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HYDROMEDA

2024 - 2025

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Director of Software Engineering: Mohammad Khan
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- Mouser for providing credit on electronics
- MATE for organizing the 2024-2025 competition and an opportunity to showcase our skill

Abstract

Hydromeda is a MATE division of Robosub, an underwater robotics organization founded at the University of Texas at Dallas. Following last year's success in the Pioneer division, Hydromeda decided to use the learning experience and shortcomings of its previous Remotely Operated Vehicle (ROV), ***VESPA***, to create a new ROV. This design focused on modularity, ease of use, and efficiency.

Subformica takes inspiration from the common ant's design of being able to move and manipulate objects in rigorous environments, whilst having an important role in an ecosystem's stability and health. The design was dictated to achieve the tasks of this year's challenge, such as moving or replacing subsea assets, collecting samples, monitoring species and environmental impact, identifying shipwrecks, and producing offshore energy.

Subformica takes on the goal that the previous ROV had in ensuring simplicity and adaptability in design, while improving the modularity of external components. Our team worked hard in making a reliable mechanical structure while allowing efficient and advanced operation. Through the culmination of our efforts, we achieved a modular and efficient ROV that is ready to compete in Alpena, MI.

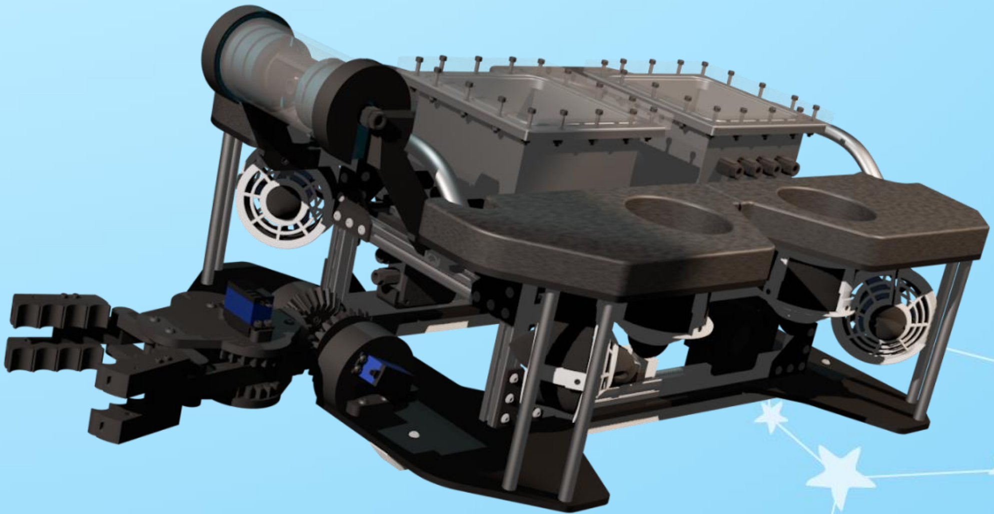


Figure 1. Render of Subformica

Safety

Philosophy

Safety is the highest priority at Hydromeda. Whenever a design decision is being made, safety is the first consideration. An ROV is unusable if it harms its users. We encourage continuous improvement of safety practices with all of our members as there is always room to strengthen and improve safety protocols.

Standards

All personnel are mandated to utilize appropriate personal protective equipment (PPE), including safety goggles and gloves, when operating power tools or handling potentially hazardous substances. This includes the use of respirators during activities such as soldering, sanding, or spray painting to ensure adequate protection.

Prior to the deployment of our ROV, a rigorous ten-minute leak inspection is conducted to affirm the integrity of the system. To enhance safety, the area our tether occupies is distinctly marked to restrict access, while continuous communication is maintained throughout underwater operations to facilitate seamless coordination.

Electrical safety is another priority. Low and high voltage systems are effectively isolated, and all components are powered down before being unplugged. Each phase of testing and launch adheres to a comprehensive checklist designed to ensure diligence and thoroughness. Team members receive extensive training on safety protocols, including the identification and location of emergency power shutoff systems.

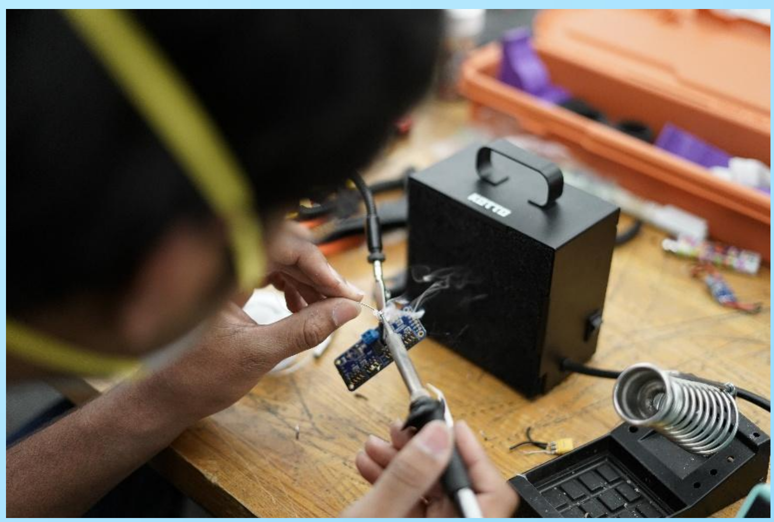


Figure 2. Member wearing PPE while soldering

Features

To mitigate risks associated with electrical overloads and mechanical strain, Hydromeda has instituted a comprehensive array of safety features for the ROV.

Electrical Protection Measures:

A dual-layered strategy has been adopted to prevent excessive current flow within the electrical system by integrating a 30-amp fuse alongside a 40-amp circuit breaker to protect internal components from potential damage. During maintenance or wiring procedures, technicians are required to disengage the main power supply and manually trip the circuit breaker to eliminate any electrical hazards.

Strain Relief Systems:

The ROV and the topside control case are equipped with strain relief mechanisms that connect to the tether. These components isolate and alleviate tension within the cable connectors, thereby preventing inadvertent disconnections and facilitating the safe retrieval of the ROV from aquatic environments.

Figure 3. Strain Relief. Left) Topside Strain Relief. Right) ROV Strain Relief

Thruster Guards:

Thruster guards are utilized to IP-20 standards to ensure no large foreign objects, especially digits, come into contact with the blades of our thrusters.

Through the incorporation of these integrated safety measures, Hydromeda underscores its commitment to fostering a secure and dependable operational environment for both personnel and equipment.

