PHOENIX ROBOTICS

BROOKS DEBARTOLO COLLEGIATE HIGH SCHOOL
TAMPA, FLORIDA, USA

Collier, Xia - Junior
Chief Executive Officer, Alternate Co-Pilot
Phuphanich, Bryce - Junior
Chief Operations Officer, Pilot
Badri, Mohammed - Senior
Chief Technician Officer, Alternate Pilot
Chao, Joshua - Junior
Chief Safety Officer, Tether Manager
Quijano, Gavin - Junior
Chief Documentation Officer,
Udagawa, Gavin - Junior
Chief Analysis Officer, Vertical Profiler Specialist
Gajadharsingh, Kristofer - Sophomore
Chief Marketing Officer, Co-Pilot
DuFault, Austen - Junior
Assistant Technician Officer, Vertical Profiler Assistant
Stein, Carson - Junior
3D Printing & Design Specialist, Props Specialist

Eric Fernandez
Mentor
Chris Hochman
Mentor
Elena Glow
Mentor

2024 MATE ROV COMPETITION

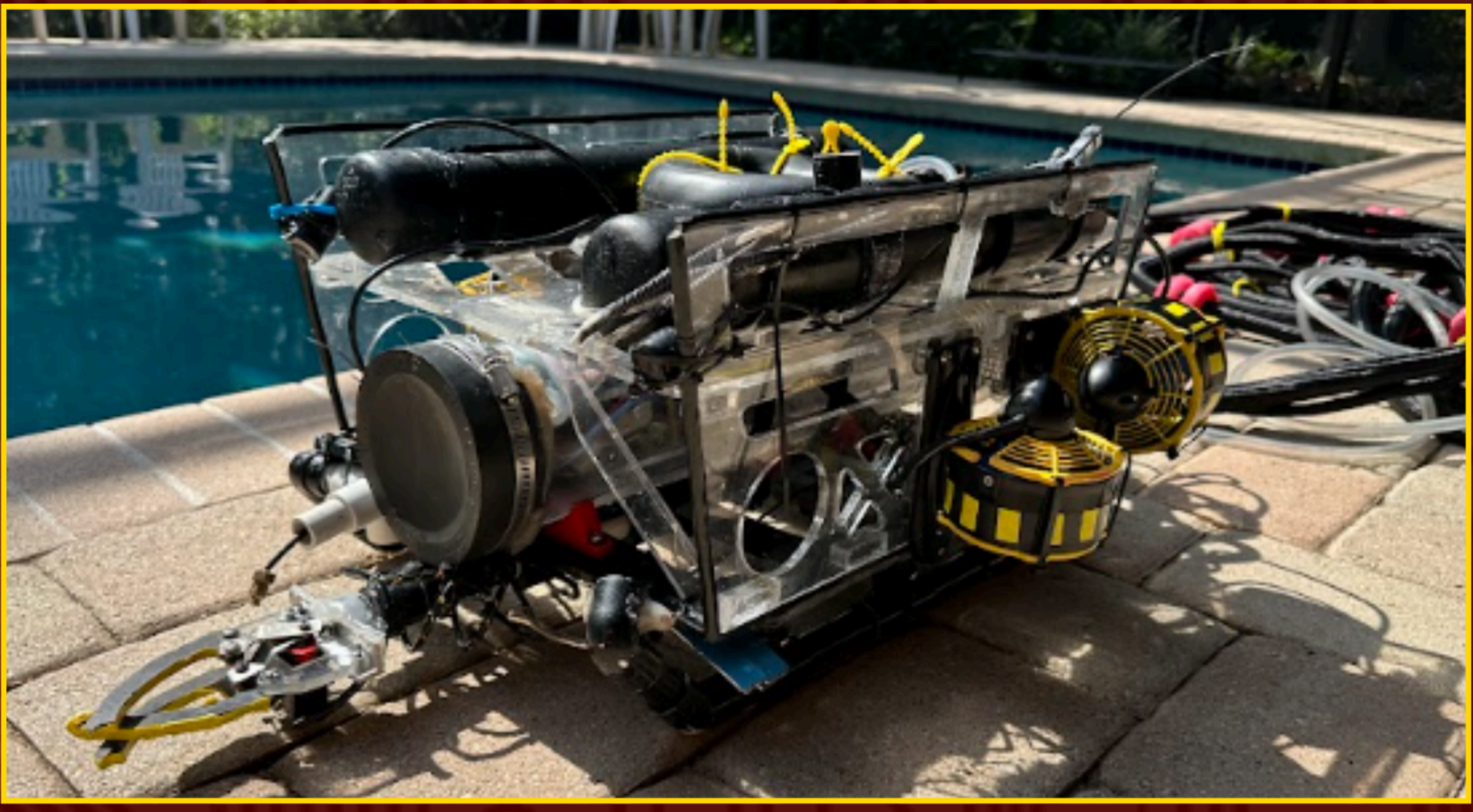


Table of Contents

Abstract

Phoenix Robotics is a company currently employing nine students who attend Brooks DeBartolo Collegiate High School, in Tampa, Florida. The members of Phoenix Robotics focus on the advancement of technology within the field of mechanics, engineering, and programming. The company is made up of determined members striving to raise awareness about marine pollution and create innovative solutions to global problems that are affordable and practical in the form of remotely operated vehicles (ROVs).

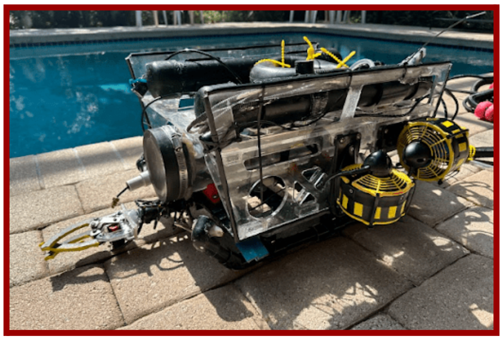


Figure 1: The Phoenix Ocean Explorer
Photo Credit: Xia Collier

This year's ROV is the Phoenix Ocean Explorer (POE) that maintains the health of ecosystems inhabiting Earth's oceans through technology that has been carefully selected and customized. This includes the use of bidirectional brushless motors controlled by specialized software. The ROV utilizes a dual camera system, integrating analog and digital cameras in harmony, providing multiple perspectives, and the ability to model structures underwater. One claw system is mounted on the POE, facilitating the completion of a variety of tasks. Phoenix Robotics designed the ROV to be cost-effective while maintaining efficiency to aid in the effort to clean Earth's oceans, allowing the POE to complete the Marine Advanced Technology Education (MATE)'s Request for Proposals (RFPs) with ease.

The POE is the result of countless hours of hard work, dedication, and teamwork. Phoenix Robotics is confident in its abilities to excel in using the POE to perform the necessary tasks with ease. Phoenix Robotics is committed to continuously breaking the barriers of innovation and environmental stewardship, and is dedicated to making a positive impact on ocean life through cutting-edge technology.

Figure 2: The Phoenix Robotics Personnel
Photo Credit: Bruce Kensky

Teamwork

Project Management

Phoenix Robotics' goal is to design and create ROVs that meet client demands. This year's ROV, POE, is an example of Phoenix Robotics' ability to produce an ROV capable of meeting the criteria of the 2024 MATE Ranger Manual to the point of excelling in the MATE World Championship. Experienced members having competed last year returned to the company and recruited prospective members with a shared ambition. To streamline operations, the company's leadership divided the members into specialized groups for the creation of component systems of the ROV. This continuing company structure enables members to provide feedback, share expertise, and collectively improve the quality of work, which fosters a culture of teamwork and innovation. With company members monitoring each other, safety can be ensured as no one person is operating machinery alone and employees can hold each other accountable for their individual responsibilities. To maximize efficiency, tasks were meticulously assigned to each department based on individual strengths, resulting in accelerated project completion and enhanced overall productivity. Through the presentation of the company at various Science, Technology, Art, and Math (STEAM) events in the Tampa Bay area, Phoenix Robotics worked towards its goal of bringing awareness to ocean conservation and the importance of environmental sustainability, along with teaching about the United Nations Ocean Science for Sustainable Development Goals (SDGs) and its relation to the MATE ROV Competition.

Scheduling and Planning

Coordination and planning enable the company to achieve ambitious goals, which require a high level of commitment from each member. Effective communication is crucial to maintaining attendance and efficiency in the company's meetings. Slack is utilized for team-wide announcements and discussions while WhatsApp is used for parental communication. Using Trello, tasks are organized into departments, tracking progress and assignment ownership. The meeting schedule has evolved over time to accommodate changing needs and pending tasks. Initially held on Tuesdays and Thursdays after school, the schedule expanded to include Fridays and eventually shifted to daily meetings in January to meet deadlines. The company also holds sessions during school breaks and on weekends, lasting approximately six hours and coordinated through announcements by administrative members.

