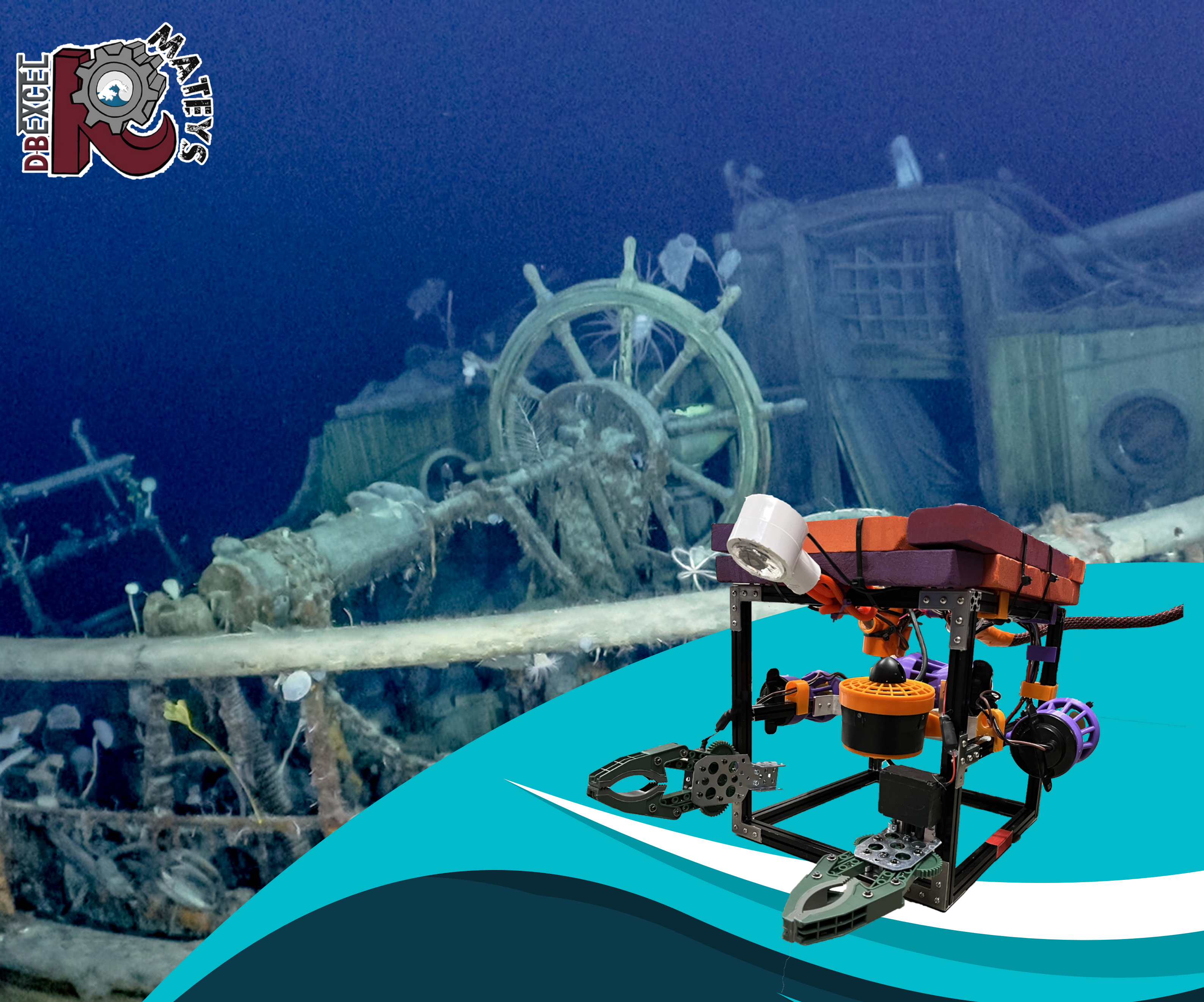


Kingsport, Tennessee, U.S.A.