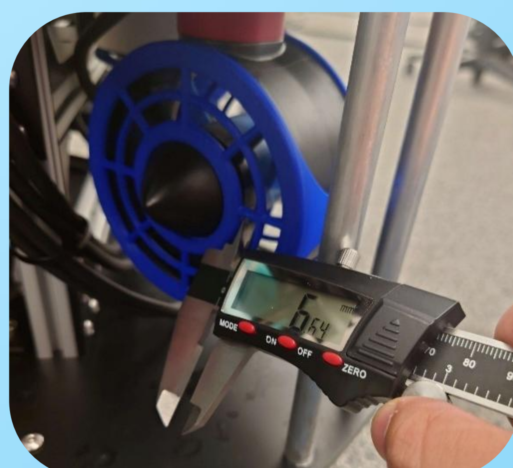


Figure 4. Thruster Guard with gap fitting IP-20 standards

Teamwork

Company & Personnel Overview

Hydromeda serves as the premier underwater robotics team at the University of Texas at Dallas (UTD), representing the MATE ROV division within the university's extensive RoboSub organization. It is crucial to clarify that, although we operate under the "RoboSub" designation at UTD, we do not have any affiliation with the RoboSub competition. Our principal focus is to participate in the MATE International ROV Competition, where student-driven innovations in marine robotics are highlighted on a global platform.

As an officially recognized student-led organization, Hydromeda brings together motivated undergraduate students with a shared passion for engineering, teamwork, and practical problem-solving. Our mission is to design, construct, and operate advanced ROVs capable of executing intricate underwater tasks in high-pressure competitive environments.

Hydromeda maintains a close collaborative relationship with the Humanoid, Biorobotics, and Smart Systems (HBS) Lab, directed by Dr. Tadesse. This partnership not only enhances our linkage to forefront research but also provides valuable mentorship and technical guidance, thereby nurturing a culture of interdisciplinary learning and innovation.

To proficiently address the multifaceted challenges associated with ROV development, our team is structured into four principal divisions, each playing an indispensable role in the engineering pipeline:

Business Division

This division is tasked with managing the team's external relations, encompassing the acquisition of sponsorships, budgeting, public outreach, and promotional initiatives. Their efforts are crucial in securing the financial resources and community engagement necessary to fulfill our engineering objectives.

Mechanical Division

Entrusted with the design and construction of the ROV's physical components, this division prioritizes structural integrity, hydrodynamic efficiency, and mechanical dependability to ensure optimal performance under demanding underwater conditions.

Software Division

This division is responsible for developing the software framework that empowers the ROV, which includes control systems, autonomous functionalities, and user interfaces. The software team ensures cohesive integration between the vehicle's onboard hardware and its mission objectives.

Electrical Division

This division oversees all electronic systems, including power distribution, wiring, sensor integration, and communication protocols. Their role is essential in ensuring that the ROV operates reliably and responds accurately to both inputs and environmental variables.

Project Management

At Hydromeda, the success of our ROV Subformica is dependent on a disciplined and adaptable project management strategy. To retain momentum, facilitate team coordination, and deliver a high-quality product, we implement an integrated approach that combines structured planning, dynamic execution, and continuous improvement. Our core practices are outlined as follows:

Agile-Inspired Workflow

We organize our development process into short, focused cycles, typically lasting between 2 to 4 weeks. At the conclusion of each cycle, we engage in thorough evaluations to assess accomplishments, identify challenges, and refine methodologies. This flexible, feedback-oriented framework empowers us to swiftly respond to evolving requirements and make necessary adjustments.

Milestone-Driven Planning

We establish clear goals and deadlines for each stage of development, ranging from the initial concept to final deployment. These milestones serve as essential checkpoints, enabling us to monitor progress, adhere to timelines, and proactively address potential obstacles.

Centralized Task Coordination with Notion

To enhance collaborative efforts, we utilize Notion for managing workflows, assigning responsibilities, and tracking task progress. Each assignment is accompanied by well-defined deliverables and timelines, fostering accountability and ensuring alignment among team members.

Weekly Team Synchronization

Regular weekly meetings are held to review updates, exchange insights, and resolve emerging issues. These instrumental discussions unite the team around common objectives. Additionally supplementary meetings are scheduled for subgroups to focus on specific technical challenges and areas of development.

Organized Documentation Systems

The maintenance of precise and accessible documentation is integral to our workflow. Through the use of both Google Drive and Notion, we uphold a comprehensive archive of technical drawings, notes, reports, and plans, ensuring preservation and ease of sharing knowledge.

Integrated Quality and Safety Assessments

Our operational framework incorporates systematic testing and quality assurance at every phase of development. By conducting rigorous evaluations to assess the performance, durability, and safety of the ROV, we can utilize these findings to continuously enhance and refine our designs.

Fostering a Culture of Mentorship and Growth

We emphasize the importance of team development by encouraging experienced members to mentor newcomers. This knowledge exchange not only cultivates individual skills but also strengthens the collective expertise of the team, ensuring that our methodologies and capabilities evolve with each project cycle.

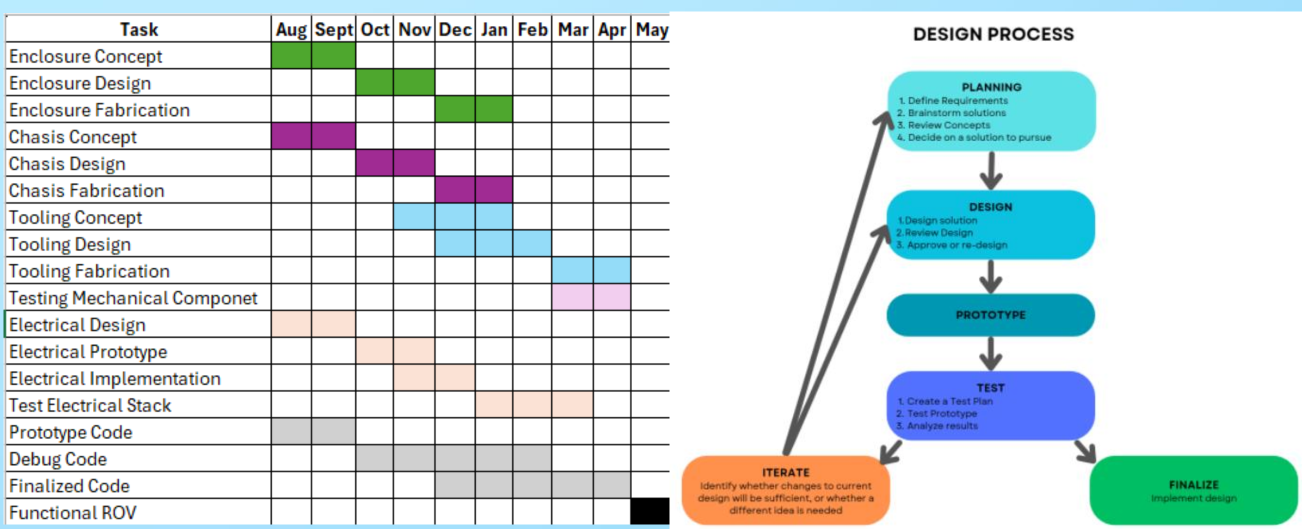


Figure 5. Project Schedule & Design Workflow

Mechanical Design

Rationale

From the start, modularity and serviceability were overarching themes in the design of the ROV. Our experience with previous ROV designs impressed upon us the importance of designing the system in a way that is modular and easily serviceable. The goal was to design an ROV from scratch that reused a minimal number of components. In designing modularly, we were able to ensure the ability to adapt. In designing with serviceability in mind, we were able to ensure that failures

Chassis

The chassis is constructed of aluminum t-slot extrusion and high-quality water-resistant phenolic panels. T-slot extrusions were chosen as the core structural component of the chassis for rigidity and modularity. They also provide a platform for a wide variety of tooling and mounting positions, making them appropriate for a wide variety of applications and uses.

