowed the team to scale the vehicle's capabilities as it allows for an eight-thruster configuration without compromising electrical safety or serviceability.

At the core of the PSE is the custom Power8Board, which manages the distribution of the ROV's 48V supply to all onboard systems. The board steps down

control electronics, tools, and cameras using high-efficiency power converters. These converters were chosen to minimize energy loss and heat generation while providing built-in protection against electrical faults such as overheating, overvoltage, and short circuits. This approach improves overall system reliability while making full use of the available power budget.

To ensure stable operation within the MATE competition's 30A current limit, the Power8Board continuously monitors both voltage and current draw through its new sensing architecture (see Figure 15). This real-time feedback allows the system to prevent brownouts and gives pilots and onboard software clear insight into power usage during operation. By actively tracking power consumption, the ROV can safely support multiple thrusters and mission tools without unexpected shutdowns.

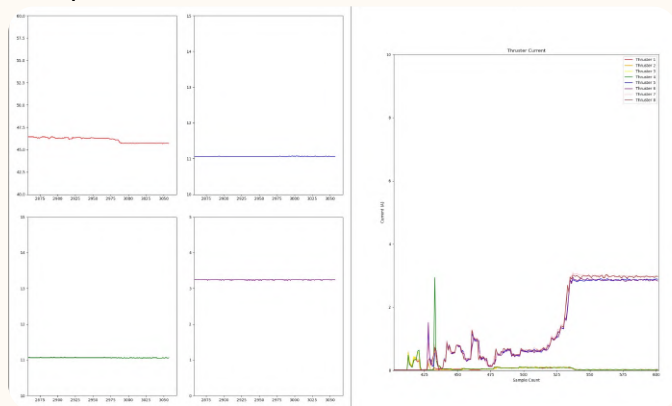


Figure 15 - Thruster Current Draw

Thruster control is handled through a combination of commercially proven electronic speed controllers and custom interface boards. Commands from the onboard computer are converted into signals suitable for the thrusters, allowing the system to flexibly support either a 6-degree-of-freedom configuration or additional mission-specific motors. This modular design ensures that future changes can be made with minimal redesign.

Thermal management was a key consideration in the PSE design. Since the voltage converters generate most of the heat within the enclosure, they are mounted directly to the aluminum interior to efficiently transfer heat to the surrounding water. Rather than designing a fully custom enclosure, ROVOTICS modified a commercially available housing to meet these thermal and size requirements. This decision reduced cost and fabrication time while leveraging the proven reliability of an off-the-shelf solution.

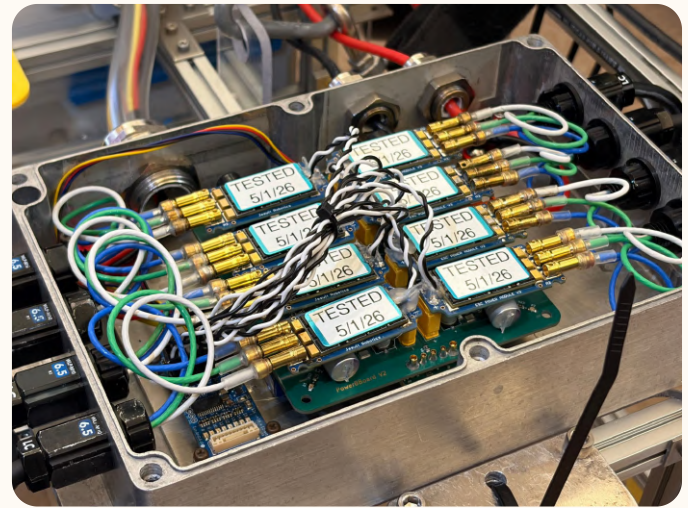


Figure 16 - PSE with New Enclosure

Control Electronics

The MEH contains *Hydra's* main computer, which was upgraded from a Raspberry Pi 4 to a Raspberry Pi 5. This change was made to handle the high USB and Ethernet bandwidth more effectively with its higher-spec CPU. This Raspberry Pi interfaces with the SuperHAT V3 (Hardware Attached on Top), a custom 6-layered printed circuit board that allows the Raspberry Pi to control power-hungry tools. The HAT interfaces with a 9-axis inertial measurement unit (IMU) to improve orientation control and pilotability. The SuperHAT is integrated with 2 leak sensor probes for safety indicators during operation. To manage the new vision system, a USB hub replaces the prior Ethernet switch and 5 volt hub, connecting camera modules directly to the Raspberry Pi.

ROVOTICS chose to purchase this commercial enclosure because its clear lid allows for an unobstructed view for internal cameras and quick visual inspection of control electronics. The MEH's built-in rails allow electronics to be easily mounted on a sliding shelf system, providing easy access to internal components.

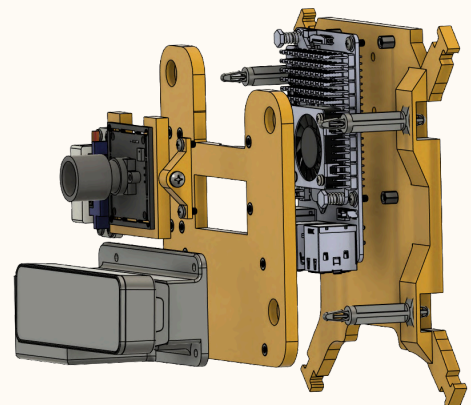


Figure 17 - MEH Exploded View

Software

ROVOTICS' software stack centers around modularity. The ROV software is split into two software substacks: Topside and Bottomside. Topside consists of all the software that runs on *Hydra's* laptop. It contains independent software packages that convert joystick input into thruster vectors, receive camera footage, and control tools. Similarly, Bottomside consists of software running directly on *Hydra's* Raspberry Pi 5, including independent packages for controlling electronic tools, communicating with ESCs, and sending camera footage. To connect all these software packages, we use ROS2 (Robotic Operating System), an open-source framework that allows programs to share data over network topics.

We focus on breaking our software architecture down into simple packages that carry a smaller number of known properties and processes. This design allows us to quickly modify code by focusing our changes on specific, isolated parts of a larger system. For instance, when updating the General Purpose Input Output (GPIO) package for the Raspberry Pi 5, we only had to modify that specific package without affecting related, independent systems like the joystick package.

Our software team has leveraged this modular approach to write and rewrite several completely new packages. We've developed a low latency camera streaming package to transmit USB camera data, a MIDI-control program that allows pilots to adjust their own sensitivities via a sliderboard, and a stereovision system to measure distances and generate 3D models underwater.

Vision System

Hydra's vision system enables the pilot to operate tools and navigate the ROV effectively. Rather than buying pre-built cameras, we chose to build a custom vision system to have more control over specific components, ensuring low-latency streaming and high-quality video. This choice drastically reduces the chance of pilot error when engaging with challenging tasks such as installing a power connector.

Our previous ethernet-based camera system encountered several notable issues, including inconsistent connectivity that frequently required the deck crew to power-cycle the ROV and low pixel throughput due to the limited capabilities of the Raspberry Pi Zero 2W. The cameras were also permanently sealed with silicone, making all internal components inaccessible. This resulted in extremely poor serviceability and time consuming repairs.

