Project Nebula

MATE ROV Competition 2025

Ranger Class

Arlington, TX

Members:

Mitchell Hulme: CEO
Graham Partee: ROV Lead, Pilot
Joel Lee: Code Lead
Nicholas Cheng: CFO, Float Lead
Benjamin Bowyer: Engineer
Ethan Rojas: Float Engineer
Liam Bray: Float Engineer

Mentors:

Douglas Johnson
Courtney Hulme, P.E.

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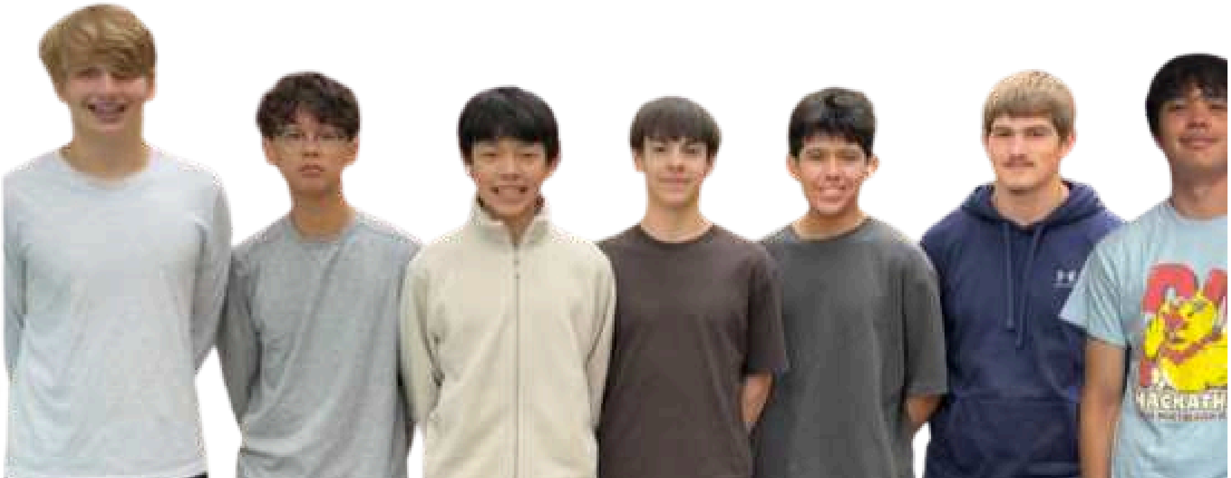
Abstract:

Project Nebula is paving the way in underwater robotics, focusing on developing and producing advanced Remotely Operated Vehicles (ROVs) for missions in diverse marine ecosystems located around the world. Based in Arlington, Texas, we are all about gathering crucial information to help us and others around us in understanding how to best advocate for the protection of aquatic environments and what affects climate change has on our planet. Our dynamic team of seven are passionate about developing innovative solutions that are high performing yet affordable.

Our mission is all about excellence. Having reached a milestone with Project OMEGA, our most advanced submarine yet. After over 675 hours of collaboration and production, Project OMEGA stands as a testament to our dedication to pushing the boundaries of technology and innovation. From its sturdy build to its top notch camera systems and movement control, every aspect of Project OMEGA shows our drive to go beyond the norm.

We take pride in being self-sufficient, having funded our journey independently over the past four years. This achievement highlights our team's creativity and determination, with every aspect of ROV development—from initial ideas to building—coming solely from our members' efforts. We produce all of our components in house, and only rely on outside sources for computers, motors, and hardware. To ensure reliability, all of our work is done exceptionally well, with modularity and replacement standing as key factors of our mission.



Project Nebula:

I. The Team

Our nonprofit is comprised of seven committed individuals from two schools, all united by a shared mission. Each member brings distinct skills that enhance our efforts in two primary focus areas. The collaboration between our teams encourages innovation, strengthens community connections, and boosts the effectiveness of our initiatives.

Main ROV:

- Mitchell Hulme, our CEO: Oversees the various team groups, ensuring everyone stays on task and meets deadlines.
- Graham Partee, the ROV Lead: Responsible for the design and structure of the ROV, collaborating with his engineer, Ben Bowyer, to ensure diligent task completion.
- Joel Lee, Code Lead: Develops the code, making certain it aligns with the specifications and requirements set by the ROV Lead.

Float:

Nicholas Cheng, the float lead manages his team of two other engineers, Ethan Rojas and Liam Bray, on the float design and construction.

II. Our Mission

At Project Nebula, we strive for a brighter, sustainable future through innovation. We are proud to make our products accessible to everyone, regardless of financial status.

III. Management and Organization

Our organization consists of two main teams. The ROV team develops the primary ROV and its components, while the Float Team creates two vertical profiling floats. Due to our small team size, each member has a specific expertise, reporting to the lead after meetings. The leads update the CEO on progress and improvement areas. This separation into groups allows our team to work extremely efficiently, and established effective communication enables our teams success.

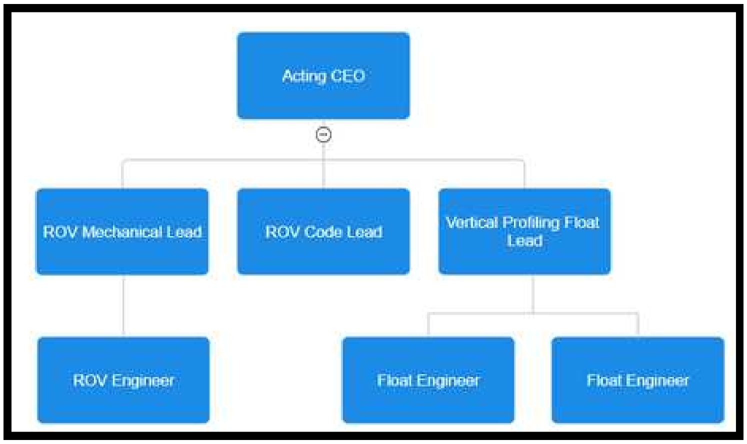


FIG. A; Company Management

Project Nebula:

The effectiveness of our team is built on careful scheduling established from our first meeting, focusing on three key components:

- Lunch Meetings: Held every school day to manage documents, present new designs, and facilitate discussions.
- Workshops: Occur every Sunday from January to the competition, aimed at refining designs and enhancing skills.
- Practices: Weekly sessions in March and April for pilots to engage with the Project OMEGA and foster teamwork.

We accommodate members' needs with additional lunch meetings when necessary. These additional meetings prevent delays and support self sufficient work.
Fig B provides a visual schedule overview.

IV. Time Management

To make certain that all elements of the ROV and NROV are finished on schedule for effective testing, we implemented a deadline schedule. This approach ensures that each component adheres to its assigned timeline.

To further optimize this process, we incorporated a GANTT chart system. The GANTT chart offers every team member a clear overview of their responsibilities along with the corresponding completion dates. Meetings lasted around 4 hours long, and were comprised of planning, working, and testing schedule.

Fig C illustrates the first half of the GANTT chart.