The phenolic panels were cut utilizing a waterjet by one of our sponsors, Advanced Waterjet Cutting, and were chosen instead of the HDPE that we have used in the past due to its rigidity. This rigidity of the phenolic panels allows us to mount tooling and thrusters confidently without having to become over-reliant on the heavier and bulkier t-slot extrusion.

The overall shape of the frame was designed with balance in mind. The side-to-side and front-to-back symmetry of the chassis ensures that the ROV's center of mass is near its centroid. Enclosure mounting panels in the center of the frame were designed for forward-aft adjustability, allowing for center-of-gravity calibration as components change over time.

Nylon sleds on the bottom of the chassis allow it to slide without being caught on the edge of the internal launch bay, making one-handed retrieval possible. Two marine-grade handles on the ROV allow for safe carrying of the vehicle.

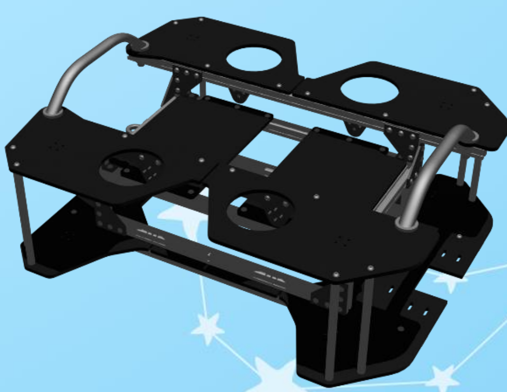


Figure 6. Chassis

Enclosure

The ROV showcases custom dual 6” x 6” enclosures used to house the electrical systems. By having two of them, the power systems are separated from the control systems to improve heat management. The enclosures are connected by an aluminum tube, allowing cables to be routed between them.

Each enclosure is fully constructed from 6061 T6 aluminum for heat conductivity, excluding the clear acrylic lids. The enclosures were fabricated by welding base plates and top flanges to aluminum square tubes. Glands were CNC milled into the flange for O-rings to be seated, creating a face seal. Penetrator holes were then milled into the side of the tubing. The lids were made out of acrylic to allow monitoring of the electronics while the enclosures are sealed. Each enclosure has an internal tray design catered to the electrical components that were fitted to each, respectively. The trays provide mounting that allows for both serviceability and the heat sinking of certain components for thermal management.

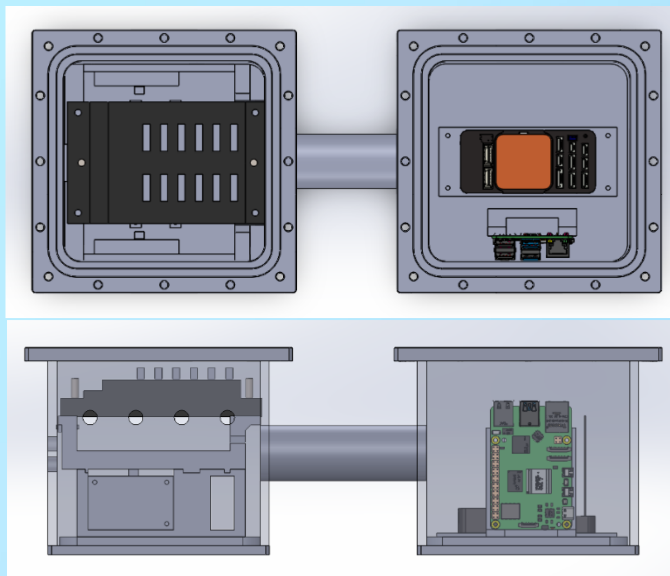


Figure 7. Top and Side view of the enclosures

Tooling

Main Claw

Differential Gear System:

The differential gear system is adeptly engineered to facilitate both rotational and vertical movement of a manipulator arm within a compact framework. The system enables the arm to complete rotation through opposing rotation of the side gears, while synchronized rotation allows the arm to tilt.

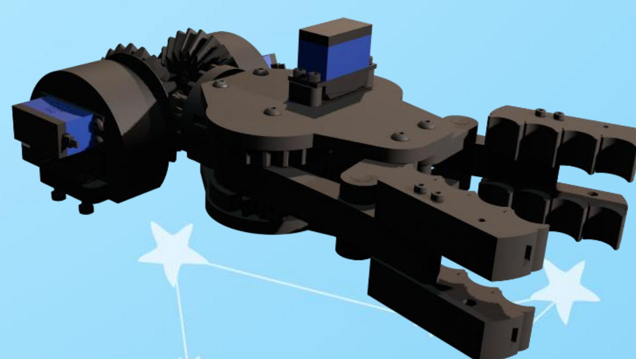


Figure 8. Main Claw with Differential Gear System

Claw:

It was determined that the claw would be powered by a servo. Therefore, a mechanical claw was chosen. The four-bar mechanism was chosen for the leverage it provides. A good grip underwater minimizes slippage. The mechanical advantage provided by the four-bar linkage would increase the normal force and therefore, the friction force. The mechanical advantage was calculated to be 1.23. The claw grips were also printed from BASF Ultrafuse TPU 95A to increase the coefficient of friction.

Figure 9. Inside Mechanism of Claw

A fractal clamp was chosen as the main claw for its adaptability. The cargo container lid, thermistors, pCO2 sensor, sacrificial anodes, and medusa jellyfish holder are all cylindrical with varying diameters. Having a claw that can adapt to these varying diameters would greatly decrease the time it takes to complete a task by reducing the amount of tool changes required. The fractal claw was also designed to close fully to accommodate smaller objects such as the power connector, connection port, and hydrophone's carrying mechanism, as well as the jellyfish polyp and hydrophone pin.