To address these concerns, we redesigned the camera system around high-quality, compact USB camera modules, all of which connect to the central Raspberry Pi 5 in the MEH. This redesign significantly simplifies the manufacturing process by eliminating extensive cable modifications and removing curing time for the silicone sealant. The redesign increased pixel throughput due to the improved computational performance of the Raspberry Pi 5. When tested, the new USB camera modules achieved a stream of 1920x1080p resolution at 30 fps with 200 ms of latency compared to 1280x720 at 30 fps with 300 ms of latency. This performance creates a smooth video feed with very little perceived latency, greatly improving the piloting experience.

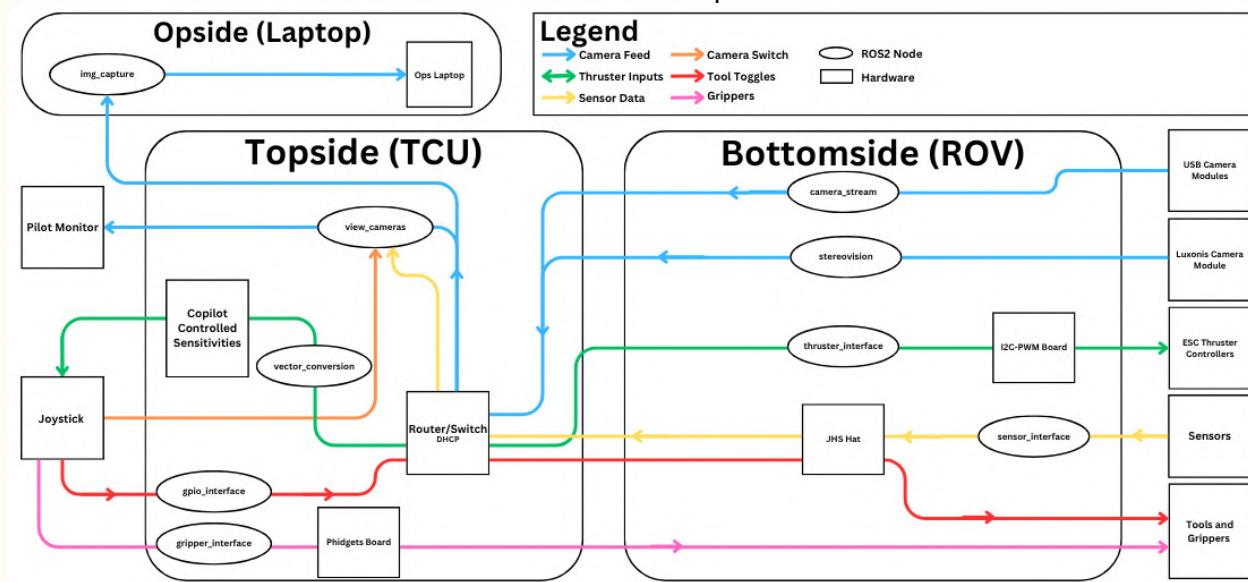


Figure 18 - Software System Diagram

Each USB camera module uses a modified USB cable that connects to a USB hub and Raspberry Pi located in the Main Electronics Housing (MEH). This compact USB hub replaces the prior Ethernet switch, freeing up valuable space in the MEH. The upgrade to the Raspberry Pi 5 also significantly improved streaming efficiency and speed.

Mechanically, the cameras are now sealed with a Blue Robotics WetLink penetrator and an O-Ring seal, allowing internal components to be easily inspected, serviced, and replaced when issues arise. Commercial camera housings are too large, expensive, and ill suited to our cameras' design needs. Our camera housings are custom made with resin 3D printed (SLA) because it is waterproof, less expensive, and able to create more complex geometries than CNC milling. The external cameras can be quickly added, removed, or adjusted on the ROV frame using snap-in mounts, greatly enhancing *Hydra's* configurability for a wide range of mission tasks.

Under this new system, each camera is designated as an HTTP server on the Raspberry Pi 5, allowing multiple users on the network to view and capture streams from multiple cameras at once with high quality and low latency.



Figure 19 - External USB Camera

Servo Camera

In the past, ROVOTICS' pilot encountered the issue of being unable to fully view the front gripper from the main camera in the MEH. Having this view is important for tasks that require precise object grabbing. This year, ROVOTICS implemented a servo motor to adjust the MEH camera's tilt. This addition allows the pilot to adjust the vertical FOV (field of view) angle, improving

visibility from the MEH. This device improves *Hydra's* pilotability by eliminating the need to reposition the ROV to better view mission tasks. For example, this servo helps in Task 1.1, which requires precise movement to slide our fingers under the basket stars and coral species. ROVOTICS has also integrated the servo with the new MIDI controller for ease of piloting.

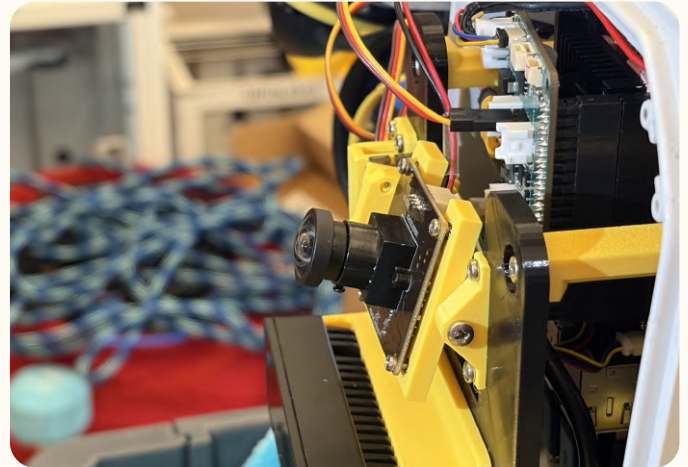


Figure 20 - MEH Servo Camera

Midi Controller

To further improve efficiency on deck, *Hydra* incorporates a MIDI controller that lets the pilot adjust his own sensitivity settings via a physical control panel. This interface provides a faster, more intuitive piloting experience, enabling rapid and precise shifts between low sensitivities for precision and high sensitivities for speed. Not only does it control sensitivities, but it can also operate other devices, such as the servo motor for the MEH camera and our magnetically coupled motor. The controller connects via a USB cable that provides both power and data. This new addition shines in Task 2.3, where the ROV needs to maintain its position for an extended period while turning a handle to remove biofouling. The integration of the MIDI controller allows the pilot to execute missions more quickly and with greater precision.

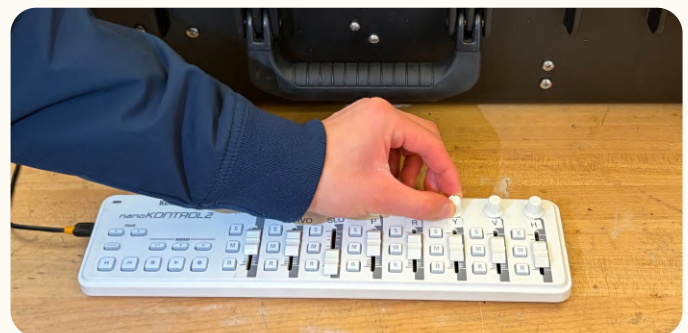


Figure 21 - Midi Controller

Stereovision

When posed with tasks like the iceberg tracking task and the coral restoration area task this year, we saw a need to develop a consistent, accurate measurement system.

After reviewing several design options, including lasers and simple pixel-measuring, we decided to address this need by integrating a stereovision camera into the MEH. With this device consisting of two cameras positioned side by side, we can determine the spatial coordinates of every object in the camera's vision to great accuracy through a series of calculations.