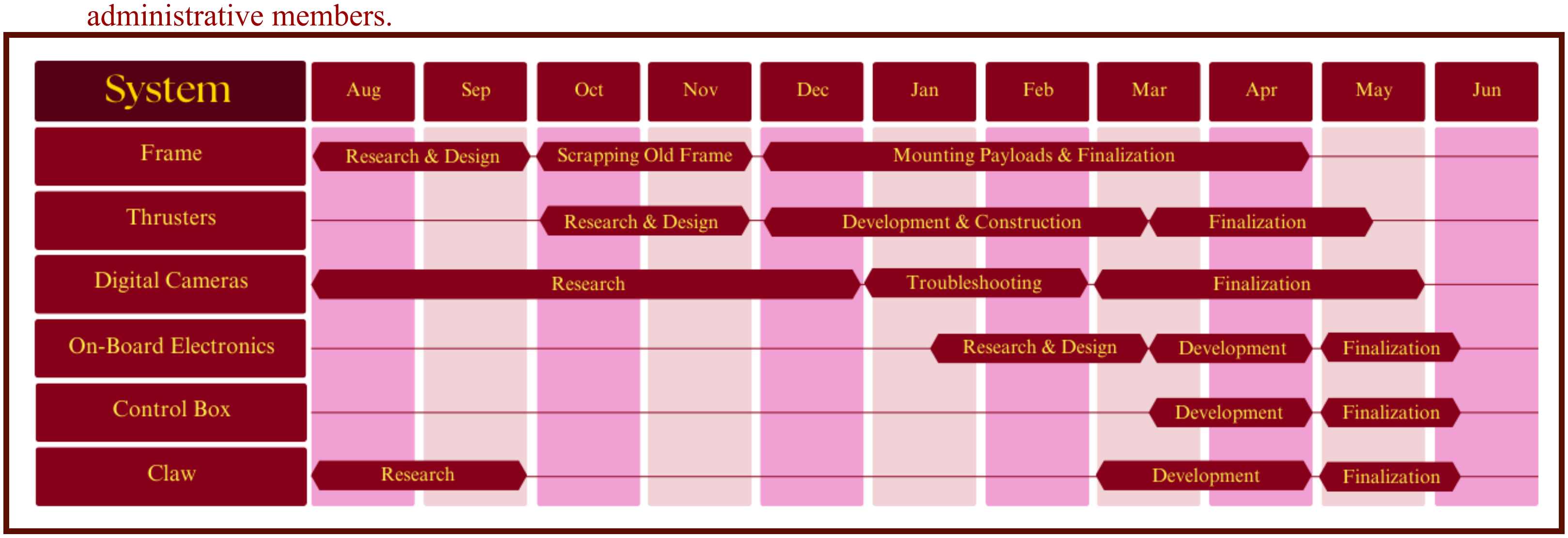
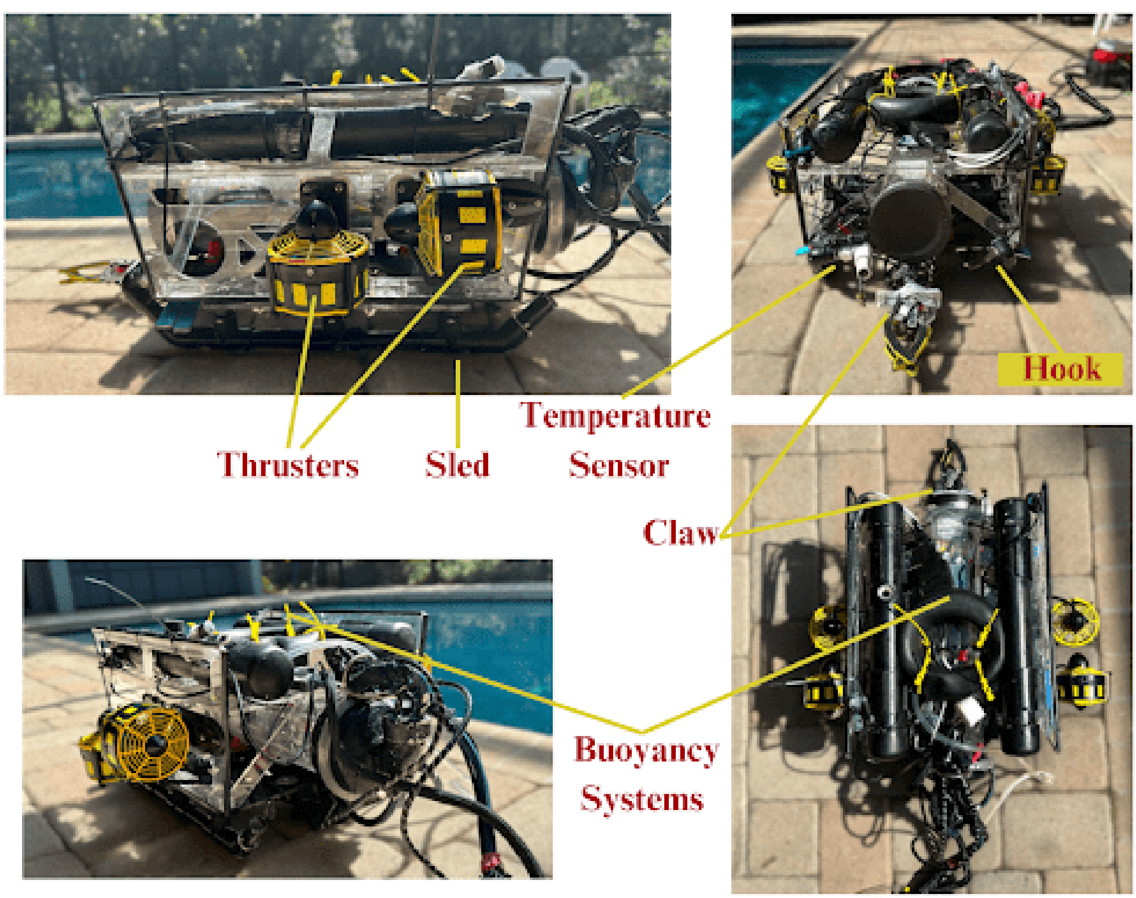


Figure 3: Gantt chart showing time spent on systems over the year
Chart Created By Gavin Quijano

Organization

In terms of resources, Slack, Trello, and Whatsapp were primarily utilized for company communication. Each served an individual purpose and function based on the desired type of communication, whether it would be a company-wide announcement, individual communication, or a team database. This allowed employees to access information from multiple departments if needed when troubleshooting systems. In terms of company procedures, each meeting day would follow a similar three-step process, which would effectively take employees through each system needing completion as well as identifying any potential issues. First, the full company would come together to discuss each group's goal for the day and to make any other important announcements or ask questions. Second, the groups would split up to complete their given task for the day. An individual would be identified during the meeting, so team members would know who to go to for help. Finally, the team would once again convene to discuss their progress, including whether they reached their goal for the day and what issues they faced. Certain protocols, such as keeping a quiet and clean working environment, refraining from sudden movements, and focusing on completing work throughout the entirety of the meeting, were enforced and were expected of each individual employee.

The Assembled ROV



Figures 4-8: Labeled Photos of the POE
Photo Credits: Xia Collier

Design Rationale

Frame

The first decision to be made was what shape the company wanted the ROV to be and what materials would be used when considering expenses and efficiency in water. Several frame designs were created in CAD (Computer Aided Design) program Onshape, with the focus of the designs being the optimization of speed, but the company determined that the mass of the frame and thruster power were more important than shape. After discussions and presentations of the different aspects that could impact the ROV's maneuverability in water, a rectangular prism shape was chosen.

It is of great importance that members of Phoenix Robotics know how previous ROV's competed in MATE competitions and the drawbacks of each machine in order to continue to advance in choosing trade-offs based on the mission tasks. Because Phoenix Robotics has participated in the MATE ROV Competition for many years, the company houses many different ROVs, all created to address certain tasks. Understanding the rationale behind the design of previous years' ROVs offers original input on potential designs that can be used and improved upon to help complete tasks with ease. Because these ROVs have been operated, employees have a better understanding of the trade-offs when choosing one design over another.

While observing and discussing the previous years' frames, the 2020–2021 frame of the U.S.S. Phoenix seemed to suit the company's needs perfectly. In order to understand the system, the POE company members began going through the Trello archives, which included various documents, photos, and data. The company came to the understanding that either aluminum, acrylic, or both should be used to construct the frame. It was concluded that the density of aluminum versus that of acrylic made it worth using acrylic for the speed increase by reducing the load on the thrusters (see Figure 9). Phoenix Robotics chose to dismantle the U.S.S. Phoenix, taking note of the positions of ballast, buoyancy, and payloads.

	HDPE	ACRYLIC	POLY-CARBONATE	ALUMINUM	PVC
DENSITY (g/cc)	0.962	1.19	1.26	3.63	3.63
IMPACT STRENGTH (kJ/m²)	3.74	2.17	10.0	16.3	2.0
FLEXIBILITY (MPa)	17.2-25.0	25.5-62.1	28.0-75.0	20.7	60
PRICE PER Kg	$8.50	$1.92	$3.50	$2.50	$0.28

Figure 9: Density, Strength, Flexibility, and Cost Comparison Between Frame Materials
Chart Created by Gavin Udagawa

Before disassembling the ROV, its physical characteristics, points of contact, and potential damage areas were all noted for post-cleaning maintenance and improvement. Although the ROV was three years old, it remained in good condition with minor scratches and a few loose joints, which were documented for future reattachment. The company inspected the electronics and payloads on the ROV, discussing the reasons behind specific characteristics and how they could be enhanced. As the ROV was being deconstructed, notes were taken on aspects that could be improved and aspects that needed to be changed for safety insurance. Furthermore, photos were taken to aid in understanding of the ROV.