Junction Box:

The junction box's function is to isolate each servo of the ROV's arm, allowing for quick troubleshooting. The box and lid is fully constructed of machined aluminium, with 4 penetrators for wires and a static o-ring for a watertight fit. The penetrators were placed to be as compact as possible while still allowing removal with a bulkhead wrench.

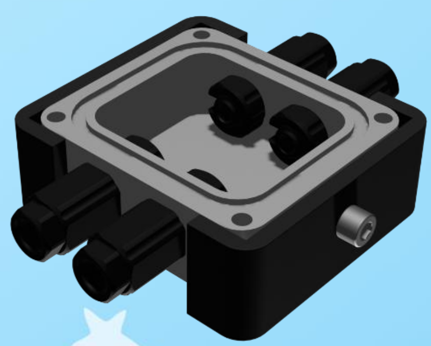


Figure 10. Junction Box for Servos

Syringe

The syringe tool was designed for the collection of fluid samples in subsea environments. Use of a rack and pinion allows for a compact design that utilizes the available T-slot rack to act as a guide rail for the rack. A pinion mounted to the side of the T-slot uses the embedded rack to actuate the syringe.

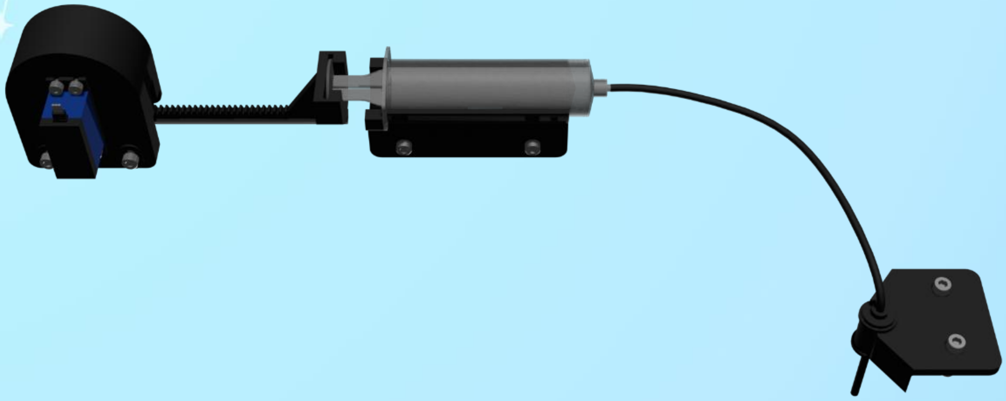


Figure 11. Syringe tool

Medusa Catcher

The aptly-named Medusa Catcher was designed to capture the medusa jellyfish. Instead of being a permanent fixture, the catcher is designed for the claw to hold onto. The main body is weighted at the base to remain upright while the claw rotates, closing the cover and capturing the jellyfish. The main body is designed to stand upright on its own and hold enough water to keep the jellyfish safe.

Cameras

Two Arducam Low-light USB Fisheye Cameras are installed in the front and the back of the ROV to view tooling and surroundings.

The front camera views the claw and in front of the ROV, while the back camera views the underside of the ROV and the claw when it is tilted downward. Each camera is mounted on a servo, allowing the ROV operator to position the cameras for an optimal angle.

Each camera enclosure is composed of a clear acrylic tube with two resin-cast end caps, utilizing static o-rings for waterproofing. Because resin has a similar density to water, the camera enclosures themselves are positively buoyant, helping the ROV move closer to neutral buoyancy.

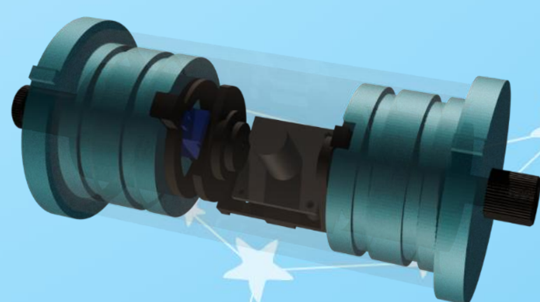


Figure 12. Camera Enclosure

Buoyancy and Ballasts

The buoyancy of the overall ROV assembly was accounted for throughout the design process. The empty volume of the main enclosure, camera enclosures, and junction box was carefully managed to achieve a buoyancy that was as close to neutral as possible upon completion. Given that the chassis and tooling underwent many changes, we knew that buoyancy would need to be compensated for once the ROV was complete. In the end, we needed to compensate with 10lb of buoyant force. To achieve this, we calculated the needed volume of Formular 150 and cut it to match the form of the top panels on the ROV, needing a thickness of 1.18”. The foam was painted, sealed, and bolted to the top panels.

Topside Station

The topside station houses the surface electronics used to connect the computer to the ROV. It is a customized Pelican case with connectors on the sides for the tether and an HDMI port for monitors. The station is separated into a top and a bottom section: the top houses components that require visuals and access during ROV operation, while the bottom houses components that seldom require constant access. The top and bottom are made of .25” transparent laser-cut acrylic panels. The top area utilizes a sliding lock mechanism to hold the top panel in place until access is needed to the bottom panel.

Figure 13. Topside Station

Tether Management

The tether is 28 meters long and consists of both an Ethernet and power cable. The cables are covered in a PET Braided Expandable Coated Sleeve to prevent abrasions. Buoyancy control was achieved using single-cell foam tubing at strategic intervals to achieve near-neutral buoyancy. The tether is contained on a spool attached to the ROV’s transport cart. This allows for quick setup and clean management of the tether.

Electrical Design

Rationale

The electrical design rationale for this year's ROV was heavily influenced by the previous year's mistakes. The leading issue with last year's design was overheating specifically, the buck converter inside the ROV would frequently overheat, causing emergency shutdowns and damaging nearby components.

Addressing this, we designed a more thermally efficient system that could withstand the necessary load to complete the tasks while staying within MATE's safety and design guidelines. Our electrical team outlined and designed the entire system within the desired enclosures. One of the major improvements we implemented was the addition of an aluminum enclosure to help dissipate heat. Additionally, we introduced a dual enclosure system to separate high-load power components from sensitive computing components, improving both thermal management and system organization.

The first enclosure, referred to as the "power chassis", connects directly to the topside tether and receives 48V input. Inside, we installed two DC-DC buck converters running in parallel, which feed into a power distribution board with in-line fuses. This enclosure acts like the "heart" of the ROV, as it routes power throughout the entire system. Because of the high current loads, we isolated this section to minimize the risk of heat-related damage to other components. The second enclosure, dubbed the "computational chassis", contains microcontrollers such as the CubePilot Cube Orange+ and the Raspberry Pi 5. These devices are responsible for managing the ROV's thrusters and onboard systems similar to a "brain". Since they are more sensitive to heat, separating them from the power components helps preserve functionality.