D-B EXCEL HIGH SCHOOL

R-MATEYS

2022 MATE ROV Competition

Ranger Class

Members

Jasmine Monroe - co-CEO/Marketing Officer

Quintin Bentley - co-CEO/ co-Pilot

Jacey McCloud - Pilot

Pearson Mills - Lead Engineer/ Safety Officer

Matthew Smith - Tether Manager

Dawson Pendleton - Mech. Engineer

Juan Camacho - Profiling Float Specialist

Micah Lawson - Lead Software Engineer

Devin Spears - Software Engineer

Connor McGlothlin - Lead Elec. Engineer

Alyssa Anderson - Mech. Engineer

Elena Evans - Design Assistant

McKinley Sexton - Software & Elec. Engineer

Kerrigan Bentley - CFO

Mikaylah Sorge - Documentation Analyst

Bee Smith - Documentation Assistant

Isaac Nelson - Assistant Safety Officer

Mentors

Zachary Gardner - Eastman Chemical Company

Erica Gardner - Coach

Table Of Contents

Abstract 3
Company Overview 4
  Company Structure 4
  Company Effort 4
  Project Management 4
UN Sustainability Goals 5
  Marine Renewable Energy 5
  Offshore Aquaculture and Blue Carbon 5
  Antarctica Then and Now – Endurance 22 and MATE Floats! 6
Design Rationale 6
  Frame 6
  Motor Scheme 7
  Manipulators 7
  Electronics 8
  Vertical Profiling Float 8
  Code 9
  Buoyancy 10
  Tether 10
  Buy vs. Build 11
  System Integration Diagram 11
Safety 11
  Product Features 11
  Protocols 11
Critical Analysis 11
  Testing & Troubleshooting 12
  Challenges 12
    Meeting Space 12
    Code 12
    Supply Chain Issue 12
    Cameras 12
  Lessons Learned 12
    Vex V1 Claw 12
    Wire Management 13
  Post-Regional Improvements 13
  Future Improvements 14
    Shielding Camera Wires 14
    All T-200'a 14
    Upgrade RPi 14
Accounting 14
  Budget & Cost Accounting 14
Conclusion 15
References 15
Acknowledgements 16
Appendix 17

Abstract

(Figure 1, R-Mateys' Company Structure
Photo Credit: Jasmine Monroe)

The R-Mateys, composed of seventeen members, is a company based in Kingsport, Tennessee, United States of America. The Marine Advanced Technology Education (MATE) center has worked with the missions set forth by the United Nations Decade of Ocean Science for Sustainable Development to battle against climate change and its detrimental effects on our oceans. Every feature of Amphitrite, whose name is derived from the Greek goddess of the sea and wife of Poseidon, has been designed to accomplish these tasks with expertise. This remotely operated vehicle (ROV) consists of an extruded aluminum frame, three Johnson Bilge Pump motors, one T200 thruster, two Vex Robotics claws, and four backup cameras. The design is made to be efficient, stable, and accurate to complete tasks with diligence and ease. This document encompasses the technical aspects such as the company information, design and fabrication of the ROV, accounting, and critical project analysis.

(Figure 2, Image Shows R-Matey's ROV
Photo Credit: Dawson Pendleton)

Company Overview

Company Structure

R-Mateys company structure leverages the strengths of each member and reflects the tasks that they have accomplished. Members took on many different tasks throughout the construction of Amphitrite. During the early portions of this season, younger members were encouraged to find their interests by experiencing a hands-on investigation of each part of the ROV, building, documentation, and writing processes. Senior members helped guide this process by discussing younger members' interests within and outside of the team, as well as taking the information provided in their applications to help them find which positions they might be interested in the most. This allowed the senior members to pass on what they learned and for the newer members to find their strengths and explore where their interests fell within the company. All members were assigned roles according to which parts of the project they attributed to.