Claws

The next design step focused on analyzing and testing the attached payloads to determine what could be reused, repurposed, or replaced. Phoenix Robotics has equipped their ROVs in previous years with two claws due to their heavy use in the product demonstration. Since this year's tasks didn't involve picking up and transporting multiple items from the surface to mission tasks, a single claw was chosen. Observing the PVC moving the claw excessively, an extra claw mount was included to stabilize it. This ensured that the servo would not detach when turning the claw. Analog servos were used for the claw system, with the open and close servos upgraded to a 25 kg rating to prevent props from 6 slipping out during manipulation. The turning servo rotates on a 360-degree continuous axis and can apply about 35 kg of force, allowing for three revolutions of the claw both clockwise and counterclockwise.

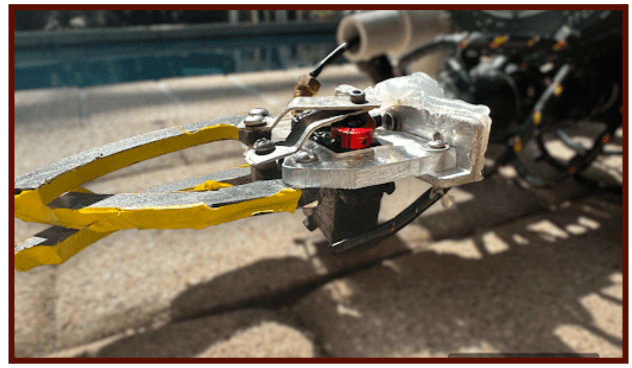


Figure 10: Photo of Revised Claw
Photo Credit: Xia Collier

Thrusters

Last year's ROV used four Dymond Dynamics thrusters; compared to the weight of the ROV, these thrusters proved to be disproportionate and inefficient while completing tasks. This created a heavy reliance on variable buoyancy for upward thrust to carry the ROV. The company began to research reliable brushless motors for ROVS and eventually discovered BlueRobotics which presented a thruster and compatible ESC for control. The company looked through its existing inventory and eventually decided that it would choose between the Blue Robotics T200 thrusters or the 1250 Johnson Pumps, which were brushed motors. The company compared various aspects of both motors to decide which would be better. As a part of this decision-making process, the company purchased a T200 thruster and performed thruster tests (*See Testing and Troubleshooting for more information*) to make better informed decisions based on the power available. Through these tests, the company finally chose to use the Blue Robotics T200 Brushless thrusters for their power and efficiency. The T200 Thruster from Blue Robotics features an innovative fully-flooded brushless motor design that sets it apart from traditional underwater thrusters. This patented design lets the entire motor be submerged in water, with the windings and stator encased and the magnets and rotor coated for waterproofing. The fully-flooded architecture provides a number of advantages. First, it enables natural water cooling of the motor, improving thermal performance. Second, it allows the plastic bushings to be water-lubricated, eliminating the need for a separate lubrication system. Finally, by avoiding compartments filled with air or oil and shaft seals, the design is inherently pressure-tolerant without the need for complex pressure compensation mechanisms.

The thruster body and propeller are constructed from durable polycarbonate plastic, with only a few exposed components made from corrosion-resistant marine-grade 316 stainless steel. This simplicity, combined with a minimal number of parts, allows Blue Robotics to offer the T200 at an affordable price point, making it a perfect choice for the POE. At its core lies a three-phase brushless outrunner motor topology, which runs with an Electronic Speed Controller (ESC) to run the thrusters. The company uses software that was mostly written in C++. This part of the software is used for the basic function of the thrusters. Using this software gave the pilot the additional ability for speed control of the thrusters to allow greater movement variety. This year, the team has implemented a four thruster system which is sufficient and additional thrusters were found to be unnecessary as the current thrusters are strong enough to effectively drive the ROV. The Blue Robotics T200 thrusters, when operating on a 12V/24A system, generate 2.90 kg of backward thrust and 3.71 kg of forward thrust. This much power helps the ROV maneuver through the water quickly allowing it to complete the various tasks MATE has assigned. The thrusters were placed strategically on the starboard and port side of the ROV to ensure that the center of thrust was in-line with the center of mass, maintaining stability. Two thrusters are facing vertically while the other two are facing horizontally, allowing for both horizontal and vertical movement in the water. While strafing is an option when implementing a four thruster system, the team did not find the ability necessary to accomplish the tasks at hand.

Cameras

In past years, the team has felt that poor camera quality has negatively affected the company's ability to efficiently gain points; thus, this year, Phoenix Robotics has pushed for newer and better camera systems. Compared to the old analog camera system, the new digital camera system, which the company has begun pioneering, is a complete evolution from last year's design, with nearly every component different. While more complex, digital camera systems allow for an increase in the quality, customization, and completion of photogrammetry tasks. Additionally, this permits the completion of automation tasks, all of which allow for an effective system with fewer cameras required, lowering the cost. This is accomplished by utilizing digital USB cameras, bought for their cost-effectiveness and quality, powered through the onboard supply, which provides up to 5 volts and 3 amps. A USB transmitter/receiver system that replaces the whole camera box to directly send all data through only a single 15-meter RJ45 CAT-6 cable is a major improvement compared to last year's four wires in the tether. The company chose to use a CAT-6 cable because it was the most cost-effective use of funds while being able to carry all the required data, able to send up to 10 GB per second. Instead of a monitor, a laptop was chosen. Although this decision to have a laptop ultimately resulted in a smaller screen compared to what a monitor could offer, a laptop provides the capability to run video software to compile multiple video feeds into a viewable experience and run photogrammetry software for task 3.3.

Buoyancy and Ballast

With a density of 1.19 g/mL, the acrylic frame does not displace much water, which sits at 1 g/mL. When combined with the addition of payloads, our ROV weighs 20 kg. The ROV is negatively buoyant in water. The frame is negatively buoyant on its own, however, not as much as other frame materials such as aluminum. The on-board electronics tube and the two PVC pipes use air spaces to make the ROV extremely buoyant. To balance this out, heavy weights are distributed strategically across the frame, keeping it stable during maneuvers. Furthermore, the tube's high air content and, by extension, buoyancy allow impressive flotation. Additionally, by controlling the variable buoyancy on land, the buoyancy can be enhanced and effectively counteract the force of gravity. This flexibility in buoyancy allows the ROV to be used in a variety of oceanic environments, where water depth may vary based on content or depth.

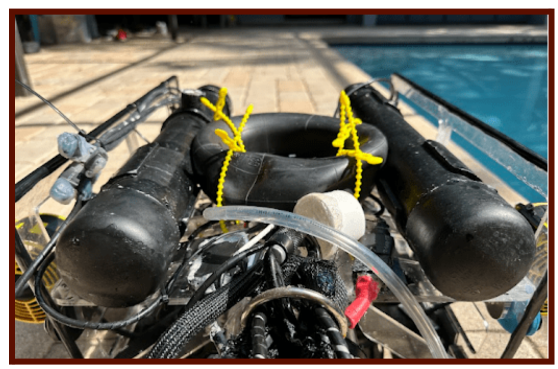
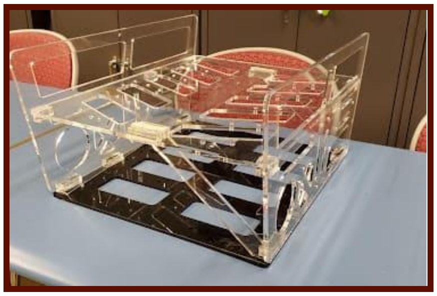


Figure 11: The Buoyancy Systems
Photo Credit: Xia Collier

Innovation

Vehicle Frame

There were several key factors that made the ROV more efficient in terms of speed and cost. The most important of these was the design of the frame with the use of acrylic panels using the company's laser cutter.



This acrylic is low-cost and extremely lightweight, with its low density of 1.19 g/mL allowing the ROV to reach high speeds easily, compared to last year's polycarbonate sheets and aluminum struts, which made the system slower and clunkier. In the past, the frame has proven to have a well-built design and maneuverability in the water. The multiple cutouts in the frame were used more for water flow than for mounting positions to improve the POE's fluid dynamics.

Figure 12: The Original Frame
Photo Credit: Elena Glow

Power Distribution & Tether

One of the company's main goals this year was to improve the power distribution to and from the ROV. Power distribution in past builds was a huge bottleneck in thruster efficiency, so this year the company worked hard to gain a full understanding of the electronics. Doing so allowed for the identification of crucial areas where improvements could be made. By fixing these issues, there was an improvement in the ROV's overall power efficiency. By having an eighteen gauge signal wire and a twelve gauge power wire, the company was able to improve the overall functioning of the ROV while also lowering the chance of brownouts.