Power Management

Power management was influenced by the issues of last year. Tackling this inside our enclosure layout, we thought a custom buck converter would be the optimal choice; however, with limited spacing and availability of parts, it was proven impractical.

As a result, we decided to continue using pre-manufactured buck converters. Fortunately, one of our team members had connections with OmniOn, a power technology company. We were able to acquire the QBDS108A0B41-62PHZ models using the connection, ensuring system and cost efficiency. Finally, in order to increase the system's load capacity, we ran the buck converters in parallel. Although causing electrical noise and current fluctuation, it still was a major improvement over last years' issues and contributed to a more reliable system.

Software Design

Rationale

The software design rationale this year focused on maximizing responsiveness and effectiveness in every control structure. We also wanted to emphasize off-the-shelf components to maximize the potential for mass production. To this end, we chose to utilize a two-computer setup consisting of a flight controller unit (“FCU”, CubePilot Cube Orange+) and a companion computer (Raspberry Pi 5). To minimize computational load onboard the ROV, we chose to route collected image data to the topside computer for processing for the photosphere task. In addition, Docker, GitHub, and regular backups were used to maintain software modularity and portability and to facilitate testing.

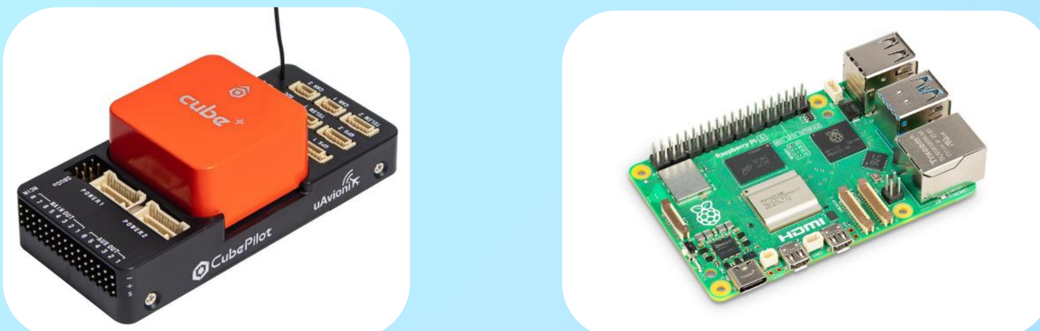


Figure 14. Cube Orange & Raspberry Pi 5

Control System

To control our ROV, we chose to use a combination of ROS2 Jazzy Jalisco (companion computer) and Ardusub (FCU), as both are currently software paradigms in the robotics field. Communication between the two systems was handled via MAVROS, a ROS2 wrapper for the MAVLink2 communication protocol that the FCU utilizes. MAVROS propagates MAVLink2 messages over a UDP port from the companion computer, which is connected to a topside router via ethernet. The topside computer connects to this router over WiFi and displays the user interface, composed of QGroundControl and the custom camera streaming interface. A controller provides pilot input to the ROV, configured through QGroundControl and Ardusub.

Ardusub allowed us to integrate a PID depth hold system based on feedback from a pressure sensor. We were able to demonstrate this using code we wrote from scratch, but we chose to go with the off-the-shelf/native solution as it provided greater responsiveness in maintaining the ROV’s depth.

As Ardusub did not have options to configure control of the claw's differential arm, we chose to manually control these using a PCA9685 breakout board connected to the Raspberry Pi over I2C. The topside computer ran a ROS2 node publishing a topic with the connected controller's inputs, which the onboard Raspberry Pi subscribed to and translated into servo positions, sending them through MAVROS to the FCU.

Camera Infrastructure

To receive and process the underwater feed on topside, an onboard script is executed that serves camera streams using GStreamer over UDP. A Python script is used to initialize stream parameters like bitrate, resolution, and a fisheye correction matrix using OpenCV before anything is sent to the topside computer. With another Python script to provide a custom user interface, the topside computer displays the feed from both cameras and allows users to capture frames from the stream. To capture frames, the script applies a color correction filter to the last 5 frames received by the topside machine, and the corrected images are stored in a local directory. The color correction filter used is the OpenCV implementation of retinex filtering, which is designed to correct colors in unfavorable lighting conditions; the pipeline for this filtering involves white balance, multi-scale retinex, normalization of pixel values, and finally bilateral filtering for denoising. The pipeline, minus bilateral filtering, leverages GPU acceleration to improve performance on the topside computer.

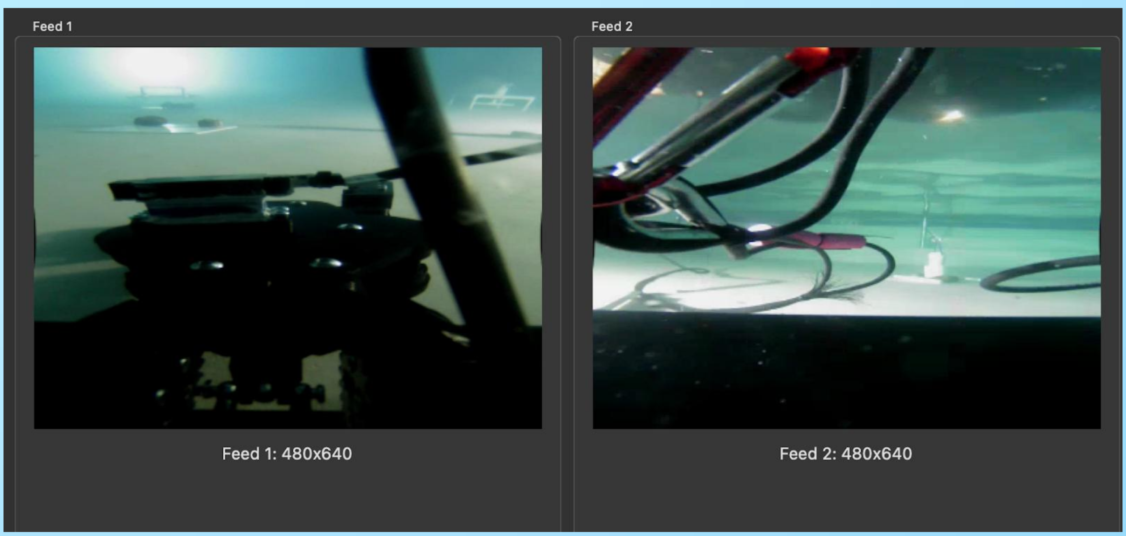


Figure 15. Camera Interface on GUI

Photosphere

To perform the photosphere construction for the shipwreck task, we wrote a Python script using OpenCV's stitching algorithms to create an equirectangular image that can be displayed in a photosphere viewer. Images are collected as frames from the video stream and are saved locally on the topside computer, after which the script is run to generate the equirectangular image to be viewed.