Company Effort

Every company member had a hand in the production of Amphitrite. From every piece of the frame to every wire, to each word on every document, the R-Mateys banded together to create Amphitrite. This season, every member of the R-Mateys stepped up to the challenge; veteran members learned new skills and passed on their knowledge while younger members found their strengths and new roles in the company. This company was founded on collaboration and friendship which was tested and strengthened by this project.

Project Management

Having a timeline is crucial for any project. During preparation for this year, a strict yet flexible schedule was made to optimize build season, pool practices, and allow for troubleshooting. Falling on past experiences, this schedule was developed to help keep the company on time and on top of tasks. (See Appendix A)

(Figure 3, Team Working Together
Photo Credit: Bee Smith)

UN Sustainability Goals

"The United Nations proclaimed a Decade of Ocean Science for Sustainable Development (2021-2030) to support efforts to reverse the cycle of decline in ocean health and to gather the global community behind a common goal: creating improved conditions for sustainable use and development of our world ocean" (2022 Ranger Manual). This is the mission behind this season of the MATE ROV competition. Every year, missions are set to better the Earth and its oceans. The R-Mateys have tirelessly worked to bring Amphitrite to life, and have designed the ROV to carry out these missions with ease.

Marine Renewable Energy

To reduce the harmful effects left on the world, developing renewable and clean energy is a hefty, but vital task. Energy is an invaluable world resource; constantly being supplied to homes, schools, businesses, restaurants, and cars in the forms of heating, air conditioning, gas, and water regulation. Finding a more efficient energy source in place of nonrenewable energy is an important task. To support this problem, Ocean Infinity works to install renewable energy systems, off-shore wind turbines, and provide them with sufficient maintenance as problems occur. The R-Mateys' ROV is equipped with the necessary technology to address these problems in similar ways. To simulate how Ocean Infinity deploys ROVs from a facility, or docking station, Amphitrite will conclude every product demonstration run by entering into the "resident ROV" docking station provided by the MATE guidelines. Amphitrite simulates installing and repairing inter-array cables that supply power to off-shore renewable energy sources by using a combination of two perpendicular claws and four motors.

Offshore Aquaculture and Blue Carbon

The cultivation of aquatic wildlife as a sustainable food source, or aquaculture, is a large part of global food supplies. As the human population grows, so do the demands for aquaculture and similar large-scale food production industries. To keep this food safe for consumption, there must be certain conditions in which this production is maintained. Adequate water quality, a correct pH (Potential Hydrogen) level, reduced temperature fluctuation, etc, are all important factors to consider. Most aquaculture production has been taken offshore and is regulated by ROVs. These ROVs monitor the conditions required to ensure a reduced probability of diseases and ensure marine wildlife is not being put at risk. Using a combination of manual and autonomous piloting, Amphitrite is able to determine fish mortality rates, make repairs, and replace structural damages.

Following Blue Carbon's initiative, Project Seagrass, Amphitrite is also capable of pruning seagrass beds so that they can be cultivated for future generations. Seagrass plays a huge role in absorbing and storing carbon dioxide and is a vital food source for many ocean species such as manatees, sea turtles, shellfish, and seahorses. Amphitrite's ability to service these needs and work to create a stimulating, healthy ocean environment is of the utmost importance.

Antarctica Then and Now — Endurance22 and MATE Floats!

Antarctica and regions in the North Pole have suffered increasing amounts of damage done by climate change and overproduction of carbon dioxide. Most significantly, warmer temperatures, melting glaciers and ice, and diminishing food sources for wildlife. These regions also act as barriers for the rest of the world because ice is a vital way water is stored and regulates ocean temperatures. Without ice, it can be expected to see high water levels that may cover low land masses on which many people live and rely on. The R-Mateys respond to these urgent tasks by creating a Vertical Profiling Float (VPF) with the ability to monitor certain aspects of the ocean. This VPF acts independently from the main ROV and simulates the work needed to stop the ocean's changing conditions.