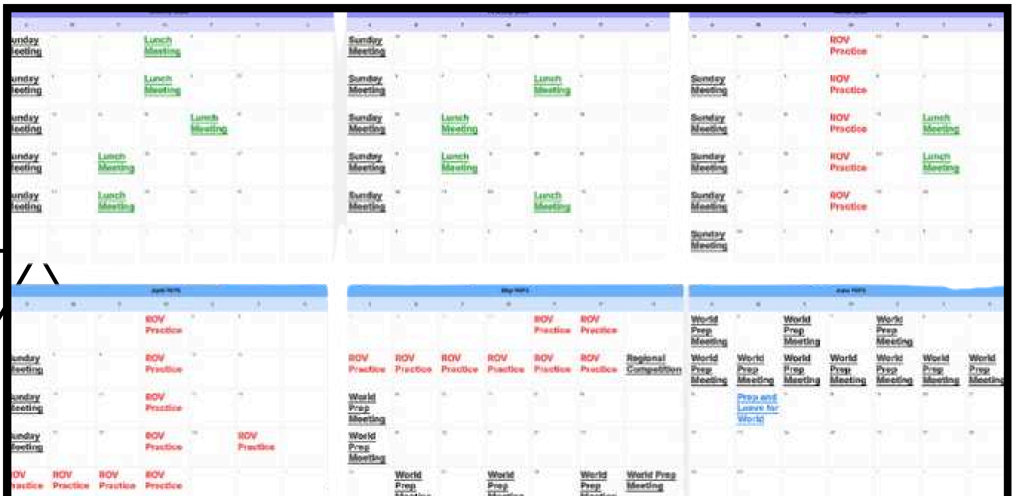


FIG. B; Schedule

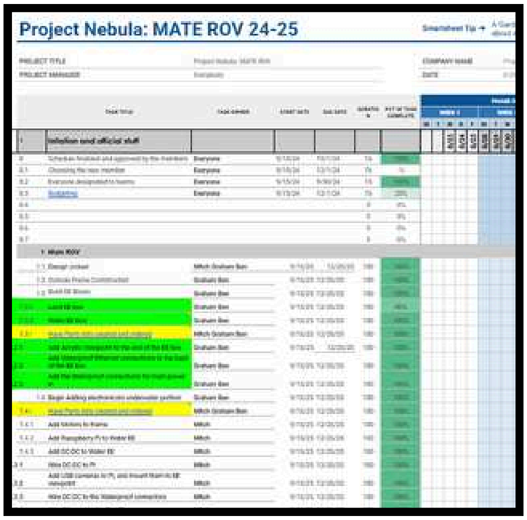


FIG. C; GANTT Chart

Design Rationale:

I. Overview:

This year, Project Nebula is thrilled to unveil its latest and most innovative product line, known as Project Omega. Project Omega represents the pinnacle of design and ingenuity, delivering solutions for all tasks outlined in this year's RFP. Each element of this project has been meticulously crafted to produce a machine that not only demonstrates strength but also showcases versatility and reliability.

The primary goals for this year's project were to enhance last year's efforts and create a more reliable and adaptable ROV. We chose each feature of the ROV with the following four key objectives in mind:

- High value
- Low cost
- Easily implemented
- Reliable
- Effective

Our goal was to develop an ROV that could effectively meet each of this year's main objectives while ensuring it remains affordable and accessible to all. In this section of the document, we will detail each design choice and the data that informed our decisions.

II. Planning:

At Project Nebula, we take pride in our simplicity and the innovative technology integrated into every design. To ensure that this year's initiative, Project OMEGA, truly pushes the boundaries of ROV technology, we needed to establish clear goals for what we aim to achieve. During the initial phase of the season, August through November, we concentrated on selecting candidate components for the project. This encompassed everything from advanced cameras to redesigned underwater electrical systems. Once we gathered the components we wished to include, we conducted a detailed analysis of each approach. This evaluation allowed us to predict the performance and effectiveness of every element, guiding us in determining the value of each investment. The planning phase enabled our team to comprehend the necessary changes. By utilizing established tools, such as the GANTT chart and a centralized whiteboard listing objectives, we ensured that each member was aware of the tasks to be completed during meetings and future discussions.

Design Rationale:

We chose to document potential solutions for each of the issues outlined. Following that, we transferred all viable ideas into a flow chart (Fig D.) of what wanted to accomplish this year.

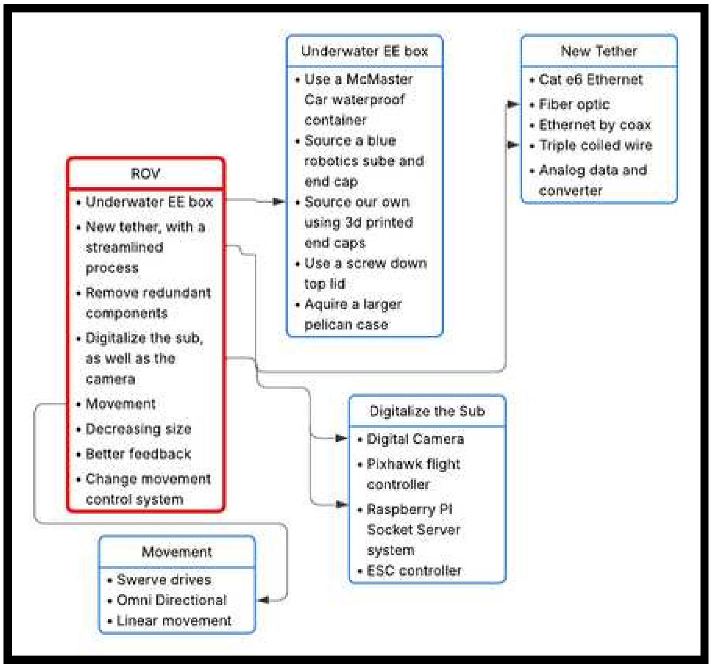


Fig D; Solution flow chart

Through this flow chart, we pinpointed potential solutions for each challenge to explore. During the remainder of the planning phase, we decided to meticulously test each option to ensure alignment with our four goals for effective implementation. Additionally, we began the sketching and development of the sub, as illustrated in Fig E. The CAD designs were modified throughout the year as new innovations and challenges emerged.

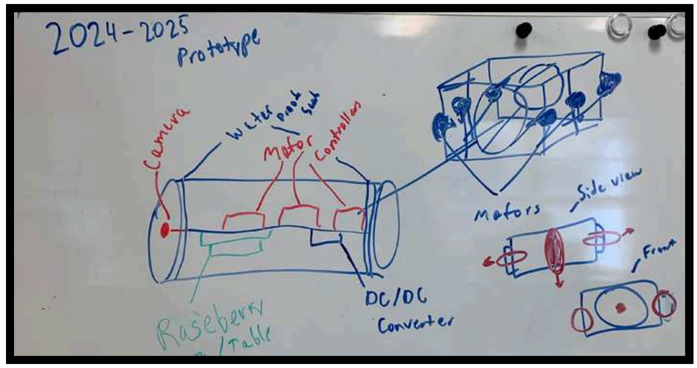


Fig E; Initial Sketches

III. Innovation and Evolution:

Based on the planned changes discussed in the previous section, we recognized the need for significant innovations throughout the year. These modifications were crucial to our success, as we understood that failing to improve upon last year's project would lead to the same challenges.

The most notable innovation in our ROV was the transition from an analog system to a digital one. By digitizing our ROV, we gained the capability to process data underwater, along with the advantages that come with it. Removing the redundant analog system that Project REDNOVA ran on also meant we had to develop new solutions to put electronics under the water.

Design Rationale:

Initially, our goal was to create a sealed submarine with a simple canister design that utilized wire penetrators for our wiring. Although this solution worked temporarily, it was not sustainable for long-term use. As a result, our team decided to explore a different waterproofing method. We evaluated the practicality of using an O-ring system in conjunction with 3D-printed end caps and an acrylic tube. This approach proved to be highly effective, enabling us to operate the new underwater EE box safely.

In parallel with digitizing our components, we had to completely reevaluate our electrical system. Instead of discarding the valuable insights gained from Project REDNOVA, we chose to model our underwater system in a remarkably similar manner, as it had demonstrated its effectiveness. Given the similarities between the designs of both projects, we were able to avoid relying on untested new parts. Additionally, the electronics required a new mounting approach, leading us to custom design an electrical plate, as illustrated in FIG F.