Float

Hydromeda's non-ROV device, SOLENOPSIS, is a vertical profiling float that serves to accomplish 2 vertical profiles while recording and transmitting depth data in accordance with task 3.1. SOLENOPSIS is controlled by a linear actuator-driven buoyancy engine to change water displacement, affecting the float's depth. As the motor retracts the custom-fit plunger, the syringe intakes or ejects water into an external bladder to control overall density, which manipulates depth.

The device's engine is constructed from a 300 mL syringe and a 250 mL IV bag bladder with a custom-designed plunger on a linear actuator. The linear actuator is controlled by an ESP32 WROOM module and powered by a NiMH 12V battery pack. The buoyancy engine and all electronics are enclosed by a 485.15mm long acrylic tube with a diameter of 114.3mm. The device features custom-made resin-cast endcaps with o-rings to ensure water tightness and specially designed 3D printed parts to ensure proper fit and cost effectiveness.

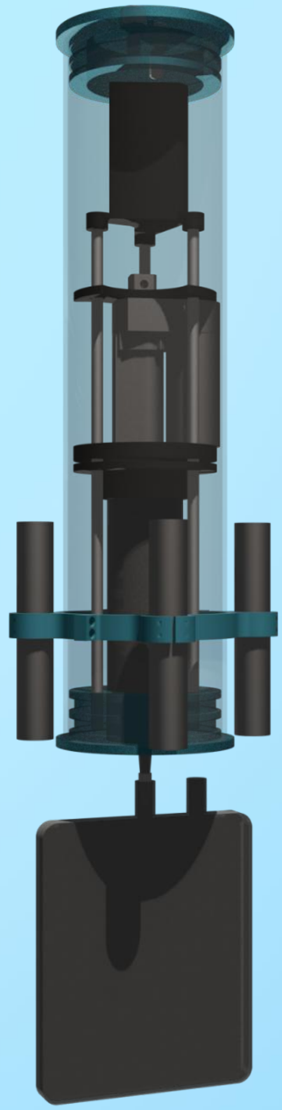


Figure 16. Solenopsis Assembly

Following deployment into the water, SOLENOPSIS will communicate with the base station wirelessly and begin its descent. During each profile, the float will utilize its onboard wireless transceiver modules to communicate the recorded depth data to the base station.

Critical Analysis

Testing

At Hydromeda, each device is carefully tested before being sent underwater. We conduct simulations on the individual components to make sure the ROV functions as close to ideal as possible. With every test, we identify issues, find solutions, and apply them for our next tests. We make sure to satisfy a checklist we have made to conduct the tests safely and come out with the desired results (refer to Launch Checklists in the Appendix).

Our team prioritizes simulations to reduce the cost of printing and redesigning the components. More specifically, simulations of the silicon enclosure for our external cameras were done to save extra time.

Troubleshooting

Mechanical:

Troubleshooting focused on prevention by testing and reproducing the errors in individual components after every iteration helped build thoughtful redesigns that resembled the expected final product. For instance, we noticed that the o-ring seal used for the camera enclosures was getting stuck, rather than smoothly sliding through when squeezed between the cap and the cylinder. Consequently the enclosure was not holding pressure. The issue was in the roughness of the casted acrylic end cap. The 3D printed part was then brushed with a thin layer of epoxy before redoing the silicon mold and the resin cap, enabling a smoother setup that holds pressure when pressure tested.

Electrical:

We initially ran our motors at 100% gain, but saw continuous failures when they stayed at full power for over a minute. By dropping the gain to 50%, we achieved both reliable, extended operation and sufficient thrust for agile maneuvering. We also traced intermittent power and signal faults by checking continuity from the source outward, then disassembling and visually inspecting connections to uncover wiring errors, misconfigurations, and overcurrent/overheat trips. All troubleshooting was performed with the ROV powered down when making any electrical changes.

Programming:

In terms of software, several different approaches were taken in order to troubleshoot issues. Ubuntu CLI knowledge came in handy when making sure that devices were correctly recognized and transmitting data, in addition to checking and editing ROS2 parameters and launch files. The team's extensive experience with Python and ROS2 allowed us to write several simple scripts in order to test functions and identify faults.

Accounting

At Hydromeda, one of the most important things we consider when making designs and operating the company is cost efficacy. As we are a relatively new student organization, limited funding requires us to examine every purchase to ensure we are spending our money in the most efficient manner. Prior to the season, Hydromeda set an initial budget based on the previous year's allocations and project costing, as well as research into past budgets of other EXPLORER class organizations.

In the past season, Hydromeda allocated funds towards R&D as we were a completely new organization. This year, we decided to nix most of the R&D category in favor of redistributing funds to ROV production and organizational costs. To keep track of costs and the evolution of our finances with respect to our budget, we created a custom spreadsheet to track every purchase and its usage in relation to the company, ensuring the best use of our funding.

Our mission is to provide marine education to students at no cost to them to participate. While this year's fundraising efforts were not enough to achieve this mission, it is Hydromeda's long-term goal to be able to support our employees without requiring financial support from them, and we are taking steps to achieve this by increasing external sponsorship efforts, focusing on community fundraising, and spreading the word through outreach initiatives. For this past year, Hydromeda's income primarily comes from personal donations, company sponsorships, and the University of Texas at Dallas.

Hydromeda 2024-2025 Income Summary		
Income Category	**Description**	**Amount**
Fundraising	Bake Sales	$309.00
Dues	Member Dues	$1,480.00
Donations	Comets Giving Days	$1,798.00
Donations	Private/Personal Donations	$3,500.00
School Funding	ECS Student Council Funding	$5,599.00
Sponsorships	Mouser	$1,000.00
Total Income		$13,686.00

Hydromeda 2024-2025 Budget Summary	
Item Description	**Estimated Cost**
Subformica (ROV) Cost	
Thrusters	$2,200.00
Tether	$400.00
Electronics	$1,200.00
Chassis	$300.00
Enclosure	$600.00
Tooling	$250.00
Control Station	$900.00
Materials	$350.00
Total	**$6,200.00**
Solenopsis (Non-ROV) Cost	
Float	$500.00
Total	**$500.00**
Team Expenses	
MATE Registration Fee	$650.00
Lodging	$2,000.00
Travel	$800.00
Snacks	$500.00
Total	**$3,950.00**