The R-Mateys also aim to help in tasks like "Reach the World," part of an expedition to search for and map sunken ships, like Ernest Shackleton's Endurance. Expeditions like these survey wrecks for historical and explorative purposes, but also for the added understanding of the chemistry behind the way ocean waters circulate and exchange heat. To replicate navigating difficult and icy waters, the R-Matey's ROV will begin with each product demonstration run by deploying through a "hole in the ice," just as expedition operators do after drilling holes in Antarctic ice. The expedition ends with the ROV entering a docking station. Amphitrite is equipped with clear, accurate camera systems that allow her operators to correctly read and map data from transect lines, shipwrecks, and other ocean anomalies.

Design Rationale

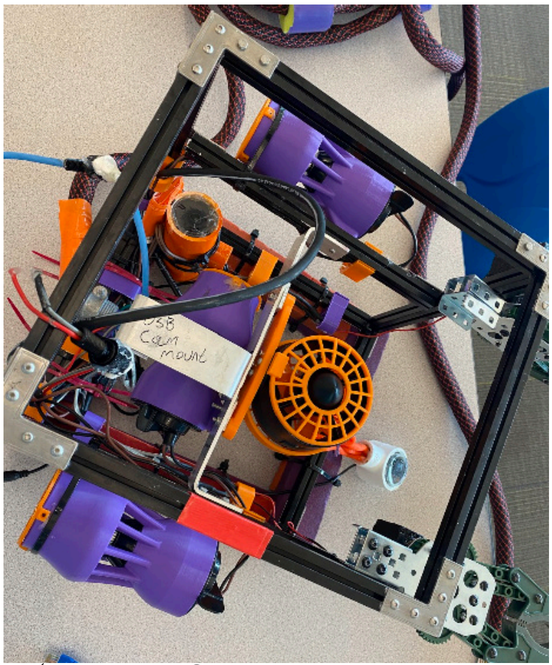
Frame

The ROV is composed of fourteen pieces of 266.7 mm (millimeter) T-slot extruded aluminum beams with a 15 mm x 15 mm cross-section. These aluminum beams allow the R-Mateys to attach different parts with ease using the slots on either side and hex head nuts and bolts. The aluminum also has an anodized coating, making it corrosion-resistant and more durable. The utilization of a cube frame makes it easier to predict Amphitrite's center of mass and mount the components so that they offset each other's weight and maintain the proper balance. All of the aluminum structure is similar to last year's- with the exception of the inside configuration and size. This year, the team decided to make the frame smaller, allowing Amphitrite to be more agile in the water. The R-Mateys used two cross beams of extruded aluminum running across the sides and a 236 mm x 25.4 mm piece of aluminum flat bar on the interior of the ROV to accommodate the T200 vertical thruster, and strafe motor. To mount the cameras on Amphitrite, the R-Mateys used flexible gear ties, PVC, and zip ties, allowing the team to easily change the viewpoint to fit the pilot's needs.

(Figure 4, 15mmx15mm Extruded Aluminum Frame, Photo Credit: Jacey McCloud)

Motor Scheme

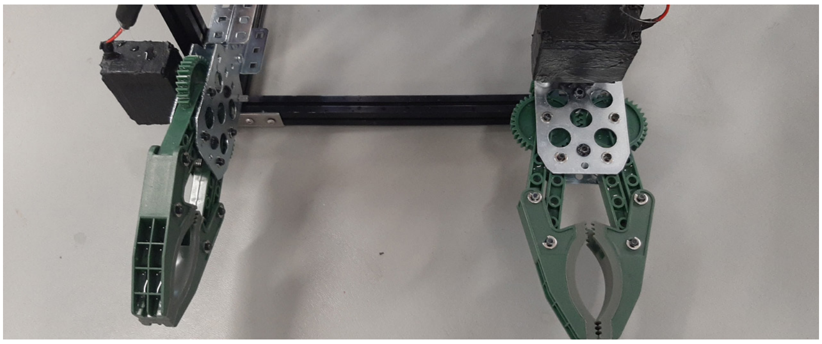
Motors are crucial to the fabrication of any ROV. The placement of these motors determines which way the ROV will be propelled. This season, the R-Mateys decided to use two different types of motors, three 1000 gallons-per-hour Johnson Bilge Pump Motors and one Blue Robotics T200 motor. The bilge pump motors are positioned to achieve strafe (side to side), forward, reverse, and turning movements. The strafe motor is mounted in the center of the ROV for balance and stabilization, which allows the pilot to make left-to-right lateral movements in the water with ease. The T200 motor from Blue Robotics has 3.94 kilograms of forward thrust at twelve volts. This thruster is placed next to the strafe motor inside the ROV center for optimized vertical movement. Having the strongest motor control the up and down movement allows Amphitrite to carry heavier loads from the bottom of the pool quickly. The reason for placing these motors on the inside is so they will not pivot the ROV around the center of gravity. This allows Amphitrite to make direct lateral movements up, down, left, and right without turning. The left and right motors are mounted on the outside of the port and starboard sides on the ROV for forward and reverse movements when used in unison, and turning movements when used independently.