Due to our niche use case involving stereovision, one challenge in this integration process was accounting for light refraction in our depth calculations. Because light needed to travel through the pool's water, the plastic lid of the MEH, and the air inside the MEH to reach the stereo camera, there were several instances of refraction. To counteract this issue, we calibrated our camera rigorously using a ChArUco board while underwater. A Charuco board is a calibration pattern that combines chessboard squares and markers to help cameras accurately detect position, orientation, and lens distortion. This realistic testing allowed us to calibrate to our exact use case, thereby greatly reducing error.

In summary, this feature enables the ROV to generate 3D models of icebergs, measure coral restoration areas, and accomplish other tasks like measuring fish without risking harm to wildlife.

Figure 22 -
Stereovision Distance
Measuring Process

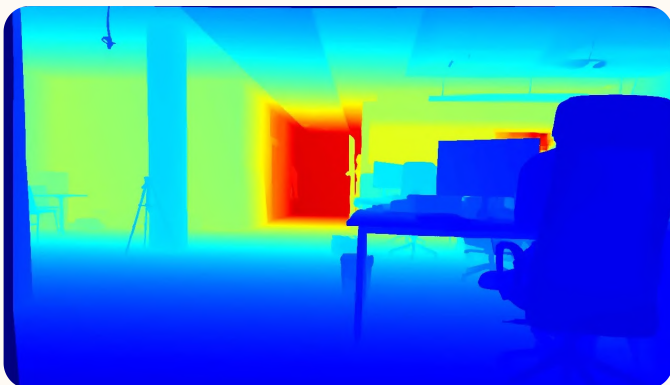
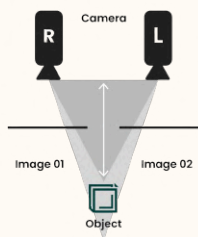


Figure 23 - Stereo Depth Map

Payload/Tools

Multipurpose Grippers

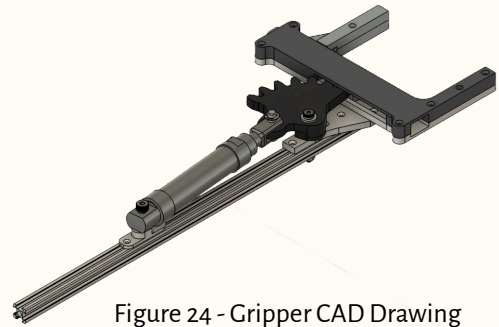


Figure 24 - Gripper CAD Drawing

The multipurpose grippers are *Hydra's* most versatile tools. The ROV is equipped with both a vertical and a horizontal gripper, each strategically placed to assist the pilot in completing tasks. The horizontal gripper is designed to reach tasks elevated above the seafloor, such as attaching a recovery line to the buoy anchor. The vertical gripper is designed to reach tasks directly on the seafloor, such as collecting species from the coral garden. This configuration allows the ROV to complete tasks more quickly and with more precision while also reducing the number of necessary dives. In addition, specialized task-specific fingers can be easily installed or removed from the grippers using quick-release pins to accommodate different payloads, making the grippers easy to modify for a variety of mission tasks.

A specialized set of coral grabbing fingers allows *Hydra* to pick up delicate specimens of coral without damaging them. The fingers have a rubber tape to grip the coral without letting it slip out. The coral grabber has the same quick-release that the all gripper fingers have to quickly switch fingers. In addition, the coral grabber fingers have a steel rod to pick up the Basket Star coral without damaging them.



Figure 25 - Operator Changing Gripper Fingers

Trident Tool

To easily and consistently attach a recovery line to the U-bolt on the buoy anchor, ROVOTICS designed a trident tool. The trident uses a toggle bolt as its spring-loaded locking mechanism, providing a simple and reliable way to attach the recovery line. The trident shape was chosen because it both guides the pilot onto the U-bolt and complements the strengths of the toggle bolt, giving the pilot two attachment points to the buoy. The dual port design accommodates pilot error, as a strong link between the U-bolt and the recovery line is still achieved regardless of which side the port is engaged. Because of the small number of parts and their easy accessibility, our trident tool is affordable and more effective than traditional methods (e.g., carabiners).

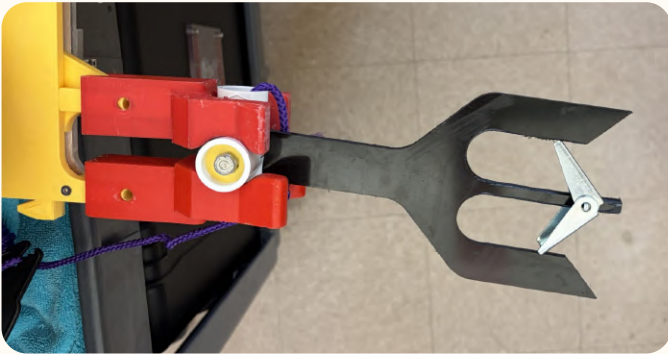


Figure 26 - Trident Tool

Magnetic Motor



Figure 27 - Magnetic Motor Internal Components

To remove biofouling on the Holyrood subsea observatory camera, ROVOTICS developed a magnetically coupled motor. This tool consists of a brushed motor housed inside a resin-printed watertight container, which rotates four neodymium magnets that couple with four corresponding magnets on the exterior of the container. This configuration allows the system to retain the precise control characteristic of a brushed motor while eliminating the

risk of corrosion or shaft leaks that could damage components.

Our attachment was designed to engage the handle to release the retrieval buoy. As the pilot approaches the handle, the motor is turned on, allowing the hooks to lock onto the handle and complete the required rotations without slipping or losing contact. The attachment is held in place by magnetic force, making it easy to swap with alternative versions. This feature made it easy to test different prototypes and determine the most effective attachment for removing the biofouling.

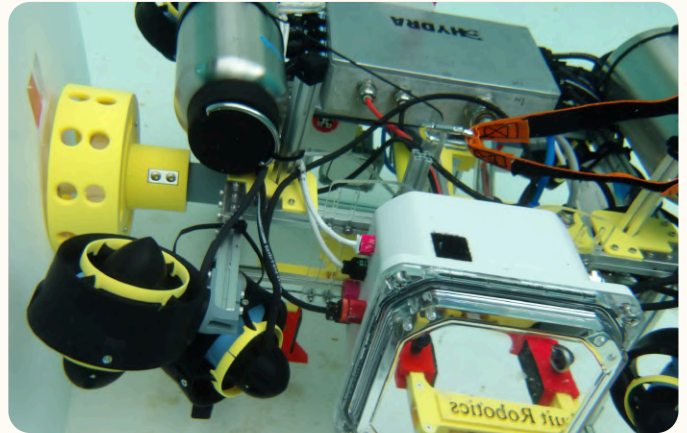


Figure 28 - Magnetic Motor Turning a Handle

Invasive Crab Detector

Hydra is also equipped with an invasive crab detection system that can autonomously detect the invasive European Green Crab in real time. The program passes each frame of the video feed to a detection model, which processes it and labels the objects. This is then displayed on the pilot screen, resulting in a clear video stream with autonomously labeled data.

Because the program would process footage in real time, the detection model had to be exceptionally fast. After careful consideration and experimentation with several models, the team chose to use YOLOv12, which is known for its speed and accuracy.