Figure 17. Income and Budget Summary of 2024-2025

Hydromeda 2024-2025 Product Costing			
Item Description	**Cost**	**Sourcing**	**True Cost**
Subformica (ROV) Cost			
Phenolic Panels	$120.00	Purchased	$120.00
T-slot Extrusion	$99.93	Purchased	$99.93
Thrusters x6	$1,200.00	Reused	$0.00
Thrusters x2	$400.00	Donated	$0.00
12mm 6061 Aluminum Rod 36"	$10.77	Purchased	$10.77
Marine Weld	$14.56	Purchased	$14.56
DP8005 Adhesive	$131.62	Purchased	$131.62
1/4" x 50' Marine Grade Heat Shrink	$12.97	Donated	$0.00
Fasteners	$137.66	Purchased	$137.66
T-slot Brackets	$30.33	Purchased	$30.33
T-slot Nuts	$16.49	Purchased	$16.49
Rope Guide 5/8"	$3.07	Purchased	$3.07
PVC Bar Stock	$19.65	Purchased	$19.65
PETG Filament	$99.32	Purchased	$99.32
35kg Brushless Servos x5	$169.95	Purchased	$169.95
9g Micro Servo x2	$7.99	Purchased	$7.99
228 Buna/Nitrile O-Ring x8	$7.19	Purchased	$7.19
Bar30 300m Depth/Pressure Sensor x2	$170.00	Purchased	$170.00
Penetrator x5	$30.00	Reused	$0.00
Penetrator x11	$66.00	Purchased	$66.00
2.5" x 10" Acrylic Tube x2	$36.36	Purchased	$36.36
Servo Hub Shaft x2	$25.98	Purchased	$25.98
Servo Shaft Adapter	$8.00	Purchased	$8.00
60ml Syringe	$3.66	Purchased	$3.66
Waterproof Hard Shell Case	$73.00	Purchased	$73.00
6061 Aluminum Plate (7" x 6" x 0.25") x2	$53.88	Purchased	$53.88
6061 Aluminum Plate 7.25" x 7.25" x 0.375"	$90.20	Purchased	$90.20
Cast Acrylic (12" x 12") x2	$47.79	Purchased	$47.79
Aluminum Tube (1.5"x 0.125" x 8")	$11.99	Purchased	$11.99
Aluminum Square Tube (6"x6"x0.25"x5") x2	$38.02	Purchased	$38.02
263 Buna/Nitrile O-Ring x2	$0.68	Purchased	$0.68
3/4 inch PET Braided Cable Sleeve 100ft	$20.99	Purchased	$20.99
Foam Comfort Grip Tubing 12" x6	$16.38	Purchased	$16.38
Antispark	$33.99	Purchased	$33.99
Subsea Cable 28 meters	$672.00	Reused	$0.00
12-Way Waterproof Boat Fuse Block	$68.24	Reused	$0.00
Blue Robotics ESCS x8	$304.00	Reused	$0.00
Raspberry Pi 5	$69.99	Purchased	$69.99
CubePilot Cube Orange Standard Set	$384.99	Reused	$0.00
3 Port Power Strip	$9.99	Reused	$0.00
Outlets Dual Side Recessed Power Strip	$35.99	Reused	$0.00
OmniOn Power QBDS108A0B41-62PHZ x2	$236.18	Donated	$0.00
GeeekPi DockerPi Power Board	$21.99	Donated	$0.00
PCB Boards x2	$17.87	Purchased	$17.87
120V Power Switch	$4.98	Reused	$0.00
Total	$5,034.64		$1,653.31

Hydromeda 2024-2025 Product Costing			
Item Description	**Cost**	**Sourcing**	**True Cost**
Solenopsis (Float) Cost			
Acrylic Tube	$66.00	Reused	$0.00
O-Rings x4	$5.00	Reused	$0.00
BlueRobotics Enclosure Vent and Plug	$11.00	Reused	$0.00
Linear Shafts x3	$21.89	Reused	$0.00
Shaft Collars x6	$7.99	Reused	$0.00
300 mL Syringe	$4.00	Donated	$0.00
BlueRobotics Bar 30 Pressure Sensor	$85.00	Purchased	$85.00
ESP32 WROOM CP2012 x2	$10.55	Purchased	$10.55
IR Sensor	$0.89	Purchased	$0.89
L298N H Bridge	$6.49	Purchased	$6.49
Tenergy NiMH 12V battery pack	$21.99	Purchased	$21.99
XL4015 Buck Converter	$4.70	Donated	$0.00
EcoWorthy 2" Stroke Linear Actuator	$39.99	Purchased	$39.99
IV Bag	$0.79	Purchased	$0.79
Fuse Holder	$0.79	Reused	$0.00
5A Fuse	$0.12	Reused	$0.00
Protoboard	$0.25	Donated	$0.00
On/Off Switch	$0.29	Donated	$0.00
Marine Weld	$14.56	Purchased	$14.56
3D Printed Parts	$15.99	Purchased	$15.99
TEExpert Epoxy Resin	$37.97	Purchased	$37.97
1" Stainless Steel Rods	$35.68	Donation	$0.00
Fasteners	$10.00	Reused	$0.00
Total	$401.93		$234.22
Team Expenses			
MATE Registration Fees			$650.00
6 Day AirBNB Stay			$1,441.00
Gas Cost			$800.00
Total			$2,891.00

Figure 18. In-depth Product Costing

Conclusion

Challenges

Although we participated in MATE ROV last year, Hydromeda still faced numerous challenges and learned enriching lessons. We learned lessons from our previous competition, but with the change in management and new teams, we had learning curves when it came to design, testing, and project management.

A significant issue that was faced was making sure that the ideas that we are proposing are feasible. As we participated last year, we wanted to be ambitious and make things that were incredibly well-engineered and unique, but in retrospect, it seems that was not feasible, as we needed to keep in mind that the more modular we wanted to be, the simpler the components would need to be.

Another major issue we faced was the communication across the teams. We had three major teams: Mechanical, Electrical, and Programming. Until far along in the journey, we were subpar at making sure all teams were on the same page, and we learned the valuable lesson of creating tighter connections between the leads, making sure there is constant conversation between them to share the status of their teams, respectively.

Time management was also a major issue that we encountered. We would be under the impression that things would go according to plan, but in most situations, that was not the case. We learned to plan for the hurdles and give ourselves time to work around issues while still being on track.