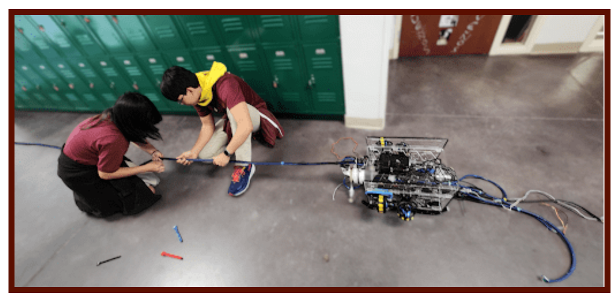


Figure 13: CEO and CSO Sheath the Tether
Photo Credit: Eric Fernandez

3D Printed Items

The POE's frame used acrylic cutouts to hold the 10.16 cm acrylic tube in place in previous years, which became unusable. Working around this, it was instead decided to create wedges that were first designed in CAD and then 3D printed to hold the tube in six places rather than just two places, providing more stability. On top of that, the tube is also held by two dive straps, strapping the tube to the bottom of the frame. This ensures contact with the tube, and the wedges and extras ensure that the tube will not move when in operation or during transportation. Additionally, the company's 3D printers were used to create more motor and claw mounts with a custom fit to the frame with a high infill to guarantee that the print is durable,

Figure 14: 3D Printed Wedges
Photo Credit: Xia Collier

especially since the thrusters are powerful and the claw mounts are on the bottom of the ROV. Thruster mounts act as a connection point for the thruster and the frame, which is a joint piece that fits in the frame, which is then screwed in at four points. Thruster shrouds were 3D printed and secured onto our thrusters with cable ties which offer four points of connections.

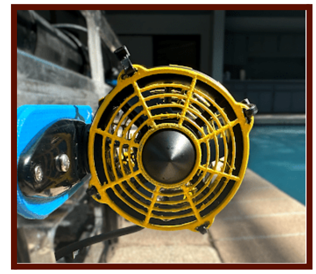


Figure 15: 3D Printed Wedges
Photo Credit: Xia Collier

Figure 16: 3D Printed Shrouds
Photo Credit: Xia Collier

Claws

Last year, there were many issues with the acrylic claws snapping and shattering when overextended because of the analog servos. To fix this issue, polycarbonate claw pieces were sent to be cut and used in place of the acrylic. This immediately fixed the snapping issue. Another issue last year involved poor grip on objects underwater. To combat this, the claw prongs were Plasti-dipped to give them a rubber coating, providing significantly better grip. A third issue with the claws last year was that the prongs were not spaced enough. Even though pieces of acrylic were cut and put between the claws, sometimes the claws would not close and interlock, causing them to break. To solve this, plastic spacers were put on the screws themselves to help support the joints of the claw. This also gave the company an easy way to quickly adjust the spacing of the claw when necessary.

Waterproofing

Figure 17: Sealing the Junction Box
Photo Credit: Eric Fernandez

This year, the ROV has a main junction box that connects a large number of wires, greatly improving organization. The wires were first connected through soldering. The junction box used was designed to connect wires through a terminal breakout, but this was removed so that the ROV's junction box could connect wires with soldering. Waterproofing of this junction box was a four step process in which wires were first fed through appropriate grommets, then connected via soldering. Next, the connections were covered with marine-grade heat shrink, first individually and then together in groups to keep the box and sealing job neat and easy. After that, 3M 06535 Marine Adhesive Sealant 5200 was spread generously in the box, ensuring that all corners, connections, and crevices were filled. Lastly, after the sealant dried, Flex Seal was layered in the junction box, effectively waterproofing the junction box. Last year, servos were waterproofed through a two step process of marine grease and PlastiDip. This year, the company incorporated a three step process in which the servo was disassembled with the motor reconstructed with 5200 sealant spread on connection points and places for possible water infiltration. Marine grease was then applied to the top gears and wire box. The servo was assembled and had 5200 pasted over the cracks and connection points on the top and bottom of the servo being put on. Additionally, as the servos were

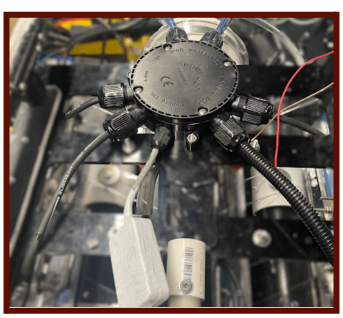


Figure 18: Finished Junction Box Photo Credit: Xia Collier

screwed in, 5200 was applied in the holes and on top of the screws after they had been screwed in. Lastly, the servo was plastidipped.

Figure 19: CEO Waterproofs
Photo Credit: Kristofer Gajadharsingh

A new waterproofing technique had to be developed for the USB transmitter used by the camera system. Originally, the company tried to put the USB transmitter into a waterproof box; the box had the wires coming in through a grommet and reinforced with a flex seal. The gasket was greased with silicon grease and sealed in with hot glue; however, the box was leaking water and dust. Ultimately, the company settled on the transmitter being wrapped in 5.08 cm diameter heat shrink to create a suitable body, applying 3M 06535 Marine Adhesive Sealant 5200 sealant on top of the body, finally reinforcing it with FlexSeal to cover any holes or potential weakness. Then was layered Plasti Dip to protect the flex seal from abrasion. The digital cameras themselves also require completely new waterproofing techniques and are layered in liquid tape to cover any seams and then put in a miniature plastic box that is sealed with hot glue and paraffin wax. Other methods of waterproofing include putting a camera in a PVC tube cut to size and sealed with silicon.

Figure 20: Waterproofed Camera
Photo Credit: Joshua Chao

Problem Solving

At Phoenix Robotics, the workforce involves individuals from diverse backgrounds each with their own unique expertise and niches. The company provides many opportunities for employees to explore various fields of interest, whether mechanical or software-oriented. This process not only reveals hidden talents among both veteran and new employees but also cultivates collaborative problem-solving capabilities. When challenges arise, team members can offer assistance based on their individual expertise, ensuring the timely and accurate completion of tasks. This collaborative approach is promoted through cross-training initiatives, which promote knowledge exchange among members and enhance the problem-solving process. To solve the problem of varying familiarity with company goals among employees, both new and experienced members should focus on learning new technologies. Team members should understand each other's systems and how they interact, which simplifies integrating components into a cohesive ROV system. By promoting continuous research and peer insights, the company ensures that the chosen systems for the ROV are efficient and adaptable to changing needs.

Employees are divided into various groups tasked with the development and implementation of new systems on the ROV. Once these groups are formed, it becomes the responsibility of every member to establish effective communication and collaboration to create innovative solutions. During discussions and company meetings, ideas and designs are thoroughly presented and evaluated by multiple team members, with the CEO ensuring that the chosen designs are both efficient and cost-effective. When transitioning into the testing phase, the primary objective was to collect data and explore various operational approaches to identify the most efficient procedures. Maintaining a consistent set of procedures and carefully documenting both independent and dependent variables during experiments significantly assists in the diagnosis of potential issues. This approach allows designated groups to collectively analyze the gathered data, offering insights into any abnormalities encountered during testing and providing strategies to prevent them in future operations. These processes are essential to the decision-making process regarding system selection. Thorough research allows for informed decisions on system functionality and compatibility with existing systems, applying the diverse skill sets of all employees to finalize designs and seamlessly integrate them into the ROV. Ultimately, through diligent study and analysis, the company confidently progresses towards selecting components for their designated systems. Phoenix Robotics' approach to problem-solving is characterized by cooperation, innovation, collaboration, and continuous improvement. By adhering to these values, the company may confidently and creatively take on and solve even the most difficult tasks, fostering innovation and success within the company's components for their assigned systems.

Systems Approach

The ROV's functionality depends on the cohesive and cooperative design of each system. Proper balancing of payloads and task items was crucial. This involved evenly distributing the vehicle's payloads, such as positioning a claw in line with the tube and balancing the ROV during travel. While this can help the ROV carry various mission components to complete the task, this approach also avoids limitations to the ROV's speed and maneuverability. The same philosophy guided the installation of onboard electronics, which were centrally placed to distribute weight evenly. The motor pairs were also strategically positioned in symmetrical locations, ensuring straight and intentional movement as well as even weight distribution. Bilateral symmetry was a significant consideration in maintaining optimal weight distribution and overall efficiency for the respective missions. The camera installation aimed to provide broad fields of vision while capturing key viewpoints, such as the manipulators. The cameras themselves utilized the acrylic frame to firmly mount themselves and were used for observing the temperature sensor, another payload, so as not to require another wire through the tether. The dual camera system allows for a combination of reliability and quality, with the analog YIWANG cameras utilized for their reliability and ease of use, while the PEGISTAN cameras are used for quality and to complete the photogrammetry task.

Vehicle Structure

The frame of the ROV is made of both black and transparent 0.635 cm acrylic sheets, which were cut using a laser cutter. Thus, this material permitted the company to cut the frame to the desired dimensions. The frame has a 48-cm length, 36-cm width, and 23-cm height. The density of acrylic, at 1.19 g/mL, keeps the frame relatively light-weight and is economical. Acrylic was chosen as the primary material used in frame construction due to its low cost and low density, as well as its ease of use with a laser cutter. The frame was bonded together with IPS adhesive weld-on 16 acrylic plastic cement that effectively distributed pressure across surfaces. One of the desirable traits of this frame is the various apertures deliberately placed throughout the body in order to mount payloads to aid in meeting the mission requirements. These cutouts not only provided plenty of space for mounting, but they also reduced the friction of the ROV in water because there isn't a big flat surface. They also decrease overall weight by eliminating unnecessary surface area.