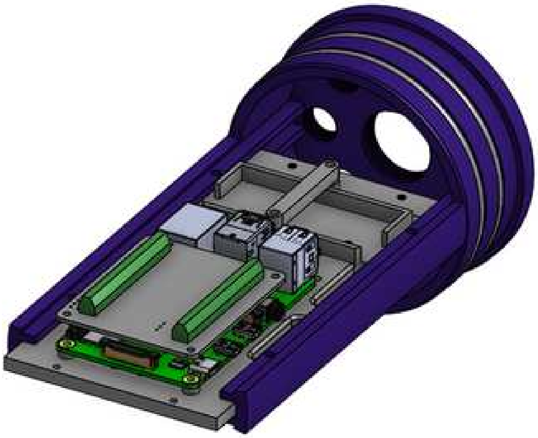


Fig F; Electrical plate

For the sake of reliability and to protect the electronics from water exposure, we depended on a hyper absorbent substance to line our box. This measure guaranteed that all our components stayed dry and operated seamlessly. Furthermore, by coating the O-rings with a layer of dielectric grease, we significantly reduced the likelihood of water entering the EE box, enhancing the safety of our ROV. We also heavily innovated our operation procedures, now utilizing frequent leak checks to make sure testing ran smoothly.

Finally we wanted to heavily improve the modularity of our ROV. In previous years we ran into issues during the product demonstration, and components could not be replaced easily. To prevent this, we

Design Rationale:

created two underwater electrical boxes that have been thoroughly tested and confirmed to function effectively. These are shown in Fig H. Additionally, we completely reimagined how our electrical system was connected, switching to simple plugs, shown in Fig G, rather than wire penetrators. This switch ensured that in case of an issue, parts could be swapped out instantaneously. We replicated this design choice in all other parts of our system, now cutting the repair time of the ROV to a tenth the time of previous years.

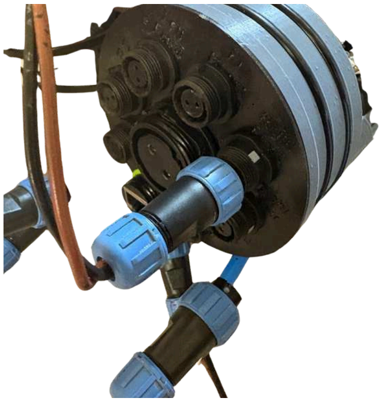


Fig G; Electrical plugs

We have also made significant advancements in our system's mobility with the new implementation of omnidirectional movement. By positioning our motors at a 45-degree angle relative to each other, we can now not only move linearly and turn but also plane smoothly.

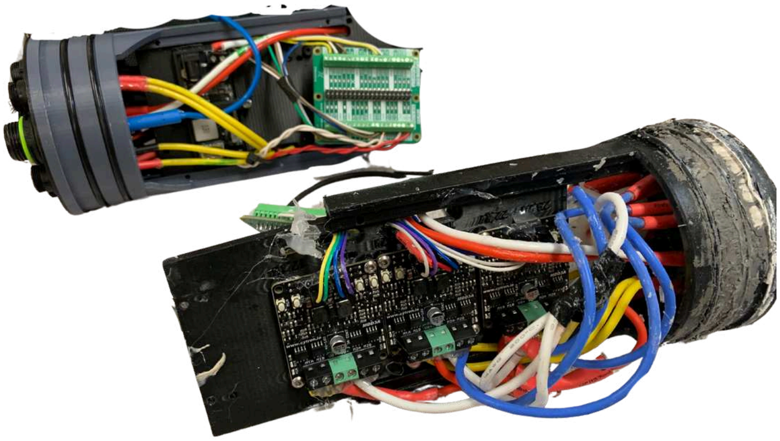


Fig H, Project OMEGA underwater EE boxes

IV. Structure and Simulations:

Project OMEGA is built around a PVC frame that supports a custom-designed underwater electrical box. The choice to use PVC as the primary material for the frame was driven by its affordability and low failure rate. Moreover, its availability at any major hardware store made it an attractive option as the primary binder for our structure.

After selecting the material and rough design, we employed Onshape CAD software to facilitate the final design of the frame. This is shown in Fig I.

The decision to remain with a cube shape was ideal as we were addtionally introducing the implentation of omni directional movement.

Design Rationale:

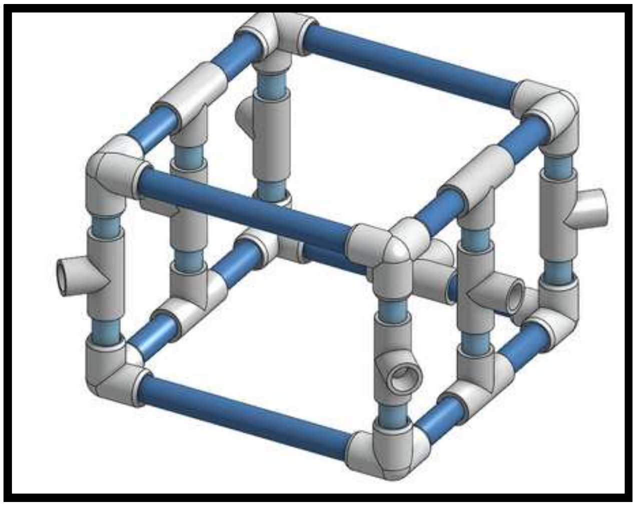


Fig I, PVC structure

Our land electrical box is made from a modified Pelican case, featuring wire penetrators to ensure proper strain relief, as shown in Fig K. A plate is included to securely hold the DC-DC converter and the Raspberry Pi. We have also incorporated WAGO connectors to improve the swappability and replaceability of the tether line in case of an incident.

Omnidirectional movement with a cube also allowed for extremely straightforward vector calculations, enabling us to estimate the sub's speed with all motors operational. Calculations are shown in Fig J.

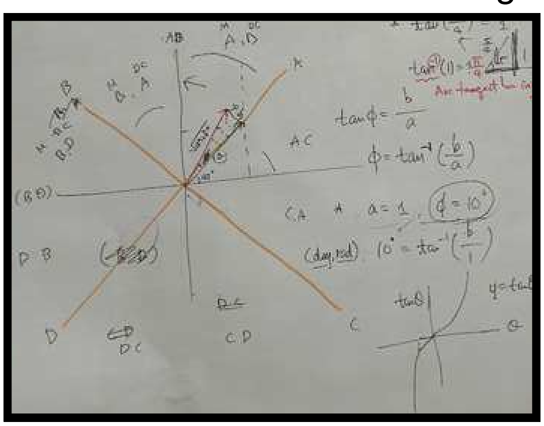


Fig J; Omni directional movement calculations

These calculations played a crucial role in the software's development, which will be detailed later in the document.

In contrast, the underwater electrical box is designed with two 3D-printed end caps within an acrylic tube. These end caps are coated with a thick layer of epoxy resin to prevent water from leaking through the infill. Furthermore, they are lined with two rubber o-rings, providing a watertight seal along the length of the pipe. The 3D-printed plate depicted in Fig F is inserted into the tube and secured to the end cap using a slide mechanism. This innovative design facilitates easy removal of the plate, enhancing accessibility for the electronics. An expanded view of the assembly can be seen in Fig L.

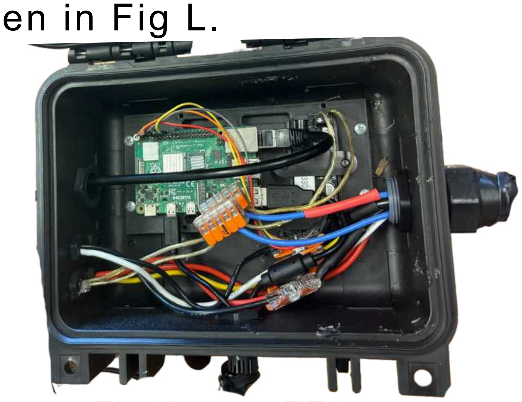


Fig K, Land EE box

Design Rationale:

V. Electronics and Components

This year's electrical system has been designed in a manner consistent with previous iterations. The rationale behind this decision is rooted in the established reliability of our developed system, which has allowed us to integrate most components while effectively reducing costs without compromising dependability.