To train the model, the team used real footage from the ROV as training data. This was crucial, as the crabs are heavily discolored by the water depth and lighting conditions. Having training data that matched the scenario the ROV will actually encounter in the field ensures consistency. To further improve accuracy, data augmentation was implemented, where data was artificially varied using image processing to simulate different conditions. Specifically, the dataset used camera exposure and motion blur augments, which

would ensure that the model would be more reliable in less than ideal scenarios. After the data was collected, several models were trained and evaluated, with the best being selected for application. All of these features allowed the model to perform well in different conditions, while still being able to run in real time. The data can be found online on roboflow.com/stuff-pqghgh/crab-8qma1/10, where it is publicly available for use.



Figure 29 - Invasive Crab Detector Annotations

Coral Retrieval Basket

To collect coral species and basket stars, a collection basket was developed to safely transport them to the surface. The basket features a mounting point at the top and mesh panels along the bottom and sides to minimize drag when operating. *Hydra's* integrated bottom gripper carries the basket down to the sea floor to be positioned near targeted species. Using a basket allows for species to be recovered without risk of harm, minimizing direct handling. In addition, the front gripper is equipped with specialized removable fingers, allowing for easy collection of coral species and basket stars.



Figure 30 - Coral Retrieval Basket

Triton Float

GO-BGC floats are designed to create a worldwide network of chemical and biological sensors that help researchers record ocean health. The floats' sensors detect and record temperature, depth, and bio-geochemical data that is then routed to a global community of researchers, contributing to a better understanding of climate change's effects on the oceans.

Triton is a GO-BGC inspired float engineered to gather vital ocean data and vertically profile to targeted depths. It uses a peristaltic pump to alter buoyancy. This design conserves battery life over syringe-based solutions. The float's operations are managed by an ESP32 microcontroller paired with a custom daughter board, allowing it to interface with various sensors and transmit depth data via Wi-Fi. The pressure relief cork is greater than 2.5 cm in diameter, ensuring the safety of operators and wildlife while complying with MATE safety specifications. To comply with the MATE fuse regulations, *Triton's* power lines are fused to 2A. There are additional 250 mA fuses on each individual battery. For power, *Triton* relies on rechargeable 9V 250mAh Ni-MH Tenenergy batteries, reducing waste and environmental impact.

Triton's features don't come at the cost of serviceability. Its flange-sealed enclosure can be taken apart in seconds, and a single XT30 power connector separates the top and bottom sections, facilitating easy maintenance.



Figure 31 - Triton Float

Critical Analysis

Vehicle Testing Methodology

To ensure safe and dependable systems, ROVOTICS emphasizes hierarchical testing and troubleshooting processes in all departments throughout the development process. During troubleshooting, we systematically isolate issues by testing one variable at a time. This process allows us to quickly identify the root cause of system issues and performance bottlenecks. After troubleshooting, ROVOTICS then prototypes solutions to address identified problems. During the prototyping process, we also carefully test each modification to ensure the original issue is fully resolved without introducing new complications or unintended system behavior.

Troubleshooting

One serious design challenge when creating *Hydra* was addressing random shutdowns of the ROV system. We determined the problem was corrosion on the tether's RJ-45 connector: our Bulgin connector's small cross-section O-ring was failing to keep a water-tight seal. After verifying the issue, we decided to replace the Bulgin connector.

Prototyping

After comparing with industry options, ROVOTICS identified three possible alternatives to the Bulgin connector problem. We could either connect ethernet directly to the ROV by using a non-removable tether, use an 8-pin SubConn connector, or devise another method to waterproof a RJ-45 coupler. Immediately, a non-removable tether was ruled out since any damage to the tether would render the entire ROV system unusable.

Result

We initially decided to invest in an 8-pin SubConn connector, due to prior successes with their power connector products. Before prototyping this connector, we decided on three primary criteria that would verify the connector's successful implementation following testing: continuity on all eight pins, bandwidth of 1 Gbps, and prolonged running of our software stack including camera streaming and thruster interfacing. Our first prototype using the SubConn connector successfully achieved continuity on all 8 pins but only achieved 100 Mbps of bandwidth, ten times less than the desired 1 Gbps needed for reliable data transmission. Analysis of the prototype concluded the

Solution	Direct Tether Connection	SubConn 8-Pin Wet-Mate Connector	PVC Pipe Union + RJ-45 Coupler + Wet Links
Pros	• No connector to damage • Simplified mechanical design	• Very reliable commercial connector • Expected multi-season lifespan	• Reasonable cost • Widely available materials • Repairable and modular
Cons	• ROV is out of service if tether is damaged • Tether is not field replaceable	• High cost • Long lead times	• Larger physical size
Waterproofing	• No connector leak path • Cannot perform vacuum checks on tether connection	• Wet-mate design prevents leaks • No additional parts required for vacuum testing	• No leaks during testing • Fully vacuum testable
Data Transmission	1 Gb	1 Gb	1 Gb
Other Test Results	Not tested due to design limitations	Could not reliably support long-term video streaming (>10 min)	• No transmission issues • No leak issues during extensive pool and vacuum testing • Wet Link penetrator allows cable repairs without replacing the entire tether
Cost	Low cost — only ROV penetrator required (< \$40)	~\$220 per inline connector pair	~\$55 per set including vacuum testing cap
Result	Not viable — tether is not a replaceable unit	Not reliable due to video streaming instability	Selected solution — passed all streaming, transmission, and waterproofing tests

Figure 32 - Decision Matrix

untwisted wire section was a source of electrical noise, affecting transmission rate. After shortening the untwisted section, we ran our bandwidth test again and achieved a transmission rate of 1 GBPS.

In our final testing stage, however, the SubConn connector still failed to run ROVOTIC's software stack for longer than 10 minutes. Additional testing to determine the cause was inconclusive, and further shortening of the untwisted section of cable was not possible. Rather than continuing with an unreliable design, ROVOTICS returned to the brainstorming and prototyping phase to reevaluate alternative solutions. This iterative engineering process ultimately led to our final design: waterproofing a standard ethernet coupler to create a more reliable and serviceable connector solution.

Several ideas were tested for use as a waterproof coupler. What worked best was a 1-inch PVC-threaded union. The size accommodated the RJ-45 coupler, featured a larger O-ring cross section reducing the risk of leaks, and utilized low-cost parts. The design also uses Blue Robotics WetLink penetrators allowing the connection to be rebuilt if any damage occurs to the cable ends. Additionally, a sealed end that mates to the ROV connection was fabricated to allow for vacuum testing of the electronic housings.

The large cross section O-ring is very durable. Its compression tolerance is so wide that we have never leaked through the connector in our 40+ hours of water testing across both ROVs, an unprecedented feat for our team. This upgrade from last year contributes to greatly improved system reliability, ensuring that *Hydra* is able to perform during long intervals in harsh environments, like those simulated in the Flume and Engineering Basin tank at the MATE ROV competition.