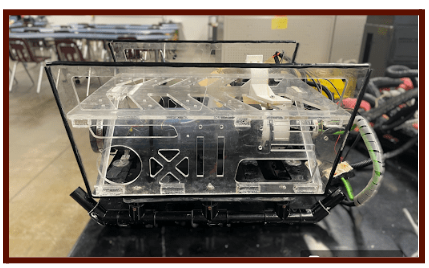
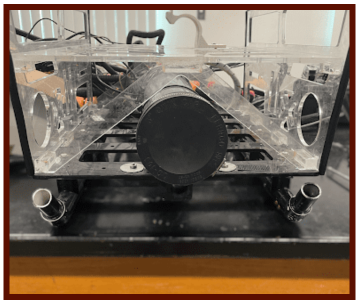


Figure 21: *Stripped Down ROV*
Photo Credit: Bryce Phuphanich

The acrylic frame has a clean design and plenty of smooth space for customization opportunities and wire organization. The acrylic shelf accommodates a larger, 10.16-cm tube for onboard electronics. PVC sleds protect the frame of the ROV and its contents, as well as the ocean floor. Static buoyancy is constructed from 2-inch PVC tubes with end caps in order to maneuver in the water with buoyancy. A tire adjusts buoyancy in water for lifting-dependent tasks, controlled by a dual-action pump on the surface. With the repurpose of a frame that needed little to no repair, the panels cost around $171, which is very inexpensive and saved the



company time. The trade-off is that since the frame was made to suit how retired members wanted it, it took time to change the frame to suit the current needs. For example, the company had to draw the supports in the front and back because a 10.16 cm diameter acrylic tube was desirable, ensuring that there was sufficient space instead of using a 7.62 cm diameter tube since there were issues with available space.

Figure 22: Stripped Down ROV
Photo Credit: Bryce Phuphanich

Vehicle Systems

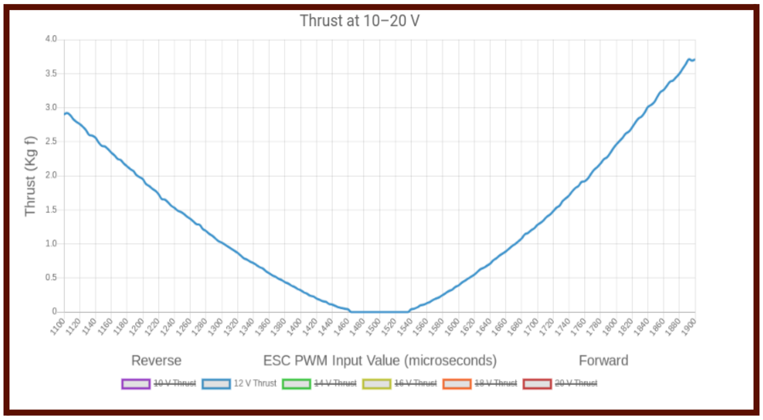
Cameras

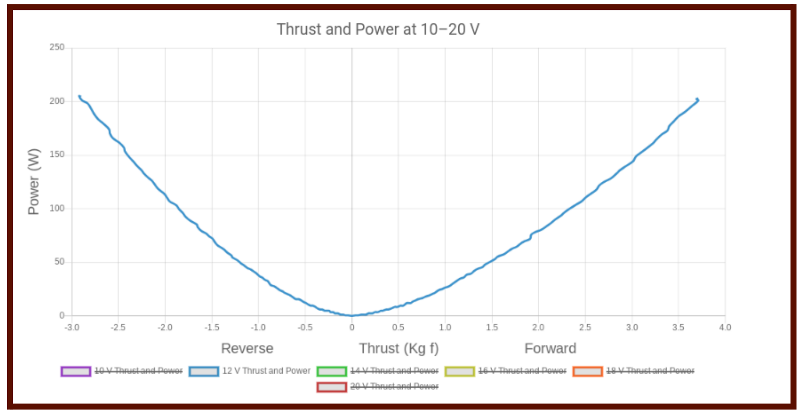
For Task 1, the cameras are specifically tailored to match the requirements of the tasks assigned by MATE this year. The cameras are high definition, easily supporting 1080p and 720p, and have low latency for assistance in precise piloting. For Task 2, multiple cameras covering different angles with a wide-angle view allowed full visibility of the surroundings to assist in effectively traversing the environment, allowing for a swift and effective ability to complete the task. Lastly, for Task 3, digital cameras, which are plugged into a computer, can perform photogrammetry and autonomously create a 3D model.

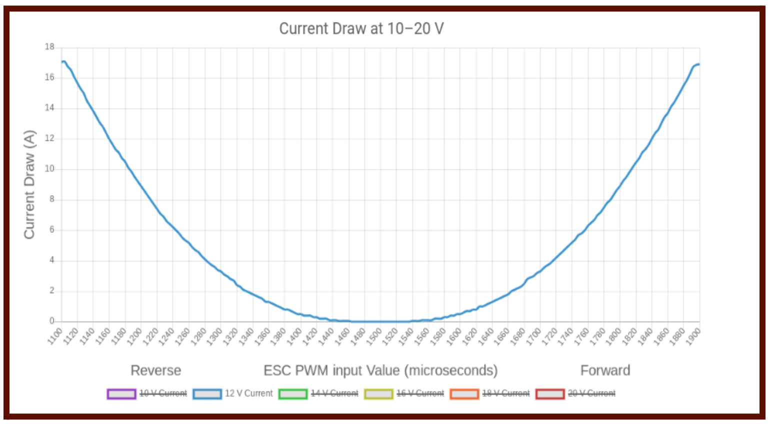
At the start of the year, it was assumed that the camera system was going to be very similar to last year's cameras, but the company noted that the analog camera system would be unlikely to successfully complete any task requiring automation and/or photogrammetry. Thus, the company began looking into building a digital camera system to accommodate this need. At first, a Raspberry Pi 4 was considered the main central point for the cameras, as this is a popular route in ROVs. But as the design was slowly refined, the company came to the realization that a Raspberry Pi 4 was unnecessary and overkill for what was needed in the system. Further research brought in the idea of using a USB transmitter/receiver system in order to directly send data to a laptop on the surface while also being able to get power from the onboard in a plug-and-play fashion.

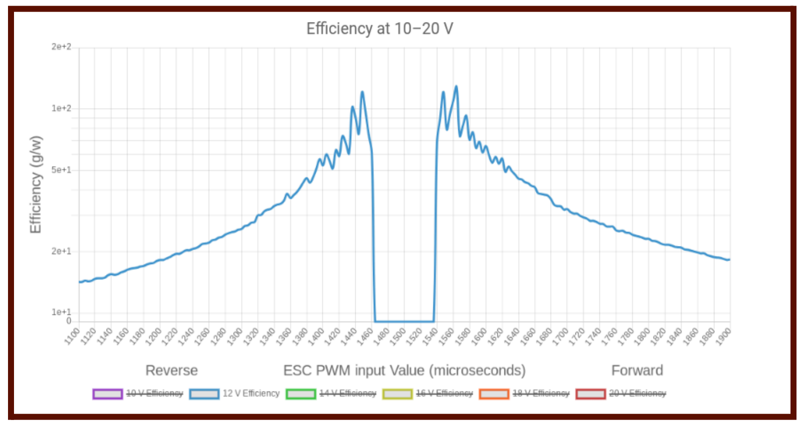
Thrusters

For each task, the thrusters permit the ROV to move in the water, allowing for the completion of every task assigned by MATE. The thrusters allow the ROV to carry heavy payloads and provide stability when navigating coral for the 3D model task. Varied inputs allow for careful control of the ROV while it is submerged, letting the pilot effectively manage the ROV through a wide range of tasks. The T200 thrusters were chosen to be used on this year's ROV since last year the company struggled with maneuvering the ROV in water using weak thrusters, and the company had to constantly use variable buoyancy to work with that struggle. The new T200 thrusters have created a new solution to the biggest problem the company had last year: the ROV is now able to maneuver swiftly in the water, and the use of variable buoyancy has been minimized significantly.









Figures 23-27: Graphs Illustrating Various Aspects of the Thrusters
Photo Credit: Blue Robotics

Claws

The claws this year are capable of opening up to 90 degrees and completing three revolutions. The company replaced the old acrylic prongs with polycarbonate-cut pieces to increase durability. These changes enable the ROV to complete mission tasks with ease. For Task 1, the claw rotates to grab the PVC securely and tightly, thanks to the open-close servo's 25 kg torque. The ROV also needed to pull a pin, which the claw's three prongs handled efficiently by gripping the pin's small hook. The ROV can then carry the recovery float to the pool's surface. The claw quickly grabs the recovery float and wraps the string around itself to bring it back. With two prongs on one side and one on the other, the claw secures the recovery line effectively. The claw is mounted with two 3D-printed mounts that secure the PVC tube in place while allowing for turning operations. For Task 2, the claw turns 90 degrees to carry the smart cable repeater horizontally, aiding in aligning the string at the waypoints. The ROV then moves to the AUV docking station, where the claw picks up the power connector, turning, opening, and closing as needed. For Task 3, involving smart reefs, the claw is mounted at two points with 3D prints featuring 100% infill, minimizing the risk of breaking and distributing pressure evenly. This design allows the claw to carry heavy systems. Made from laser-cut polycarbonate, the claw is durable and resistant to shattering. It easily activates the irrigation system by rotating the dial 360 degrees. Unlike last year's acrylic claw, the new design handles the irrigation system and maneuvers oblong-shaped corals. For sturgeon restoration, the claw picks up the receiver, then attaches a scooper to collect a sediment sample from the spawn site. The claw pieces had been cut in the past; the aluminum was repurposed. There was no reason to cut more because there are four more complete sets of claws consisting of the polycarb-cut prongs and mounts. The aluminum was repurposed and cut to size to ensure the claw would be securely mounted with four screws.