Reflections

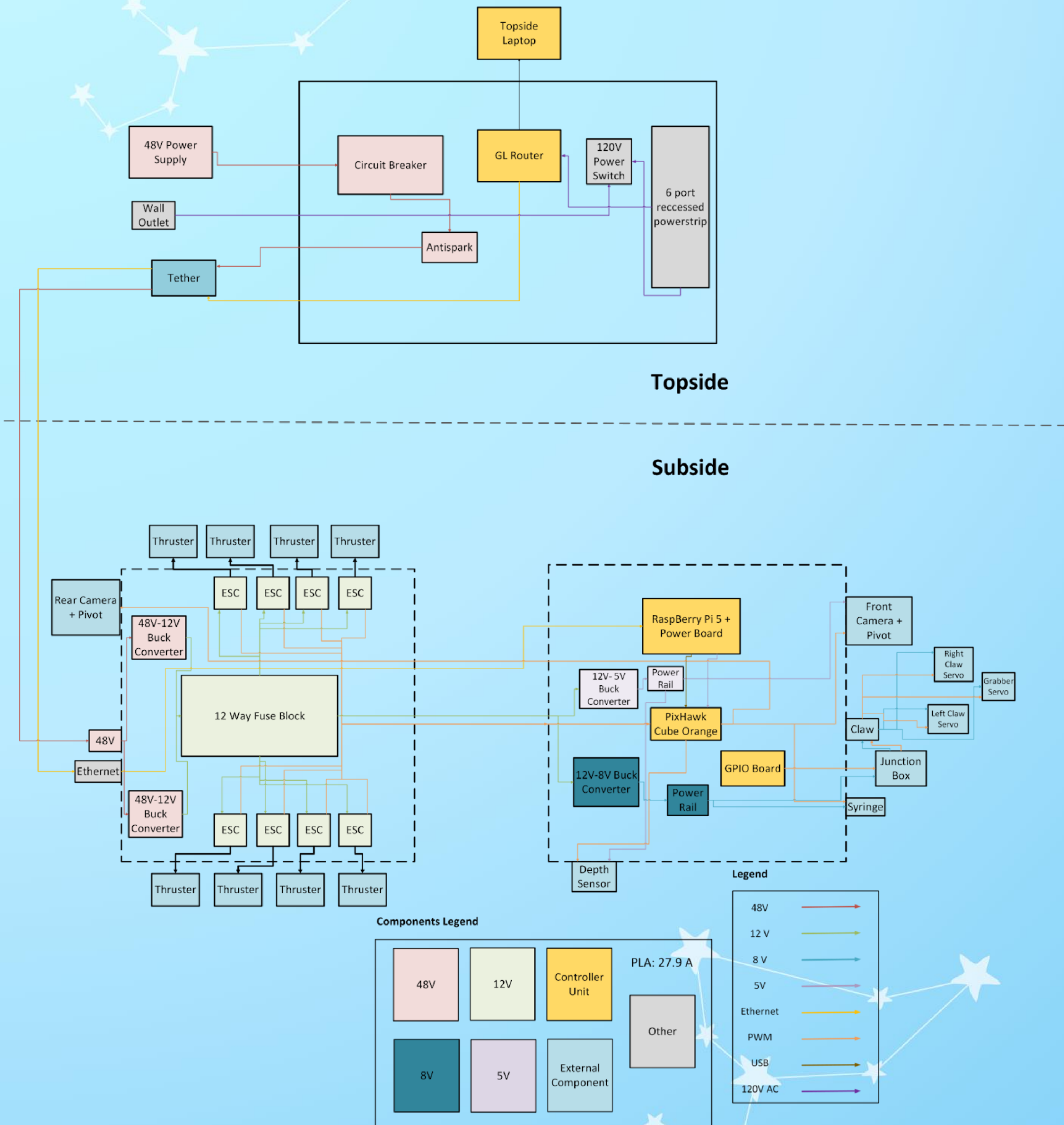
The work we were able to do with Subformica has been transformative. The creation of this ROV showed us the importance of teamwork, perseverance, and constant learning. The collaboration between all the teams involved really brought our ROV to life. Aside from the given teams, Electrical, Mechanical, and Programming, the Business team was able to give us valuable employees and provide us with funds that were crucial in completing our ROV.

Banking on our participation in last year's competition, we were still able to learn skills that last year's competition did not teach us. We learned that ambition has to be faced with reality and that the field of marine robotics has taught skills that can only be learned by no one else.

In conclusion, the journey of developing Subformica has had its ups and downs. The support from our sponsors, mentors, and the University of Texas at Dallas has been invaluable. We are ecstatic to advance our knowledge in the field of underwater robotics, driven by the passion for innovation that defines Hydromeda.

Appendix

Systems Integration Document:



Launch Checklist

Mechanical Check

Pre-Launch Checklist

- Ensure all penetrators and OK valves are tightened.
- Check enclosure seals:
  - Ensure all endcap screws are installed to compress face seals.
  - Ensure endcaps have all screws installed and are tightened properly.
- Verify strain relief on both ROV-side and topside tether.

Launch Procedure

- Launch ROV
- Remind everyone continuously not to walk over the tether at any point during the launch.
- Monitor the tether for tangling.
- Be ready to signal the electrical team for emergency shutoff if needed.
- When retrieving the ROV:
  - Only grab tether cables and handles.
  - Do NOT pull the ROV from thrusters or tooling cables.

Post-Launch Procedure

- Dry the ROV.
- Spool in the tether and secure the ends to the spool.
- Carry the ROV by the handle.
- Place both ROV and tether onto the dolly.

Electrical Check

Pre-Launch

- Power Distribution Screws are tightened
- No exposed or bare wires
- No electrical contacts are grounded to the aluminum tray
- The 48V input connector is connected properly
- 12V connectors for the ESC are connected properly
- 12V for the Buck Converter is properly attached
- Raspberry Pi and Cube Orange are connected
  - This consists of using the IR Remote to turn on the RPi Board
- ESC and Servo pins are properly installed and sturdy
- The Ethernet cables are connected
- The Topside Computer is properly connected

Launch

- Anderson Connector Connected
- XT90 Connector Securely Connected
- Power Cable Connected
- HDMI Displays Connected
- USB Hub is interfacing with the Topside Computer
- All Topside devices receive power after 120V power is connected and powered on

Post-Launch

- Disconnect and protect wires on the spool
- Ensure Topside components are safe
- If any components were exposed to water, dry them properly before powering

Program Check

Pre-launch:

- Transport topside components safely
- Check to make sure topside computer is adequately charged for test
- Ensure proper connections between the Raspberry Pi and Cube Orange
- Test function of Raspberry Pi and Cube Orange, and connection between components, before ROV is sealed up
- Ensure cameras are working properly

Launch:

  - Ensure ethernet is connected correctly
  - Ensure router is able to access web for debugging purposes
  - Ensure that Raspberry Pi is pingable from topside
  - Ensure correct communication between Raspberry Pi and Cube Orange (MAVROS initializes correctly)
  - Post-launch:
- Make sure all components are powered off correctly
- Transport all topside components safely to avoid damage

References

[1] “ArduSub and the ArduPilot Project,” ArduSub, https://www.ardusub.com/.

[2] “O-Ring Gland Calculator,” Apple Rubber, https://www.applerubber.com/oring-gland-calculator/.

[3] “T200 thruster,” Blue Robotics, https://bluerobotics.com/store/thrusters/t100-t200-thrusters/t200-thruster-r2-rp/.