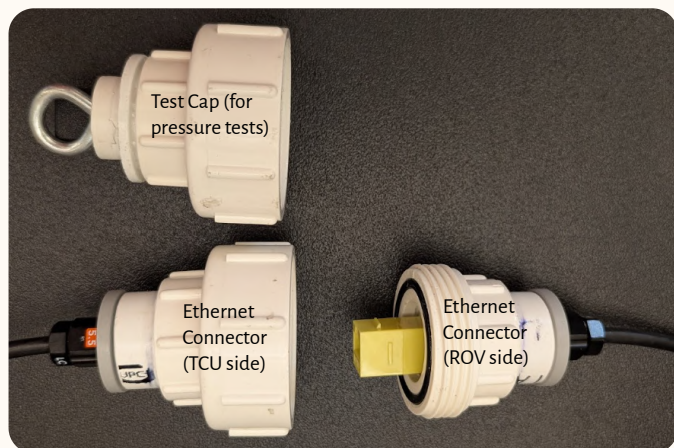


Figure 33 - Final Ethernet Connector Design

Safety

ROVOTICS' safety philosophy focuses on identifying hazards early and implementing measures that protect personnel, equipment, and the environment. Safety is incorporated into every stage of the engineering and operational process, including design, manufacturing, in-water testing, and deck operations. To reduce risk and prevent injuries, ROVOTICS uses Job Safety and Environmental Assessments (JSEAs), operational checklists, standardized procedures, and team mentoring to reinforce safe practices. Supporting this safety-first culture, ROVOTICS has a dedicated Safety Officer responsible for maintaining safety compliance and accountability. Detailed JSEAs and Operational Safety Checklists for construction, testing, and deployment are included in the Appendix.

Personnel Safety

ROVOTICS prioritizes personnel safety through training, standardized procedures, and proper protective equipment. All students complete safety orientations, PPE demonstrations, and machine-specific training before operating shop equipment. Coaches and senior team members certify students on tools such as CNC machines, lathes, bandsaws, sanders, soldering equipment, and 3D printers to ensure safe operation. The lab is equipped with safety glasses, gloves, hearing protection, fire extinguishers, first aid kits, and a ventilated soldering hood to reduce hazards.

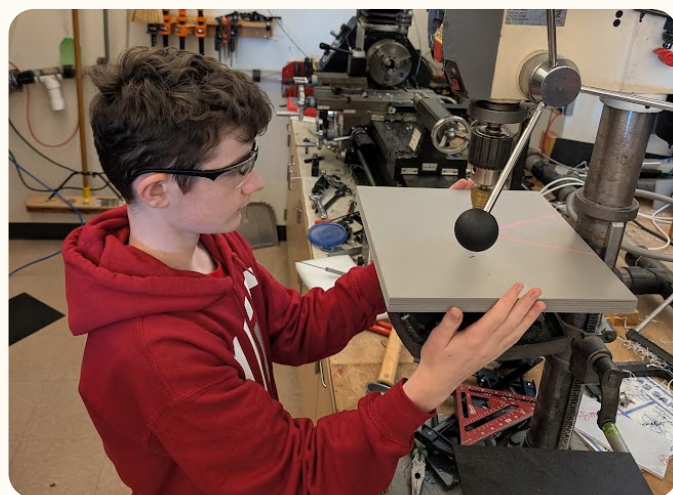


Figure 34 - PPE Worn during Drill Usage

During manufacturing and assembly, students follow machine-specific safety procedures, material handling

guidelines, and soldering ventilation protocols to reduce the risk of injury and equipment damage. Construction checklists ensure PPE is worn, tools are inspected, and workspaces remain organized before fabrication begins.

Equipment/Environment

Hydra and *Triton* were designed with safety, reliability, and environmental protection as key priorities. *Hydra* includes thruster guards, rounded edges, and shrouded gripper pinch points to reduce the risk of injury to operators and marine life. The tether system uses strain reliefs, nylon mesh protection, and distributed buoyancy to reduce cable stress, minimize the risk of entanglement, and prevent damage to underwater infrastructure. Electrical connectors and pneumatic lines are color coded to prevent incorrect connections, while waterproof connectors are thoroughly tested for reliability.

Additional safeguards include a single-point emergency shutoff switch and software startup protections that place the ROV in a safe state during initialization to prevent accidental activation. *Hydra*'s neutral buoyancy and precise maneuverability reduce unintended contact with sensitive marine habitats and underwater infrastructure.

Triton, our float includes a pressure relief plug to prevent internal pressure buildup and a clear enclosure for quick visual inspection without disassembly. The float's main power switch is protected inside the enclosure but remains easily accessible for safe shutdown. Software timeouts and operational limits help prevent equipment damage and reduce operator risk. ROVOTICS also uses rechargeable batteries to reduce waste and environmental impact.



Figure 35 - Tether Strain Relief

Safety also extends to the underwater environment where *Hydra* operates. Specialized gripper fingers handle delicate coral species at the base instead of fragile tentacles to reduce damage during collection tasks. A magnetically coupled biofouling removal tool disengages under excessive torque to prevent damage to sensitive observatory equipment.

Operational Safety

ROVOTICS follows detailed operational procedures to ensure the safe deployment and operation of both *Hydra* and *Triton*. Before deck operations, both systems complete vacuum leak testing and a Power-On Self-Test (POST) to verify watertight integrity and confirm that electrical, pneumatic, and software systems are functioning properly. These procedures help identify faults before deployment and reduce the likelihood of failures in the field.

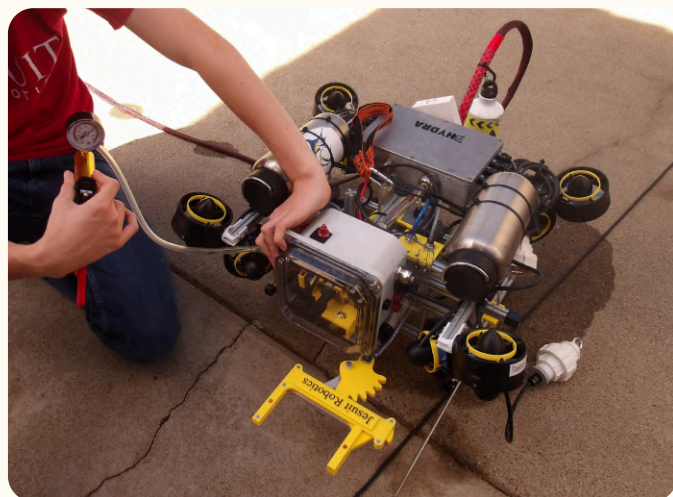


Figure 36 - Pre-Dive Vacuum Check

Before deploying the ROV, deck crew members review the JSEA and Operational Safety Checklist to identify hazards, confirm emergency procedures, verify tether routing, and ensure emergency shutoff accessibility. Team members regularly cross-check each other's work to reduce operational errors and reinforce accountability.

Once on deck, the tether is properly flaked and managed to reduce trip hazards, minimize entanglement risk, and maintain reliable communication between the ROV and topside systems. Before launch, the deck crew performs a second POST to confirm all systems remain operational after setup and transport. The Operational Safety Checklist provides a step-by-step process for setup, mission execution, recovery, and shutdown

procedures. Critical stages require multi-person verification of tether routing, power system readiness, waterproof connector integrity, and emergency shutdown accessibility before operations continue. Through preventative testing, operational checklists, and continuous mentoring, ROVOTICS maintains a strong culture of safety in the lab and during field operations.