Hook

The utility hook, mounted on the sled and removable if necessary, plays a significant role in Task 2 by aligning the smart cable at waypoints and adjusting the cable positioning as necessary. In Task 3, after placing the irrigation system, the hook is used to move the sprinkler on the coral. Numerous utility hooks were found in the workshop, along with other trinkets. The hook was secured to one of the end pieces of the sled. There was no reason to alter the hook because it already had rounded edges, and an employee simply had to drill into a PVC joint to mount the hook with simple adhesive. Similar to last year, the ROV used a hook to aid with task two: Smart Cables for Ocean Observing. Last year, a fish hook was used, which was greatly altered in order to ensure the safety of employees and the surrounding environment. This year, the company instead used a stainless steel utility hook, which has round and smooth edges on all surface areas. This greatly eased the work necessary when incorporating a second-priority system. The hook on the ROV this year is stainless steel aluminum and has an ergonomic shape, which aids in the completion of tasks as well as ensuring the safety of personnel and the environment while operating.

Figure 28: The Hook
Photo Credit: Xia Collier

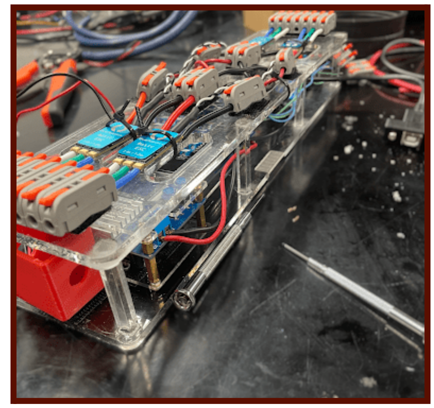
Temperature sensor

This year, the company incorporated a temperature sensor on the POE to ensure the effective completion of Tasks 1 and 2. After positioning the smart cable and confirming the waypoints, the temperature sensor was used to check the smart cable's readings. Purchased for $51, this temperature sensor allowed for a completely onboard sensor instead of making multiple joints, which would increase the tether diameter by a significant degree. An onboard sensor only needs power to run the system. It runs on 12V; power regulation was unnecessary; and it came with a coupling. For a monitor, a temperature sensor, and a coupling, $51 proved to be a reasonable cost.

Figure 29: The Temperature Sensor Strapped to PVC
Photo Credit:Xia Collier

Control/Electrical System

Electronic design



This year, the company decided to go with a two-leveled acrylic tray that would be inserted into a 10-centimeter-thick acrylic tube that is located in the center of the frame. This tray holds four Basic Blue Robotics Electronic Speed Controllers (ESC's), which are connected to an Arduino shield and an Arduino Mega, which would transmit the analog signals given by the controller to the thrusters. The camera USB transmitter, while not in the onboard tube, gets power from it, is thoroughly water-proofed, and is mounted on the top of the ROV. Additionally, there is a set of analog servos, the first being 360° and the second being 270°, that allow the manipulators to move.

Figure 30: ROV Electronics

Photo Credit: Bryce Phuphanich

Control Box

The company simplified the previous iteration of the control box, reducing the size and number of components within. The box itself consists of the USB receiver, power switch, voltage regulator, and Wago connectors. There are also two controllers that receive signals from the tether and allow the pilots to interact with the ROV.

Cabling management

As the team was designing the on-board, we had to come up with some ways to manage the wires coming to and from the tether. The company specifically designed an acrylic tray for the on board with slats cut using a laser cutter to ensure the wires can go between the levels of the tube. The wires were then sheathed as an extra level of protection. This then was strapped down with zip ties to keep wires from tangling.

Tether Design

The tether is composed of two wires: the main power wire, which is 12 gauge, and the signal wire, which is 18 gauge. The main power wire provides the power necessary to operate the ROV, while the signal wire communicates information between the ROV and the pilot. Variable buoyancy is controlled through a dual-action pump with a tube running down the tether. The tether is wrapped in sheathing, and buoyancy was added around the tether to aid in keeping the tether out of the way while operating the ROV. Lastly, the camera wires are strung around the tether in their own sheathing to reduce the size of the tether. A reduction in size helps make the tether more manageable and dominate the ROV less.

Figure 31: CSO Inspects Tether
Photo Credit: Kris Gajadharsingh

Tether Management Protocol

The tether measures approximately 15.24 meters from the pigtail to the control box, ensuring the ROV has enough range of movement. When the ROV is in use, unused tether is coiled poolside to prevent damage, maintain organization, and allow for quick adjustments in length. Additionally tether is coiled when the ROV is stored which keeps it tangle-free and easily accessible for future use.

Analog Camera System

The analog camera system consists of four cyclical fishing cameras. The cameras are YIWANG cyclical fishing cameras fit for underwater use. Each one is coated in a rubber layer of PlastiDip for protection from debris, wall collisions, and other physical obstructions. Then, the cameras were mounted onto the ROV in such a way that they maximized the total viewing area surrounding the ROV, minimizing overlap and ensuring optimized visibility. This assists in claw operation while performing tasks, as high visibility makes it easier to operate. Despite room to expand the number of cameras, a total of four has proven to be sufficient, and thus power is not wasted on additional cameras. Camera data is fed into the camera box, an Apache 3800, which was selected for its durability and compatibility. The analog camera box is powered by the control box, which then disseminates into the cameras and 17.8-cm monitors mounted on the camera box, creating a streamlined and reliable power supply. Overall, this system is durable, reliable, simple yet effective, and has provided consistent results throughout multiple years and interactions with the POE.

Digital Camera System

Figure 32: Laptop Camera Feed
Photo Credit: Joshua Chao

The digital camera system consists of four HD PEGIASTAN USB cameras designed for high-quality imaging; however, they require separate waterproofing procedures as a trade-off. They are mounted towards the front of the ROV for the photogrammetry task. They are also used to model a coral restoration area in a CAD program for Task 3.3. These USB cameras are all plugged into a USB transmitter, an aluminum box that has been waterproofed with 5200 caulk sealant, wrapped in heat shrink, reinforced with FlexSeal, and layered in PlastiDip, maximizing waterproofing and ensuring the safety of both the transmitter and user. This transmitter serves multiple key purposes, as it powers the cameras and redirects the digital camera feeds. The cameras themselves take 5 volts at 6.6 amps total. The transmitter receives power from a 5 volt, 3 amp cable that connects to the onboard. It is its own independent circuit, connected to nothing else but power and ground. Moreover, the transmitter receives all digital camera feeds and redirects them through a 15-meter CAT6 cable that runs up through the tether to a USB receiver in the control box. The receiver, another aluminum box inside the control, takes the CAT-6's input and transmits it through a USB-B port that is translated to a USB-A cable via an adapter, which is then plugged into a laptop. The camera feed is finally processed with OBS, a software on the laptop that has been selected for a variety of reasons. It runs well on any Windows computer, and by using an easy-to-run program, we can ensure it provides a smooth experience for the pilot. Additionally, because it is free and accessible, it was the perfect choice for the processing software.

The use of these two camera systems aids in the fulfillment of the tasks of the MATE ROV competition. Two separate systems were chosen because, in previous years, the expansion of the analog system had begun to stall improvements and the introduction of a digital camera system had opened vast opportunities for improvement.

However, analog cameras were used as an extension of previous years' systems, thanks to their proven reliability and simplicity of use. The analog system has a plug-and-play quality that makes it exceptionally consistent and streamlined. Two models of cameras are utilized: the PEGATINAS cameras and the Walfront cameras. The PEGATISAN cameras were chosen in spite of their high cost because of their excellent image quality, allowing for greater visual reliability of the system as a whole and being capable of performing the photogrammatic task. The Walfront cameras were chosen due to their effectiveness relative to their low price, allowing for the testing of different waterproofing techniques. Overall, the camera system has undergone extensive consideration of alternatives and various iterations to get to its current iteration.