To support the SPX motors, we employ three MDD3A motor controllers. The MDD3A units are connected in parallel and draw power from a dedicated line running through the tether, ensuring that each SPX motor receives sufficient power. Each MDD3A unit can control two motors and receives signals from the main computational unit, the Raspberry Pi, via dedicated GPIO pins, as illustrated in Fig O.

All onboard computations are conducted using a Raspberry Pi 4. This computer chip is capable of processing and transmitting substantial amounts of information to and from another Raspberry Pi 4 located on the surface.

Information is transmitted via a Cat 6e Ethernet cable, which connects both the land and underwater Raspberry Pi devices.

For camera functionality and feedback, we use a Raspberry Pi Camera Module V3. This module is connected to the legacy port on the underwater Raspberry Pi 4, enabling the operator to view a clear video feed streamed through the Ethernet cable.

To provide power to both Raspberry Pis, both on land and underwater, we implement a DC-DC voltage step-down converter from 12V to 5V DC. This ensures that our Raspberry Pis receive the necessary power while also serving as a voltage surge protector for these delicate components.

Fig P illustrates the flow of information between the components.

Fig O, MDD3A control

Design Rationale:

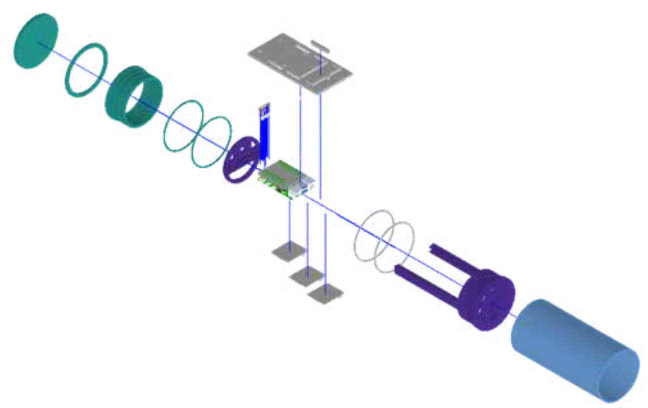


Fig L; Expanded view of underwater EE box

To enhance operational safety in marine environments, we created custom shrouding that was 3D printed to fit our SPX motors perfectly. These shrouds, illustrated in Fig M, also helped streamline the water flow, resulting in a slight improvement in our motors' efficiency.

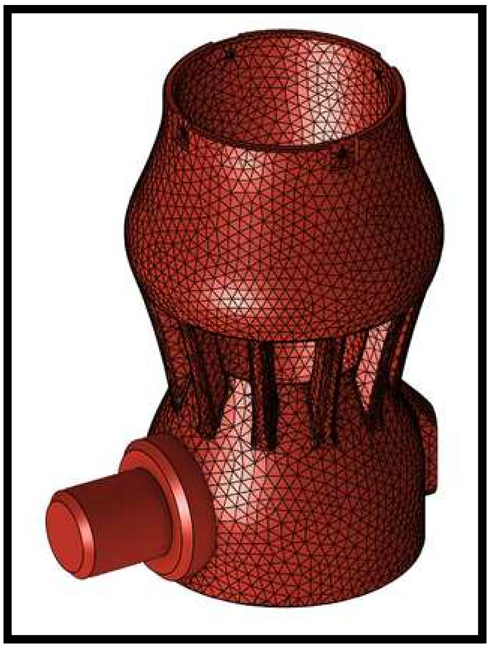


Fig M; Motor Shrouds

For ballast and weight distribution, we used the underwater electrical box as a large float chamber and added custom-made weight chambers to achieve neutral buoyancy. These chambers contained lead shot and were mounted at the bottom of the ROV for stability.

To ensure our ROV would perform effectively in the water, we carried out SimScale water flow simulations, as shown in Fig. N. These simulations provided essential data, confirming that our designed components would function at peak efficiency. Additionally, we conducted a series of rigorous tests to assess both the performance and durability of our design under various conditions. These tests included pressure assessments at different depths and stress evaluations to determine the resilience of the materials used in construction.

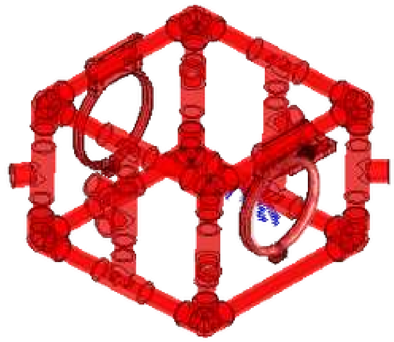


Fig N; Flow simulations, showing pressure displacement

Design Rationale:

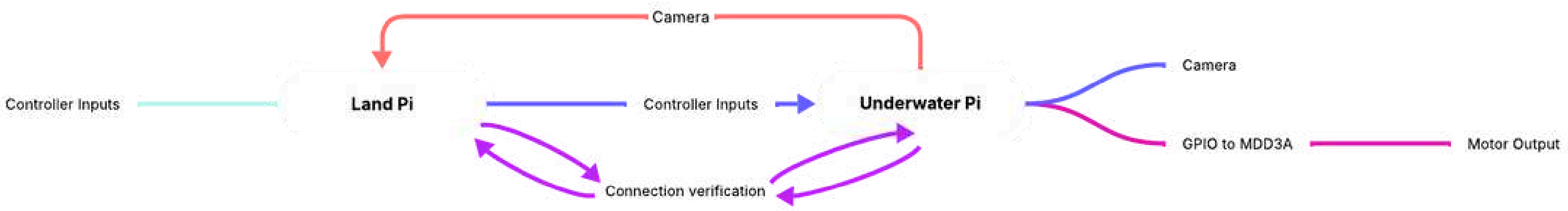


Fig P; Information exchange

The tether employs two distinct 12V power lines that extend from the primary power source to the ROV. The main power line consists of dual coiled wire bundles with three wires within the coil. To ensure sufficient mobility underwater, we chose to encase the coiled wire with a silicone covering. This design allows the tether to remain highly flexible while minimizing voltage loss.

To determine the optimal amount of wire, we used a voltage loss calculator to assess the necessary length and gauge of wire required, as illustrated in Fig Q.

Inputs

User Mode	Residential
Current Type	DC
Units for Length	Feet
Phase	Single
Conductor	Copper
Installation	Cable, Conduit (non-Steel), & Direct Burial
Length of Cable Run	45.0 Feet
Voltage	12 Volts
Max Voltage Drop	10 %
Current at end of Cable Run	15 Amps
Power Factor	0.9

Results for Minumum Conductor Size Calculation
1 conductor per phase utilizing a 8 AWG copper conductor installed Cable, Conduit (non-Steel), & Direct Burial will limit the voltage drop to 7.51% or less when supplying 15 amps for 45 feet on a 12 volt single phase system.

Engineering Information

40	Amps Rated ampacity of selected conductor
0.7421	Ohms Resistance (Ohms per 1000 feet)
0.0520	Ohms Reactance (Ohms per 1000 feet)
0.9	Power Factor
1.20	Maximum allowable voltage drop at 10%
0.902	Actual voltage drop loss at 7.51% for the circuit

Fig Q; Voltage loss calculation

Based on our calculation, we determined that an 8-gauge wire would meet our needs. For flexibility, we opted to coil three 14-gauge wires, which would meet the amperage requirements. This strategy allowed us to repurpose some of last year's tether, ultimately lowering design costs. The tether is illustrated in Fig R.

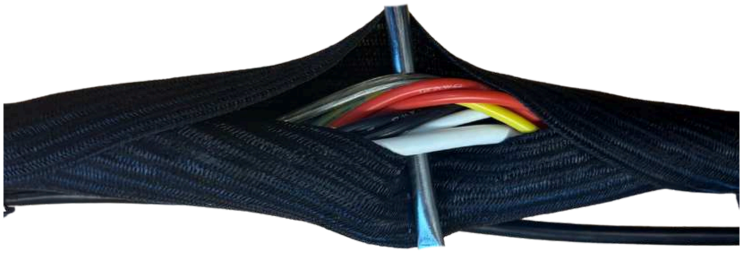


Fig R; Tether

The second 12vdc line uses 14 gauge stranded copper. This line exclusively powers both of our Raspberry Pis and their corresponding DC to DC converters. The dedicated line is needed to prevent motor back EMF from crashing the Pis. As previously noted, data is transmitted via a Cat 6 Ethernet connection.