Figure 37 - ROVOTICS Deck Crew during Operation

Accounting Budget

ROVOTICS uses a structured project budgeting and accounting process to manage planned versus actual spending throughout the engineering lifecycle. At the start of the project, the team develops a Total Project Budget using the prior year’s actual costs, documented Bills of Materials (BOMs), and projected R&D expenses for new technologies such as *Hydra’s* eight-thruster propulsion system and stereovision capabilities. Funding for the project is provided through Jesuit High School, community donations, and private sources. ROVOTICS used a Twin ROV strategy to improve engineering, pilot, deck crew, operations, and safety training for mission tasks. Because *Hydra* is based on a proven standard platform with well-documented BOMs and historical cost data, forecasting the budget for the second identical ROV was straightforward and predictable during project planning. Led by the COO, standardized BOM spreadsheets are used to track required components and ensure purchases align with the Project Budget. These detailed BOMs document the quantity, purpose, and

cost of every component, helping the team minimize waste, prevent overspending, and improve purchasing accuracy. Before orders are placed, leads and coaches review BOMs to verify that purchases are necessary, technically justified, and within budget. All purchase receipts and expenses are tracked in a Project Cost Sheet that undergoes monthly reviews to monitor spending and maintain accountability. The 2025–2026 Project Cost Sheet is provided in U.S. Dollars (USD) shown in Figure 38. Transportation, travel, and meal expenses are estimated separately because individual team members are responsible for covering those costs.

Budget and Cost Accounting

AVAILABLE FUNDS:				
Category	Name		Amount (USD)	
	Carryforward Balance from 2025		\$7,142.02	
Income	Jesuit School Funding		\$20,000.00	
Income	Student Fund Raising		\$7,250.00	
Income	Donations		\$7,000.00	
Income	MATE Competition Awards		\$300.00	
			Total:	\$41,692.02
ROV TOTAL COST (USD):				
Production Expenses	Type	Budget	Project Cost	Difference
Frame, housing, & thrusters	Purchased	\$1,200.00	\$2,386.01	-\$1,186.01
TCU, pneumatics	New	\$3,000.00	\$3,017.60	-\$17.60
Tether & Connectors	Purchased	\$1,500.00	\$1,504.00	-\$4.00
Electronics & Connectors	Purchased	\$1,300.00	\$1,290.60	\$9.40
Power systems Enclosure	Purchased	\$1,200.00	\$1,118.81	\$81.19
Mission Tools	Purchased	\$500.00	\$377.14	\$122.86
USB Cameras	Purchased	\$400.00	\$373.24	\$26.76
Mission Control Center	Re-used	\$1,350.00	\$0.00	\$1,350.00
LAB materials	Purchased	\$500.00	\$500.00	\$0.00
Production Budget		\$10,950.00	\$10,567.40	\$382.60
R&D Expenses	Type	Budget	Project Cost	Difference
Twin-ROV	Re-used	\$7,350.00	\$7,350.00	\$0.00
Test Benches	New	\$250.00	\$250.00	\$0.00
Stereovision System	New	\$300.00	\$287.00	\$13.00
Power Board for 8 thrusters	New	\$200.00	\$178.00	\$22.00
R&D Budget		\$8,100.00	\$8,065.00	\$35.00
OPERATIONS EXPENSES (USD)				
Operations Expenses	Type	Budget	Project Cost	Difference
Lodging	Purchased	\$ 10,000.00	\$ 12,500.00	\$ (2,500.00)
Mission Props	Purchased	\$ 300.00	\$ 375.00	\$ (75.00)
MATE Entry Fee	Purchased	\$ 650.00	\$ 650.00	\$ -
Power Fluid Quiz Fee	Purchased	\$ 25.00	\$ 25.00	\$ -
Shipping	Purchased	\$ 4,500.00	\$ 7,000.00	\$ (2,500.00)
Operations Budget		\$ 15,475.00	\$ 20,550.00	\$ (5,075.00)
PROJECT COST SUMMARY				
Category			Amount	
Available Income			\$41,692.02	
Total ROV Cost			\$18,632.40	
Operations Expenses			\$20,550.00	
Total Project Cost			\$39,182.40	
Carry Forward 2026			\$2,509.62	
Employee Paid Expenses	Type	Budget	Project Cost	Difference
Competition Meals	Purchased	\$ 3,600.00	\$ 4,000.00	\$ (400.00)
Transportation & hotel subsid	Purchased	\$ 5,000.00	\$ 4,548.00	\$ 452.00
Estimated Employee Fees		\$ 8,600.00	\$ 8,548.00	\$ 52.00

Figure 38 - Budget & Cost Accounting Table

Acknowledgments

MATE Center and Marine Technology Society

- Sponsoring this year's competition

Oceaneering International

- Their support of the MATE competition

Jesuit High School

- Their generous donation of funding and pool access

Our Coaches: Jay Isaacs, Cheryl Kiyama, Steve Kiyama, Michael Sharp, Virginia Clemmens

- Their dedication, guidance, and time

MacArtney Underwater Technology

- Providing connectors at a discounted price

Benevity, Verizon and PG&E

- Providing matching grants to donations.

GitHub

- Providing complimentary private code repositories

Autodesk

- Supplying a quality CAD software for 3D modeling

KiCad EDA

- Providing a free, open-source software environment to design PCBs

Our Families

- Their continued financial support and encouragement

Notebook LLM

- ROVOTICS acknowledges the use of Artificial Intelligence (AI) tools to assist with portions of the refinement and editing of this report. AI was used to support grammar, formatting, and iterative review over technical writing. It was not, however, used for direct editing.



Appendix

Operations Safety Checklist

Pre-Power Procedure (Pilot, Co-pilot & Deck Crew)

- Area clear and safe (no tripping hazards, items in the way)
- Verify power switches and circuit breakers on TCU are off
- Tether flaked out on the deck and free from damage
- Tether connected to TCU and secured
- Tether connected and secured to ROV
- Tether strain relief connected to ROV
- Verify the electronics housing sealed
- Visually inspect electronics for damaged wires, loose connections
- Fasteners are tight on the electronics housing
- Thrusters free from obstructions
- Power source connected to TCU
- Vacuum test electronics housing (see vacuum test procedure)
- Verify vacuum check port is securely capped

Vacuum Test Procedure (Deck Crew)

- Verify MEH housing fasteners are secure and visually inspect front cover seal.
- Verify PSE screws are secure.
- Verify screw caps on all cameras are secure and o-ring seal is properly seated.
- Connect vacuum hand pump to ROV electronics housing
- Pump electronics housing to -35 kPa (vacuum), this is 10 inches of Hg on the gage.
- Verify electronics chamber holds -35 kPa (vacuum) for 5 minutes
- Remove vacuum pump and securely cap vacuum check port
- Stow vacuum hand pump back in case

Power-Up Procedure (Pilot, Co-pilot & Deck Crew)

- Verify TCU receiving 48V nominal
- Control computers up and running
- Ensure deck crew members are attentive

- Power on TCU
- Place ROV in water
- Perform thruster test/verify thrusters are working properly (joystick movements correspond with thruster activity)
- Switch between each camera to verify video feeds and proper camera positioning.
- Test any electrical or pneumatic tools that require pilot control

Launch Procedure (Pilot, Co-pilot & Deck Crew)

- Visually check for bubbles
- If there are bubbles from the electronic housings, remove ROV from water immediately and call out “electronics leak”. Proceed with Leak Detection Protocol
- If no issues are observed, the deck crew calls out “ready to launch”
- Co-pilot calls out, “Prepare to launch”
- Deck crew members handling ROV call out “hands off!”
- Co-pilot calls out “thrusters engaged” and pilot begins mission
- Call out, “performing thruster test”

ROV Retrieval (Pilot, Co-pilot & Deck Crew)

- Pilot calls “ROV surfacing”
- The deck crew calls “ROV on the surface. Disable thrusters”
- Co-Pilot disables thrusters and calls out “Thrusters disabled”
- The deck crew calls “Hands On”, and removes ROV from the water
- After securing the ROV on deck, the deck crew calls out “ROV secured on deck”
- Co-Pilot powers down TCU if the team is demobilizing from deck.