Build vs. Buy

Phoenix Robotics carefully considers the items used in its ROVs. The company decided between purchasing high-quality parts, building custom ones, or recycling old ones. The manipulator, which is used in every task assigned by MATE, is made of ABS plastic on the claws, while the base is made out of polycarbonate plastic. The materials for the manipulator were laser-cut and ready to be assembled. The manipulator is attracted to the frame with a 3D-printed mount. The ROV frame was built out of laser-cut acrylic plastic and assembled with acrylic glue. The ROV's tether strain relief was built to suppress the stress on the tether wire using a stainless steel metal o-ring and a sturdy carabiner. The static buoyancy was made using two 2-inch PVC tubes and was capped with 2-inch PVC caps on both sides of the tubes. The tray inside the onboard tube was made out of acrylic that was laser cut to fit the tube and has various holes that are used to organize the wires inside. The shrouds on the thrusters were 3D printed to fit the T200 thrusters as a way to protect members from any hand injuries when working on the ROV. The PVC sleds were built to protect the bottom of the ROV from any damage that would affect its performance. Overall, the company used a variety of build techniques, ranging from 3D printing to modular building with PVC, acting as a price-saving measure and ensuring the ROV fits within the company's ideals. Some components had to be purchased as building them was not feasible. For example, the T200 brushless motors were purchased from the company BlueRobotics. These motors were chosen for purchase because of the company's positive experience with the company in the past. The company also bought electronic speed controllers (ESCs) from BlueRobotics to control the speed of the thrusters. The tether was purchased as protection for the wires, where integrity could not be sacrificed. The digital cameras were bought as a way to complete the scan of the coral restoration area in Task 3. The plastic shovel was bought as a way to obtain the sediment sample in Task 3.

New vs. Reused

When possible, Phoenix Robotics reuses materials from previous ROVs, creating a cost-effective and environmentally friendly system of recycling. This year, the acrylic frame, manipulators, and variable buoyancy system were all recycled from previous Phoenix Robotics ROVs. In order for the ROV to operate, the previously mentioned T200's were purchased with bidirectional ESC's. New thrusters were purchased because of the previous ROV's difficulty with movement, and these new thrusters mitigated this issue. Other systems also require the use of new materials, like cameras. This year, Phoenix Robotics has decided to reuse its old analog system because of the effectiveness noted in the analog camera system along with reliability and durability. It was deemed that the analog cameras required no adjustments. But Task 3, "From the Red Sea to Tennessee," held an automatic requirement in which the company needed to automatically construct a 3-D model using photogrammetry. Therefore, it was decided that we would build a digital camera system as well. This was done because, while the old analog system was effective, it couldn't perform the task required. Thus, the digital camera system was constructed to fulfill this requirement. Additionally, the manipulators and variable buoyancy system were perfectly functional and did not require further revisions. It was unnecessary to make changes to these systems, so the company decided to reuse them in order to spend more time on the systems that require greater attention. Furthermore, the acrylic frame was reused from a previous ROV as it was incredibly effective and flexible in application. The frame was reused as it was cost-effective to recycle an old frame and assisted in reducing the time consumption of the team, allowing for more important systems to be addressed.

Safety

Content

Phoenix Robotics is a company dedicated to ensuring that all employees understand the importance of safety and its role in everyday operations. with the help of two MSSC CPT Phoenix Robotics employees who are certified in their understanding of OSHA safety procedures. Every member has been trained on how to operate all the tools in the workshop in order to ensure all safety protocols are followed and the risk of an unsafe working environment is minimized. Goggles are needed at all times, with proper tool handling and maintenance being essential knowledge for any member working with or near a tool. Unsafe practices and handling of tools are reinforced as unacceptable oversight, and employees found to be in violation of the procedures and rules in place are informed of their mistake and shown the proper methods in order to ensure that the mistake is not repeated. The POE takes safety precautions by eliminating sharp corners through filing or by design and using tether strain relief to protect wires from tugging. Additionally, motor shrouds have yellow tape stripes in accordance with OSHA guidelines. Tygon tubing lines the frame to protect the machine from fracture due to the fragility of acrylic. IP 20 shrouds protect the motors from debris, in particular during the smart cable task. The shrouds protect the motors from entanglement and potential damage.

Safety Procedures

A more detailed description of Phoenix Robotics' safety precautions and procedures can be found in the Job Safety Analysis (JSA) document. The company's safety procedures are thorough and wide-reaching, spanning both the construction and operation of the ROV. During construction, employees are required to tie back long hair, wear closed toed-shoes, and utilize personal protective equipment (PPE). The absence of PPE during construction results in the offender being reprimanded and re-educated to prevent repeat offenses and potential future injuries. PPE must be applied by all users before power tools can be turned on, reducing the risks of eye damage, appendage trauma, and, in the case of welding, blinding. Precautions are also taken with the operation and testing of the ROV, both in and out of the water. All systems are verified to be functional before the ROV is submerged, including management of the tether and props to avoid tripping hazards, camera and control box setup, claw operability tests, waterproofing checks to ensure no electrocution hazards, and all others mentioned in the JSA. In the event of a system failure, power is immediately cut off, and all personnel are alerted of the failure. Clear and thorough communication is essential to effectively upholding safety standards established by Phoenix Robotics, and maintaining a strong communication base is the backbone of the company's safety procedures and precautions.

Critical Analysis

Testing and Troubleshooting of Thrusters

The Blue Robotics thruster testing initializes at each voltage and commands the ESC to run the thruster in 4μs (pulse with increment) steps from neutral to full throttle. At each step, the thruster immediately runs for 1.5 seconds to eliminate startup transients, then continues for two more seconds, collecting data points. These points are then averaged to generate the final values for that throttle level. The thruster then rests for 30 seconds to allow the test tank water to reset. At full throttle, this procedure repeats five times, averaging all data points. This attempts to fairly represent full throttle performance. Any values below 300 RPM are dropped to zero, as rotation below this is inconsistent, causing jerky motion and varying thrust.

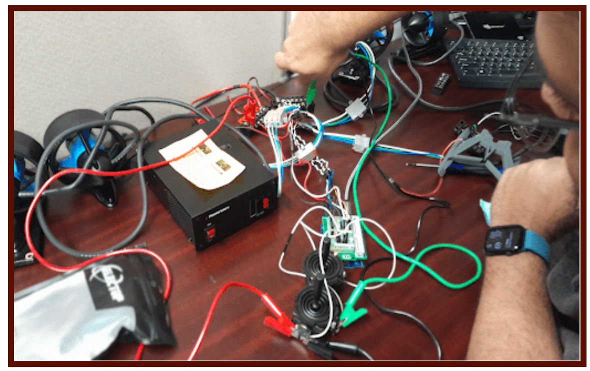


Figure 33: Thruster Testing With Joysticks
Photo Credit: Xia Collier

The company tests every component bought or built to ensure it compares with the standard set to be achieved in order to complete the ROV. During the building phase, the T200 brushless thrusters by Blue Robotics were tested numerous times to validate the performance stated by Blue Robotics. The company uses the five whys as the methodology to base testing on. The team members have been trained to respond to any issues or problems that occur during the product demonstration or when running a systems check. Every time the ROV is powered on, the company runs through a checklist to ensure the safety of others and the success of the ROV. The company has conducted many tests on all of the various systems since getting started on the ROV. If a problem occurs, members will gather together, find where the issue has occurred, and brainstorm solutions to solve the complication. The company has run into many electrical problems this year. One of the biggest issues was troubleshooting the on-board controllers and cameras. During this time period, the onboard and thrusters had to be redesigned to fit the new standards. The team strategically had to figure out how to integrate all of the electronics from the control box to a tube on the ROV. During the testing and prototyping phase of the onboard electronics and thrusters, the team faced many difficult challenges.

Testing and Troubleshooting of Cameras

Due to the various parts and functions of the camera systems, failures or breakdowns are bound to occur, and this is why it is important to conduct frequent testing and maintenance to ensure that if anything does break, repairs can be made quickly and efficiently. Spare connectors and wires are always available to provide controls when testing certain components; cat cable testers and different camera software are also used to assist in isolating various issues that may arise. For example, when a technical issue occurred leading to a malfunction in the camera systems, the company didn’t know where the problem could be coming from as there were many different components and parts that could have malfunctioned. So in order to resolve this, the company methodically isolated and tested each component with other “control” components and plugged in test components that were known to work in order to expose those parts that had malfunctioned.

Accounting

Budget & Funding

In the beginning of the fall, the company knew that the ROV was going to cost around $3,000. There was also a budget for travel that came out to be $7,000. This meant that the overall projected cost from August 2023 to August 2024 would be a total of $10,000; this budget gave the company some breathing room for error and changes to the system if needed.

For funding, the company started fund-raising at the beginning of the year through different means, such as GoFundMe posts and soliciting donations from generous organizations such as Calypso Dive Shop and Mid-Florida Credit Union. As expenses are raised due to travel costs, the patronage of people such as team sponsors, Brooks and Bowdoin, would be called upon to significantly aid the company's finances.

Income	
Source	**Amount**
Donations from Anonymous donors on GoFundMe	$435.00
Publix	$250.00
Mid-Florida Credit Union	$250.00
Paul Bowdoin	$3,000.00
Anonymous Donations	$100.00
CANDO	$500.00
Total	**$4,535.00**

Spending

For the company's spending, Phoenix Robotics followed a strict plan. First, research was done on the internet on different alternative prices and parts, and, once found, the chosen parts would be put into a form on Google Sheets. This order form would be sent to the CEO for approval and ordering. With this plan, the purchasing method was organized, easily keeping track of all the parts and spending. Total spending for this year to date is $571.46. The company tried to minimize spending in order to allow for possible unexpected issues and to ensure that the company would have extra money to use for next year. The company thus reused or recycled a variety of parts from previous ROVs, including the analog camera system and the frame.