Design Rationale:

The design of the underwater EE box has been meticulously planned to guarantee durability and reliability across varying conditions. Constructed from corrosion-resistant materials, it provides exceptional protection for the delicate electronics contained within. The enclosure includes a series of watertight seals and gaskets that effectively prevent water ingress, ensuring the components' longevity and performance.

In addition to its protective features, the EE box is designed for easy maintenance. Equipped with quick-release latches, it allows for swift access to internal systems, simplifying routine inspections and essential repairs. The strategic arrangement of connectors and ports also enhances efficient cable management, reducing the risk of tangling or damage during deployment.

Using readily available components ensures that each part can be easily replaced in case of a failure.

Fig H illustrates the underwater section of the EE box, while the complete SID can be found in **Appendix A**.

VI. Propulsion:

For propulsion, we assessed three thrusters: the MATE bilge pump thruster with a custom Kort Nozzle, the Diamond Dynamics TD1.2, and the Blue Robotics T200. We conducted actual current and thrust tests on both the SPX and TD1.2 thrusters, while data for the T200 was sourced from the Blue Robotics website.

Price|Thrust|Amp

- SPX Bilge Pump: $38 | 0.8 | 2.5
- Diamond Dynamics: $64 | 1.2 | 6.6
- Blue Robotics T200: $258 | 3.7 | 17

We opted to use the SPX thrusters for the following reasons:

- Cost: We already had them on hand.
- Power: Using other options would have required software limiting of thrust to remain within our power budget.
- Thrust/Power: The MATE thrusters provide the best thrust-to-power ratio.

Each of the motors was placed at a 45 degree angle from neutral to allow for omni directional movement across planes. As noted above, it also maximizes thrust in any one direction. Vertically oriented thrusters were placed on each side of the ROV for depth control.

Design Rationale:

Fig T shows this testing, and shows the SPX motors in action.

Fig T; Motor testing

VII. Manipulation:

Reflecting on the lessons learned from last year, we concluded that our manipulator system needed a complete overhaul. Instead of depending on a previously unreliable servo system, which frequently failed due to internal corrosion, we opted for a different kind of waterproof servo.

The manipulator relies on a waterproof servo, that is sealed from all edges to prevent internal water from leaking in. The servo is attached to two gears, which are then attached to the claw. Using a pivot point at the midpoint of the claws length, it allows for the arms to open and close linearly.

In the event of a electrical failure, we also have a backup hook, as illustrated in Fig U.

Fig U, Backup Claw

Both claws are meticulously crafted to fulfill the tasks needed for this year's competition. The operator has the flexibility to use either claw based on specific requirements and can switch them out effortlessly throughout the event.

Our design not only improves functionality but also streamlines maintenance, reducing the time and effort required to keep the system in optimal condition. By focusing on these aspects, we aim to enhance our performance and reliability.

In preparation for this year's challenges, extensive testing has been conducted to simulate various scenarios the claws might encounter. This rigorous evaluation process has helped us identify potential weaknesses and refine our design to withstand demanding conditions.

Design Rationale:

VIII. Code:

For the MATE ROV Ranger class competition, we decided to code our submarine with three major objectives in mind: reliability, precision, and readability. The code we made this year ensures great real-time control with accurate feedback while maintaining simplicity to remove any chances of errors during demos.

Our ROV software architecture follows a distributed approach over 3 main systems of Python code, which control our entire submarine. These systems are shown in Fig V.

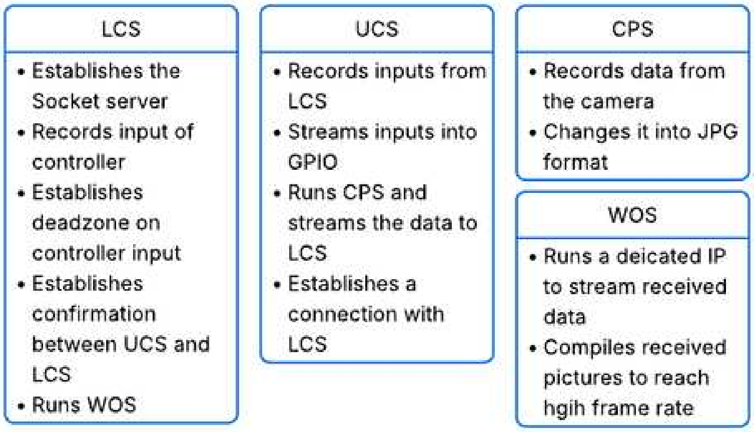


Fig V; Code systems.

Land Control Software (LCS):

The LCS is located inside the Land EE box and performs many functions in terms of input processing. Firstly, using the socket library, we connect to our UCS (Underwater Control System) and receive confirmation that we did connect.

Fig W; Flight sticks

Secondly, our LCS takes in input from a controller (in this case, 2 separate flight stick controllers, shown in Fig V) and extracts relevant data such as joystick position, button presses, and button pressure in real time to keep us updated with the latest data. With this data, we can deadzone it to remove accidental motor movement when it is not intended. Finally, with this data, we send it to the UCS for the next step in controlling the submarine.

Underwater Control Software (UCS):

The UCS is located inside the Underwater EE box and is somewhat more complicated than our LCS, as it is one of the core parts of the submarine and contains a few more functions as well.

Design Rationale:

The UCS is the system responsible for establishing the socket server and managing the connection while it receives and interprets commands. Upon receiving commands from the LCS, the UCS breaks them down into individual lines and extracts pertinent information from each one.

From this point, we use the GPIO Zero library to manage the ROV thrusters. By implementing an intuitive algorithm, we can compute the necessary motor inputs for optimal omnidirectional movement. To ensure peak performance, we employ two threads: one that handles input from the LCS, and the other that directly manages each motor, enabling asynchronous operation.

Fig X illustrates the data transfer between these core processes.

Camera Processing Software (CPS) and Website Opener Software (WOS):

Our Camera System is split into 2 main bits of code, which are the CPS and WOS. The CPS is located on the underwater EE box along with the UCS. The UCS first works by capturing the video stream from our dedicated pi camera and uses MJPEG processing to split up the video into frames using the JPEG image format (Shown in Fig Y).

We then send these frames to a website made by the CPS and use multi-threading to handle multiple client connections simultaneously. Our WOS is much simpler, however, as all it does is open the website that CPS made and simply formats it to fit our needs to control the submarine. Our video feed can be seen in Fig Z.

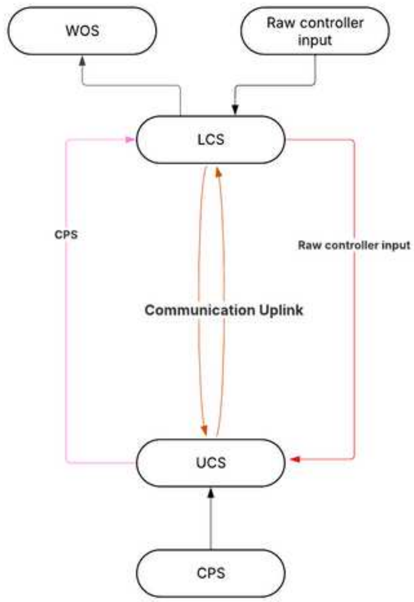


Fig X, Data Transfer

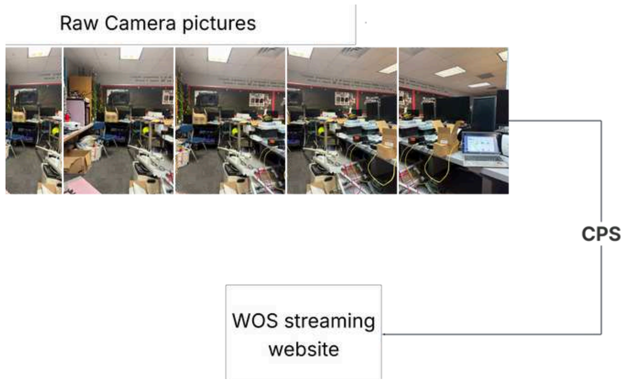


Fig Y, Image streaming

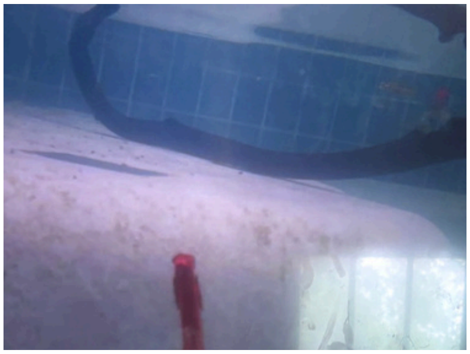


Fig Z, Video feed

Design Rationale:

IX: Vertical Profiling Float

The Demon Diver represents the third generation of Project Nebula's autonomous vertical profiling float, specifically designed to monitor the effects of climate change on oceanic health. Its movement is powered by a 300ml syringe, managed by a custom servo mechanism and controlled by the Xiao ESP32C3 microcontroller. Figure AA illustrates the basic input and control mechanism of the NROV. Crafted from cost-effective 3D-printed PLA plastic, this float is the most affordable option available on the market. It features a modular internal layout that includes compartments for electronics, lead shot, and a buoyancy control system. The float receives commands and transmits data to a land-based laptop via custom Python software and Bluetooth. Bluetooth is particularly suitable for this application due to its design for short-range communication amidst a noisy RF environment.

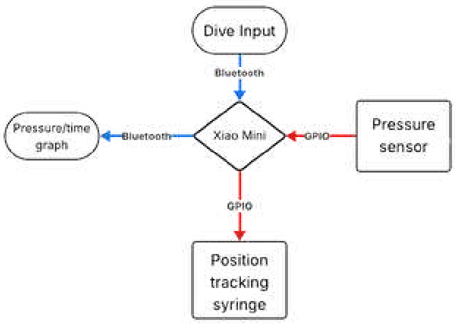


Fig AA, Diver control

After learning from our mistaes last year due to circuit shorting and not having spare parts, we implemented custom printed circuit board (PCB) that simplifies wiring and ensures reliable connections between the microcontroller, servo motor, pressure sensor, and battery system. The float is powered by four rechargeable AA NiMH batteries, replacing the older triple-AA alkalines for greater energy capacity and environmental benefit.

Safety matters, so a 2-amp blade fuse protects critical electrical components and a pressure relief plug at the float's top prevents structural failure due to overpressure. Separating electronics from the weight chamber protects electronic components from getting damaged from possible water leakages.

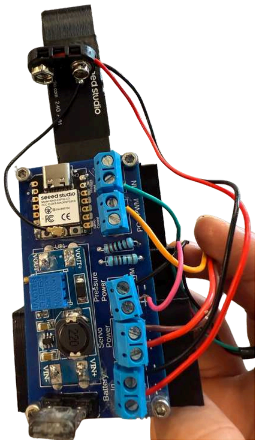


Figure AB. Demon Diver Electrical Architecture

Design Rationale:

X. Safety

At Project Nebula, safety is one of our top priorities. We are committed to ensuring that all our products are not only safe to use but also secure to handle and dismantle.

The design of Project OMEGA is fundamentally focused on safety, featuring a comprehensive range of protective elements. Before launching the ROV, we conduct a detailed launch checklist shown in Appendix B, and a Job Safety Environmental Analysis (JSEA) to reduce the risks of injuries and hazards during the launch process.

Once the ROV is launched and powered, multiple safety systems are integrated into the technology to guarantee that its operation is continuously monitored and any potential issues are promptly resolved. These systems include a main fuse at the power intake to protect our ROV from amperage surges (Fig AC). Additionally, each of the DC-DC converters functions as a surge protector for our Raspberry Pis, preventing damage from overvoltage to these critical components.

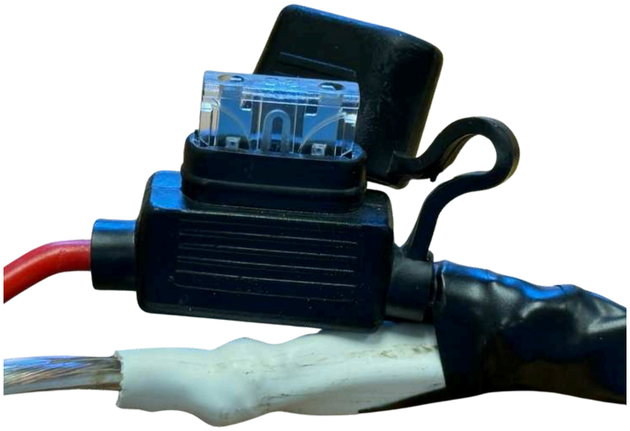


Fig AC; Main Power Fuse

The design of the ROV places a strong emphasis on safety. The uniquely crafted motor shrouds are designed to reduce the intake of foreign objects, including fish, thus protecting the propellers. Furthermore, the ROV's compact size (Fig AD) helps to avoid causing damage to surrounding underwater objects. The motors are positioned with sufficient clearance from the ocean floor, which prevents sand and other debris from entering the propellers and being stirred up. All these features contribute to a healthier ecosystem and help ensure that our ROV does not inflict lasting harm on its environment.

Fig AD: ROV Size, coke can for reference

Design Rationale:

XI. Challenges

During the development of the ROV, we faced several challenges. Anticipating that we would encounter various issues along the way, we utilized a decision tree to solve them, as illustrated in Fig AE.

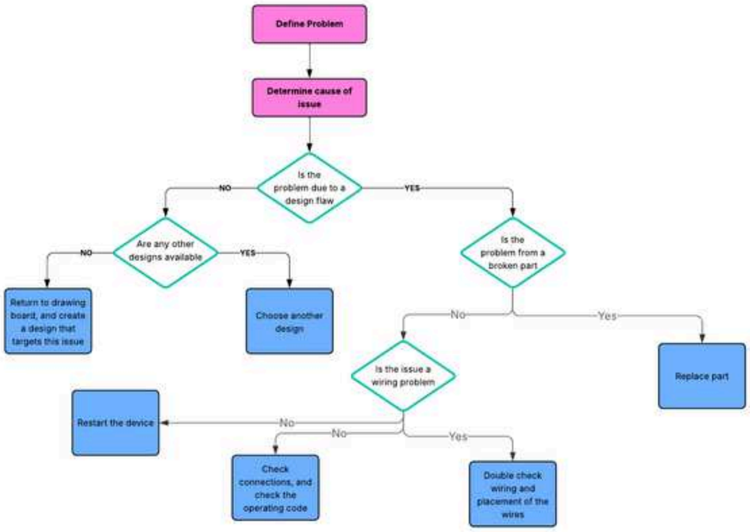


Fig AE: Problem decision tree

By utilizing this decision tree, we successfully addressed several challenges encountered during testing, including issues like the motors unexpectedly shutting down and the underwater EE box developing a leak.The decision tree allowed us to systematically analyze these problems and implement effective solutions.

This methodical approach not only resolved immediate concerns but also improved the overall reliability and performance of the ROV.

I. Rationale:

At Project Nebula, our top priority is safety in every aspect of developing and creating our ROV. As our safety officer, Graham Partee, aptly states, “If we can’t ensure safety while doing it, we shouldn’t be doing it.” To fulfill our mission, we integrate safety into all facets of ROV development and related workspaces. Each team member undergoes comprehensive training on all tools employed and is required to adhere to strict safety checklists and protocols during the construction and operation of the ROV.