Leak Detection Protocol (Pilot, Co-pilot & Deck Crew)

- Power down system and remove ROV from water if running a mission. Recover ROV by pulling to the surface using the tether if required.
- Visually Inspect to determine source of leak. Do not disassemble any part of the ROV until the leak is located.
- Install pressure testing equipment and use soapy water to verify the leak source.

- Create a plan to repair the leak and check all systems for damage and proper operation.
- Document the cause of the leak and implement corrective action or design changes as required

Loss of Communication (Pilot, Co-pilot & Deck Crew)

- Cycle power on TCU to reboot ROV
- If no communications, power down ROV, retrieve via tether
- If communication restored, confirm there are no leaks, resume operations
- If communication is not restored, begin troubleshooting procedures, Isolate the issue. Is there a hardware or software cause? Proceed to analyze/ isolate cause
- Document the cause of the failure and implement corrective action or repair as required

Pit Maintenance (All Team members)

- Pit is organized and free of garbage.
- Verify all tools and cables are neatly stored and there are no trip hazards.
- Check electrical cords and correct any possible electrical hazards
- Clean Thrusters with Deionized Water
- Inspect Tether Power and Network Connectors
- Check supplies and organize a shopping list if anything is needed for repair or upkeep.
- Verify TCU, ROV and tether are clean, dry and properly stored. Protective caps for electrical connectors should be in place
- ROV, TCU and tether have been readied for use on the next mission run

Inspect and Test Pneumatic System (Pilot, Copilot & Deck Crew)

- Verify all pneumatics lines are properly connected to the air source, TCU, and ROV
- Verify that the compressor is switched on
- Activate pneumatics system and open main valve
- Verify there are no leaks and pneumatic lines are securely connected while under pressure
- Activate any pneumatic tool and verify the pressure returns to 2.75 Bar (40PSI) after the tool is shut off. Adjust pressure regulator to 2.75 Bar (40PSI) if required and repeat the test until 2.75 Bar (40 psi) is achieved