Purchased	**Item**	Qty	Unit Value	Total
On Board System	Arduino Mega	1	$20.00	$20.00
	Basic ESC	1	$38.00	$38.00
	Arduino Shield	1	$32.00	$32.00
	Voltage Regulator	1	$13.65	$13.65
	Wago Connector Set	1	$39.95	$39.95
	RVBOATPAT Connector set	1	$13.59	$13.59
	Pololu Micro Maestro 6-Channel USB Servo Controller	1	$24.95	$24.95

Camera				
	USB Extender 165ft 50m 4-port USB HUB	1	$60.00	$60.00
	15m Cat RJA54 Cable	1	$28.35	$28.35
	Wall Front Camera	1	$9.89	$9.89
	FHD Camera	1	$38.00	$38.00
	USB A to USB a Female extender	4	$7.48	$29.92
	USB male A to USB male A 1 meter extender	1	$9.05	$9.05
Claw				
	Analog Servo	2	$34.99	$70.00
On Surface				
	25 amp Fuse	25	$2.28	$21.12
	Switch	1		
	Voltage regulator	1		
	USB Transmitter	1		
Total				**$427.35**

Reused Items	Item	Qty	Unit Value	Total
Frame	Acrylic Frame	1	$125.00	$125.00
Analog Camera System	7in Car Rear View Monitors	3	$35.00	$105.00
	Yiwang Cameras	4	$20.00	$80.00
	5V, 3A Wire Connectors	9	$0.91	$8.27
	Bus Board	1	$20.00	$20.00
	Voltage Regulator	1	$13.65	$13.65
	Apache 3800 Case	1	$42.00	$42.00
Total				**$391.92**

Donated	Item	Qty	Unit Value	total
Gajadharsingh	55ft Tether Wire	1	$70.00	$70.00
Calypso Dive Shop	T200 Blue Robotics Thrusters	2	$250.00	$500.00
MITRE	T200 Blue Robotics Thrusters	2	$250.00	$500.00
Total				**$1,070.00**

Acknowledgements

Thank you…

Derrick Brooks: For continuous financial and moral support

Derrick Brooks Charities and DeBartolo Family Foundation: For covering travel expenses.

Publix and PDQ: For continuous financial support for general expenses.

Calypso Dive Shop: For providing financial support for the purchase of a Blue Robotics T200 Thruster with an ESC

Mid-Florida Credit Union: For financial support and connecting Phoenix Robotics with CANDO.

MITRE: For the donation of two Blue Robotics T200 Thrusters with ESCs

2 Extreme Auto: For financial support and donation of wire used for power and signal for the tether.

Elena Fernandez and parents of members of Phoenix Robotics: For providing facilities and supporting team endeavors emotionally and financially.

The Badri Family: For providing the team with a pool for practice.

Suzanne Fernandez: For providing the team with a pool for practice.

Paul Bowdoin: For financial and mentoring support.

Mike McGivern: For providing connections and mentorship.

Eric Fernandez: For sharing knowledge and mentorship in advanced machinery and electronics.

Cheryl Hyde: For providing facilities and supporting team endeavors.

Chris Hochman: For mentorship and insight during international competitions.

Elena Glow: For continued support through review of documentation.

CANDO: For financial support and assistance in corporate responsibility

MATE: For the opportunity to gain experiences that help us learn technical and soft skills crucial for success in the workforce.

References

Blue Robotics Inc. "T200 Thruster for ROVs, AUVs, and Marine Robotics." *Blue Robotics*, bluerobotics.com/store/thrusters/t100-t200-thrusters/t200-thruster-r2-rp/.

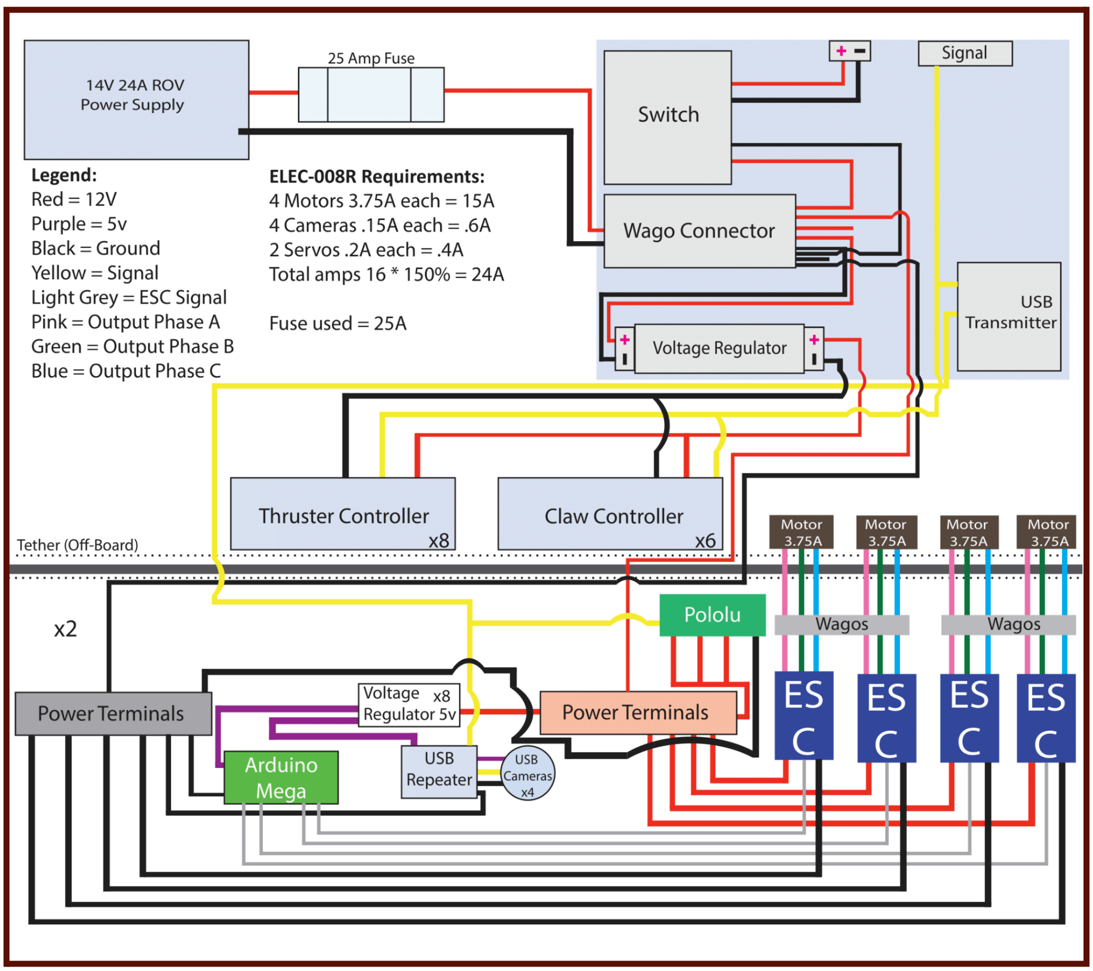
MTS/MATE. "MATE ROV Competition Website." *Materovcompetition.org*, materovcompetition.org/.

UNESCO. "United Nations Decade of Ocean Science for Sustainable Development (2021-2030)." *Unesco.org*, 2021, www.unesco.org/en/decades/ocean-decade.

MatWeb. "Online Materials Information Resource - MatWeb." *Www.matweb.com*, www.matweb.com/index.aspx.

Appendices

Appendices A



Appendices B

Safety checklist

1. **Unloading**

- ☐ Area is cleaned and organized for operation
- ☐ Team members wear proper PPE.
- ☐ Control box with controllers are removed from ROV box and placed on table
- ☐ Camera box and air pump are placed on the table
- ☐ The profiler is carried and placed on the table .
- ☐ Tether is removed from container and placed on the pool deck
- ☐ Laptop is carried and placed on the table for graphing and cameras
- ☐ Rov is removed from the container and placed on the pool deck

2. **ROV set-up**

- ☐ Control box is opened and connections are checked
- ☐ Analog Cameras are plugged in along with the air pump
- ☐ The profiler is configured and set up.
- ☐ The clip is removed from the tether and tension is relieved from the wire
- ☐ The laptop is plugged into the USB receiver

3. **power/confirmation**

- ☐ Pilots communicate that power is being turned on.
- ☐ Verbal confirmation that everyone on deck understands that power is on
- ☐ Laptop is turned on
- ☐ ROV is powered and thrusters and manipulator is tested
- ☐ Cameras are checked that they are in the correct position
- ☐ Tether is laid out and examined for strain and entanglement
- ☐ OBS is set up, the analog cameras are checked.

4. **launch**

- ☐ Pilots sit down and gets ready for demonstration
- ☐ Vertical profiler is turned on.
- ☐ Tether is managed gives slack to the ROV
- ☐ The profiler communications are checked
- ☐ Verbal confirmation is given that everything is go.
- ☐ The ROV is transported into the pool.

5. **Post-Run**

- ☐ ROV surfaces by the pool deck.
- ☐ Pilot set down controllers and give go-ahead to take ROV out of the water
- ☐ ROV is taken out of the pool.
- ☐ Pilots communicate that power is turning off
- ☐ The laptop and analog camera box is unplugged and closed
- ☐ Clean up mission station of control box
- ☐ Pack up profiler and end transmission/graphing
- ☐ Pack up ROV, roll and clip up tether.
- ☐ Leave mission station with all materials brought