II. Protocol

Safety protocols are implemented to ensure secure operations throughout both the assembly and usage of the ROV. We designate a supervisor and an operator, accompanied by a thorough checklist for their reference. The supervisor is responsible for ensuring that the operator, whether working with machinery or the ROV, diligently follows each step outlined in the checklist. This method reduces risks and guarantees the safety of everyone involved while using the equipment.

A sample safety launch checklist can be found in Appendix B.

Accounting & Closing:

I. Budgeting

To achieve our goals this year, we implemented a detailed budgeting system focused on our fundraising needs. We successfully reduced the expenses for Project OMEGA, with total production costs for new ROV parts around $250. A design budget of roughly $2,200 was set aside, while the largest expense was $5,000 allocated for travel to both regional and global competitions. Our proactive budgeting approach has allowed us to stay alert in our fundraising efforts and set clear objectives for future improvements. All funds raised come from donations and the hard work of our members. A rough budget estimate sheet is available in Appendix C.

II. Cost Accounting

Following the establishment of initial cost estimates and a budget, we began selecting components and making adjustments to align with our financial plan.

Each final component was documented in a cost accounting record, which can be found in Appendix D. By reusing several of these components, we significantly lowered the overall cost of the ROV.

I. Acknowledgments

We would like to express our heartfelt gratitude to Mr. Johnson, our mentor. His guidance and support have been priceless throughout the years, and words cannot fully capture our appreciation for all the help he has offered. We are truly thankful for the opportunity to utilize your shop and for your unwavering support during difficult times.

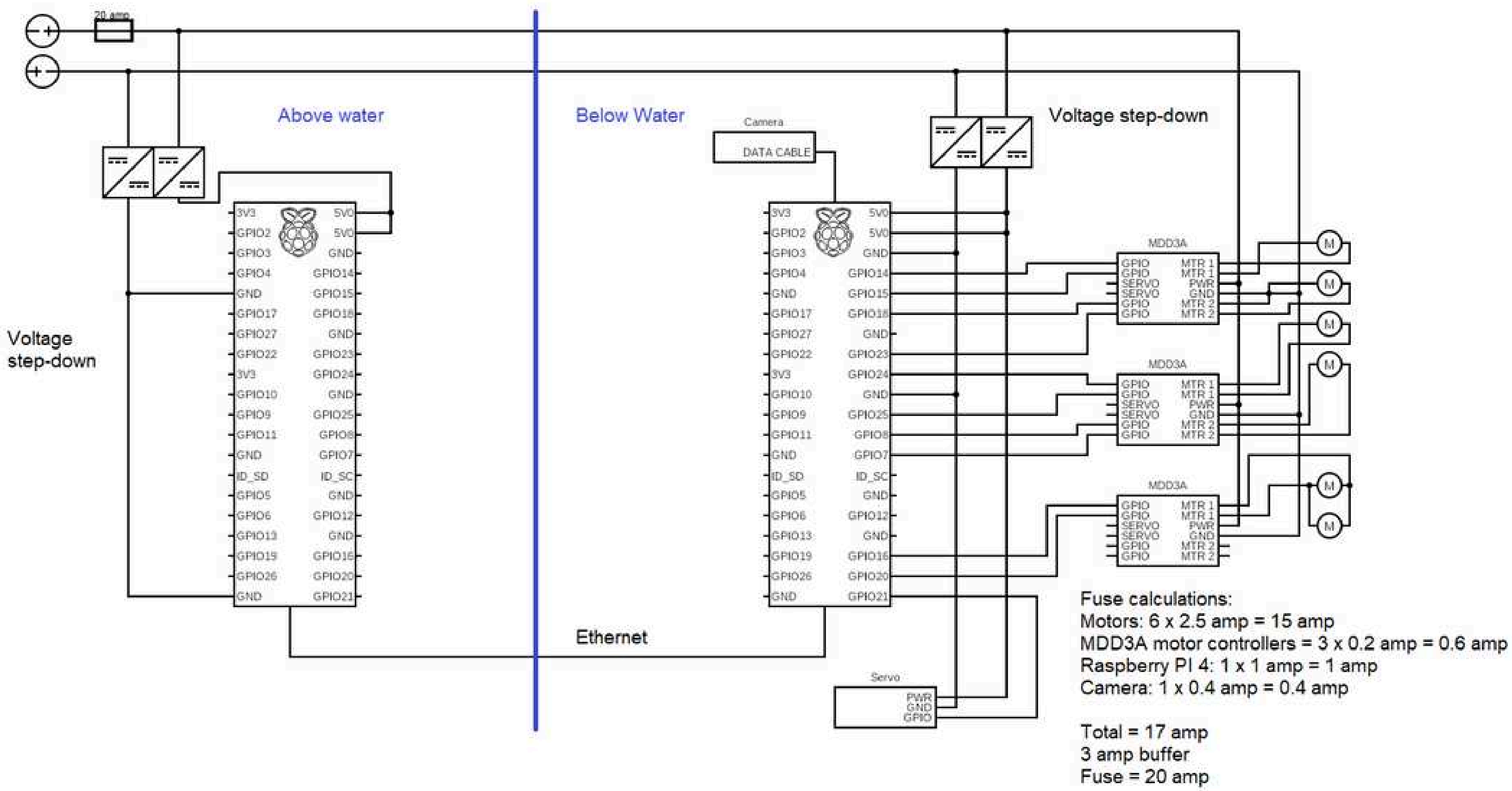
Our sincere appreciation goes to the team at Gearn Industries for your assistance. Your support has been essential, and we genuinely value it.

Lastly, we extend our gratitude to our two anonymous donors who helped fund our journey.

II. References:

- https://en.wikipedia.org/wiki/Bluetooth
- https://www.southwire.com/calculator-vdrop
- https://bluerobotics.com/store/thrusters/t100-t200-thrusters/t200-thruster-r2-rp/
- https://cad.onshape.com/documents/5bb2a3c8ff928a36f31f5f01/w/9a45aaabb6eff411d395f6e4/e/01151ce0281e926eb657c6c9
- https://lucid.app/documents#/documents?folder_id=home

Appendix A:



Project OMEGA full SID

Appendix B:

Project Nebula - ROV Launch Checklist

Pre-Launch Inspection

□ Visual Inspection

- □ Inspect ROV frame for damage, loose components, or stress points
- □ Check all thrusters for debris or obstructions
- □ Verify all motor shrouds are secure and undamaged
- □ Inspect tether for cuts, abrasions, or exposed wiring
- □ Confirm all electrical connections are secure and properly sealed
- □ Check underwater EE box O-ring seals for proper placement
- □ Verify underwater EE box is dry inside before closing
- □ Confirm all end caps are properly secured with fasteners
- □ Verify ballast weights are properly secured
- □ Check camera housing and lens for debris or damage

□ Electrical Systems Check

- □ Verify main fuse is intact and properly rated
- □ Check that DC-DC converters are securely mounted
- □ Confirm Raspberry Pi power indicators are functioning normally
- □ Inspect all wiring connections for proper strain relief
- □ Verify WAGO connectors are properly secured
- □ Test camera feed prior to water entry
- □ Verify control station display is functioning properly

□ Mechanical Systems Check

- □ Test movement of all manipulators/claws
- □ Verify pneumatic system pressure is within operational range
- □ Check backup hook is secure and properly positioned
- □ Confirm all thrusters spin freely
- □ Verify all manipulator tools are securely attached

Tether Management

□ Tether Preparation

- □ Untangle and straighten tether completely
- □ Verify tether length is appropriate for mission depth
- □ Check tether float attachments (if applicable)
- □ Designate team member as tether manager
- □ Review tether management protocol with team

Control Station Setup

□ Software Check

- □ Boot Raspberry Pi control system
- □ Confirm software initializes without errors
- □ Verify communication between surface and underwater systems
- □ Check controller calibration and response
- □ Confirm video feed is operational

Appendix C:

Income:	Description:			Amount:
Donations	Received donations from our two anonymous donors and parents			$900
Fundraising	Fundraising through efforts made by members			$1,300
Total				$2,200
Expense:	Description:	Type:	Replacement Cost	Budget:
ROV:	Propulsion	Re-Used	$120	$0
	Frame	New	$100	$100
	Tether	Re-Used	$60	$0
	Underwater EE box frame	New	$120	$90
	3D Printer Filament	New	$150	$150
	Pelican box	Re-Used	$50	$0
	Electronic components	New	$500	$500
	Controller	Re-Used	$40	$0
		New	$20	$20
NROV:	3D printer filament	New	$130	$130
	Custom PCB	New	$40	$40
	Electronic components	New	$50	$50
	Syringe	Re-Used	$15	$0
	Misc	New	$30	$30
Travel:	Hotels (Region and world)	New	$5,000	$0
	Travel (Region and world)	New	$2,000	$0
Shop:	Tools and supplies	New	$600	$600
Corporate:	501c3 Registration	New	$300	$300
	Mate Registration fee	New	$450	$450
Prop Materials:	Materials	New	$200	$200
			Total Cost	Budgeted Value
Totals			$9,975	$2,660

Projected Budget

Appendix D:

Date	Item	Vendor	Cost	Category
11/22/2024	Resistor Pack	Amazon	$13.99	Electronics
11/20/2024	Switches, connectors, dc-dc converter	Amazon	$50.05	Electronics
11/21/2024	Raspberry Pi 4	Amazon	$55.69	Electronics
12/23/2024	Power Adapter	Amazon	$6.99	Electronics
12/17/2024	Ethernet cable	Amazon	$9.89	Cables and Connectors
12/9/2024	dc-dc converter	Amazon	$9.99	Electronics
12/14/2024	pressure sensor	Amazon	$20.99	Electronics
1/7/2025	solder	Amazon	$11.99	Shop Supplies
1/2/2025	Anderson power poll connectors	Amazon	$17.99	Cables and Connectors
1/21/2025	female-female jumpers	Amazon	$3.99	Cables and Connectors
1/21/2025	O rings	Amazon	$6.58	Hardware
1/15/2025	USB C to barrel connector	Amazon	$5.99	Cables and Connectors
1/22/2025	O rings	McMaster-Carr	$27.02	Hardware
11/25/2024	Feedback Servo	Robot Shop	$27.13	Hardware
9/25/2024	501c3 Application Fee	IRS	$275.00	Corporate
9/11/2024	Non Profit Incorporation fee	State of Texas	$25.00	Corporate
9/13/2024	Diamond Dynamics Motor	Amazon	$69.28	Hardware
1/25/2025	Jumper Wires	Amazon	$3.99	Cables and Connectors
2/18/2025	3D printer filament	Amazon	$18.99	3D Printer Filament
2/15/2025	Servo	Amazon	$24.99	Hardware
2/12/2025	3D printer filament	Amazon	$18.99	Shop Supplies
2/12/2025	DC Barrel Jack	Amazon	$5.99	Cables and Connectors
2/6/2025	Breakout Board Raspberry Pi	Amazon	$11.95	Hardware
5/13/2025	Syringe and 3D filament	Amazon	$22.98	3D Printer Filament
5/13/2025	Epoxy Resin	Amazon	$72.22	Shop Supplies
5/12/2025	SD Cards	Amazon	$18.99	Electronics
5/12/2025	Micro Servos	Amazon	$8.01	Hardware
5/6/2025	PS3 Controllers	Amazon	$20.69	Electronics
5/5/2025	Acrylic Tubes	Amazon	$26.99	Hardware
5/5/2025	Pi4, Pi Camera, Pi GPIO Breakout	Amazon	$84.93	Electronics
4/22/2025	PLA Filament	Amazon	$13.99	3D Printer Filament
4/28/2025	Contact Cleaner	Amazon	$16.19	Shop Supplies
4/21/2025	SP13 Connectors	Amazon	$36.45	Cables and Connectors
4/19/2025	Syringes	Amazon	$11.98	Hardware
4/17/2025	360° continuous servo	Amazon	$20.98	Hardware
4/17/2025	Battery Holders	Amazon	$6.49	Hardware
4/17/2025	SP13 Connectors	Amazon	$30.40	Cables and Connectors
4/16/2025	PLA Filament	Amazon	$13.99	3D Printer Filament
4/14/2025	RJ45 waterproof connectors	Amazon	$13.99	Cables and Connectors
4/12/2025	Rubber End Caps	Amazon	$8.99	Hardware
4/8/2025	Fuses	Amazon	$7.99	Hardware
4/9/2025	PLA Filament	Amazon	$13.99	3D Printer Filament
4/8/2025	Battery Holders	Amazon	$6.49	Hardware
4/8/2025	dc-dc converter	Amazon	$9.49	Electronics
4/6/2025	Cable Glands	Amazon	$7.99	Hardware
4/7/2025	Acrylic Tubes	Amazon	$26.99	Hardware
4/4/2025	SD Cards	Amazon	$15.99	Electronics
4/5/2025	Pi GPIO Breakout	Amazon	$11.95	Electronics
4/5/2025	CNC Router Bit	Amazon	$16.99	Tools
4/5/2025	SP13 Connectors, RJ45 connectors, dc-dc	Amazon	$30.69	Cables and Connectors
4/5/2025	NiMH Batteries	Amazon	$9.59	Hardware
3/26/2025	Syringes	Amazon	$12.99	Hardware
3/24/2025	RE 29 Power Connectors	Amazon	$26.99	Cables and Connectors
3/22/2025	Cyanoacrylate Glue	Amazon	$13.99	Shop Supplies
3/21/2025	Tap set	Amazon	$9.99	Tools
3/21/2025	PLA Filament	Amazon	$13.49	Shop Supplies
3/17/2025	Acrylics Sheet	Amazon	$23.53	Shop Supplies
3/18/2025	O rings	Amazon	$13.99	Hardware
3/16/2025	Acrylic Tubes	Amazon	$26.99	Hardware
3/16/2025	Epoxy Resin	Amazon	$110.00	Shop Supplies
3/13/2025	RJ45 waterproof connectors	Amazon	$13.99	Cables and Connectors
3/12/2025	Diode Assortment	Amazon	$9.99	Electronics
3/10/2025	Lead Shot	Amazon	$17.99	Hardware
3/11/2025	PLA Filament	Amazon	$29.98	3D Printer Filament
3/11/2025	Battery Holders	Amazon	$8.99	Hardware
3/11/2025	pressure sensor	Amazon	$28.16	Hardware
3/8/2025	Machine Screws	Amazon	$9.87	Shop Supplies
3/6/2025	dc-dc converter	Amazon	$15.99	Electronics
3/3/2025	SP13 Connectors	Amazon	$4.99	Cables and Connectors
3/3/2025	Fuse holders	Amazon	$11.99	Hardware
2/28/2025	NiMH Batteries and Charger	Amazon	$23.57	Tools
4/14/2025	MATE Registration	Active	$450.00	MATE Registration
5/6/2025	O rings	McMaster-Carr	$28.33	Hardware
5/5/2025	Pi4 Motor controllers	Digikey	$57.35	Electronics
4/3/2025	Pi4 Motor controllers	Digikey	$74.76	Electronics
3/6/2025	PVC pipe, sand	Home Depot	$31.74	Demo Props
3/28/2025	PVC fittings for props	Home Depot	$70.48	Demo Props
11/17/2024	Servo	Digikey	$24.98	Hardware
3/31/2025	Servo	Robot Shop	$31.13	Hardware
3/16/2025	Printed Circuit Boards	PCBWay	27.16	Electronics
	Totals			
	Hardware		526	
	Electronics		526.19	
	Shop Supplies		290.27	
	Tools		50.55	
	Demo Props		102.22	
	Cables and Connectors		209.33	
	Corporate		300	
	MATE Registration		450	
	3D Printer Filament		113.92	
	Total		$2,547.48	

Cost Accounting