ROV SID

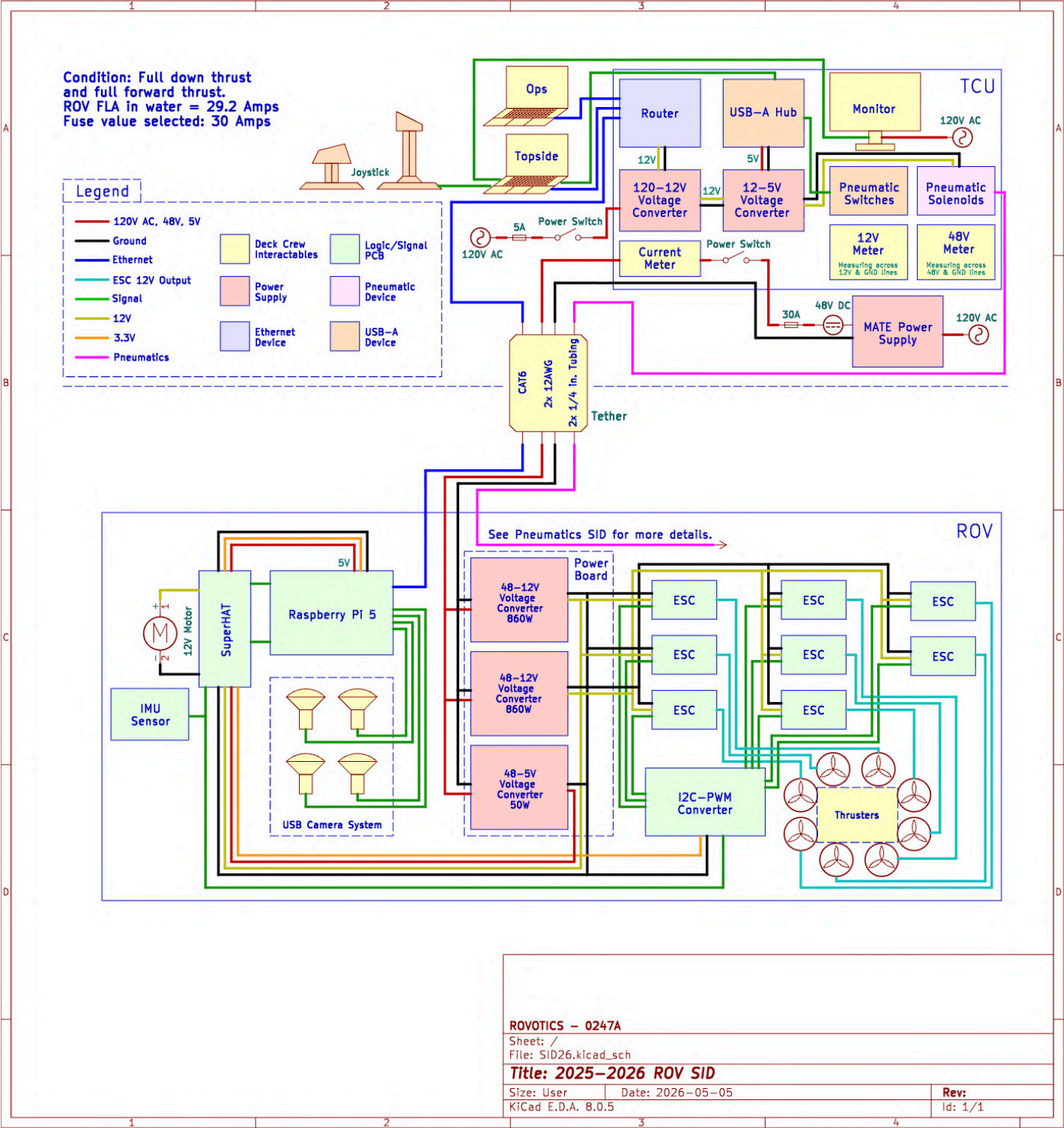


Figure 39 - ROV SID

Float SID

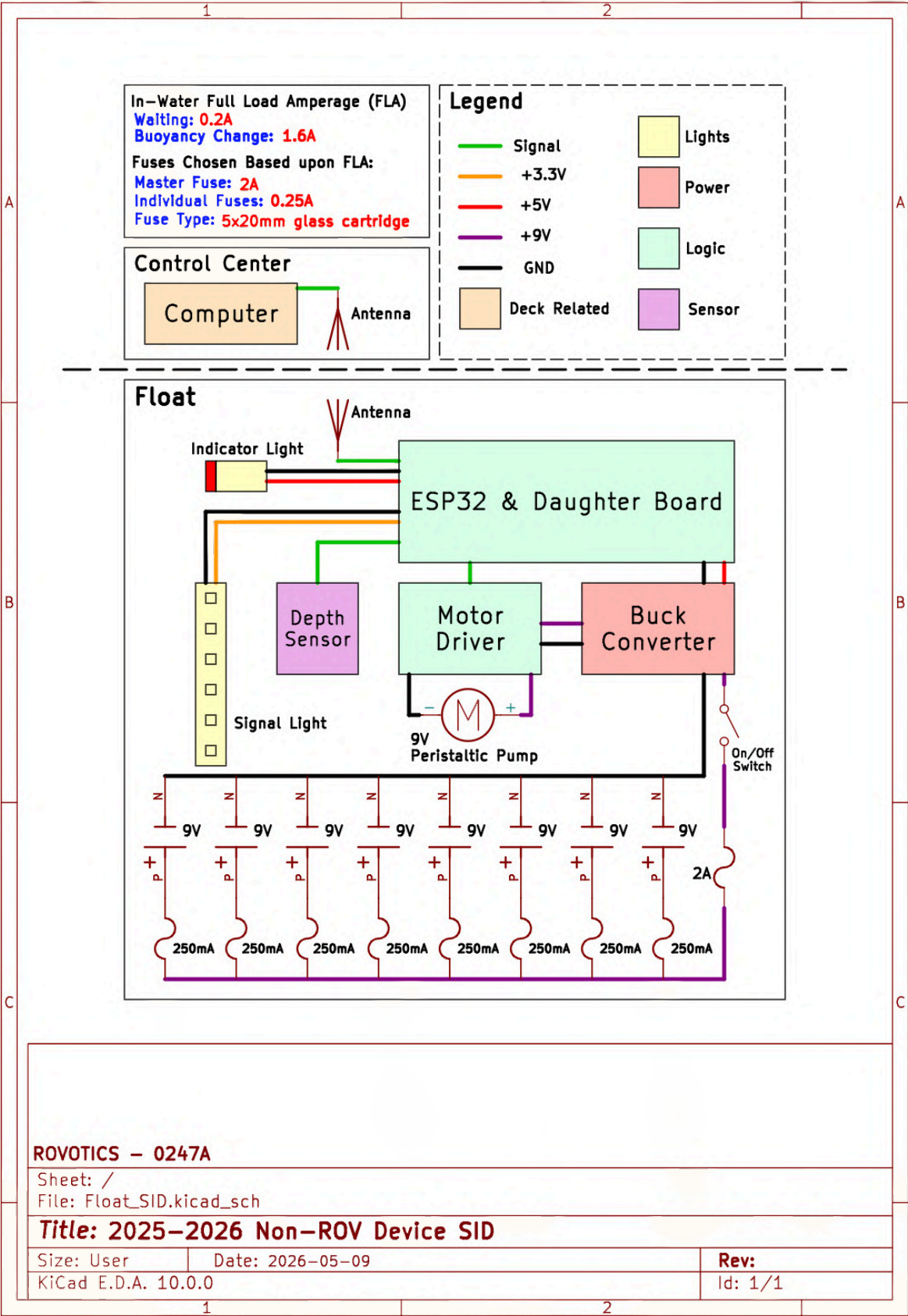


Figure 40 - FloatSID

Pneumatics SID

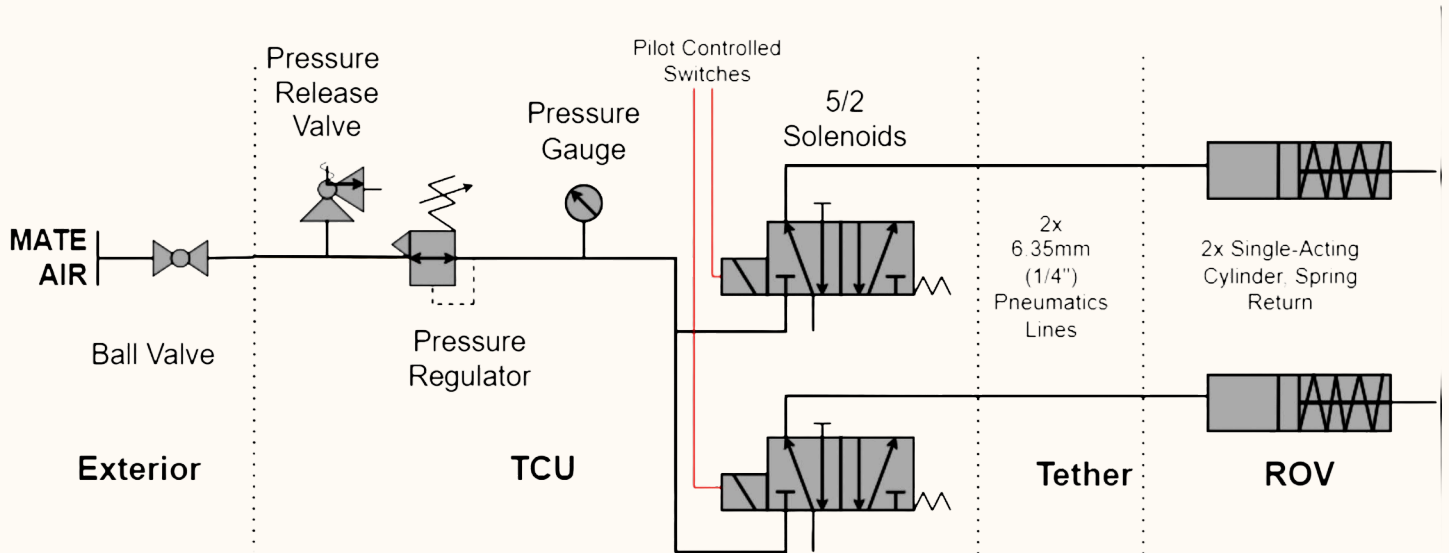


Figure 41 - Pneumatics SID

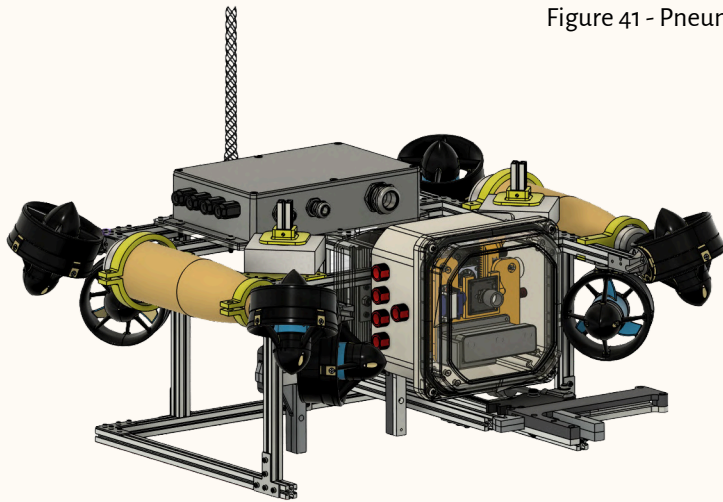


Figure 42 - Hydra ROV CAD

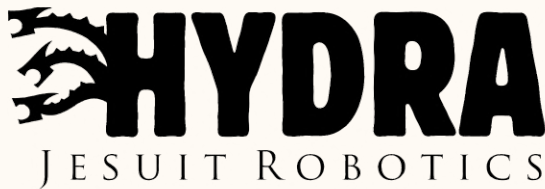


Figure 43 - Triton Float CAD



References

1. Mate ROV Competition, <https://materovcompetition.org/2026>
2. Ocean Decade Challenges, <https://oceandecade.org/>
3. GO-BGC Float, <https://www.go-bgc.org/floats>
4. Underwater Robotics: Science, Design, and Fabrication, <https://bluerobotics.com/store/the-reef/book-moore-ed1/>