(Figure 5, ROV Motors,
Photo Credit: Jacey McCloud)

Manipulators

Manipulators, or claws, give the ROV the ability to interact with objects to complete missions. The R-Mateys are using two Vex Version One claws this season. These are mounted on either side of the front of Amphitrite, with one claw positioned vertically and the other horizontally. This not only allows the company to easily pick up more than one thing at a time but also to be able to pick up objects in positions only accessible by a vertically mounted claw or only a horizontally mounted claw. Having two claws positioned differently allows the ROV to complete tasks efficiently and easily. However, running both claws at the same time takes up too much amperage for the limit set by the competition, so the company decided to install a switch that allows only one of the claws to be used at a time. This ensures that while in use, the max amperage is not exceeded.



(Figure 6, Two Vex V1 Claws mounted on ROV,
Photo Credit: Dawson Pendleton)

Electronics

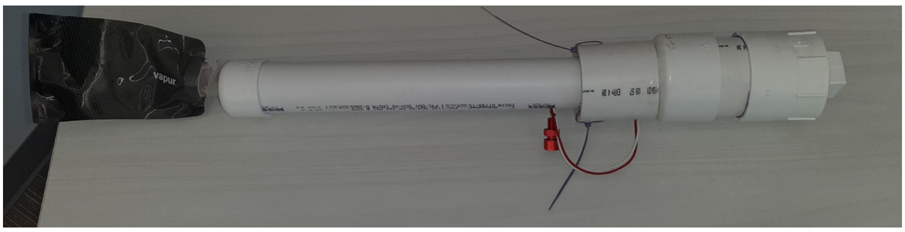
Power comes into the control box from the top and flows through a watt meter to monitor the system in real-time. The company uses a power distribution module to route power to all components, making them independent from each other. This allows for the protection of the control box with fuses that are easily replaceable. The distribution module supplies power to four motors, motor controllers, two claws, one Raspberry Pi (RPi), three monitors, and four cameras. The control box is equipped with a voltage reducer that lowers the voltage from 12 volts to 5 volts, as required by the Raspberry Pi.

(Figure 7, Picture shows R-Mateys' Control Box, Photo Credit: Dawson Pendleton)

From the RPi in the control box, a keyboard, mouse, and two Logitech F310 Gamepads serve as the main user interface. The controller's joysticks and buttons are programmed to perform certain functions within the code. For example, the left joystick when moved on the horizontal axis controls vertical motion. The RPi serves as the brain of the control box and ROV, converting the controller inputs into usable signals for motor controllers. These signals then send the correct amount of power to each respective motor. The four cameras are positioned to provide optimal visibility of the tasks we are completing, one pointing upwards for the hole in the ice, one facing forwards to help with all of the tasks, one facing sideways to view the vertical transect line, and one facing downwards for tasks such as mapping the shipwreck. Each of these cameras is connected to multiple monitors. The claw camera is connected to a ten-inch monitor while the other three are connected to two different seven-inch monitors, with a Fosmon A1602 RCA Splitter to allow switching between each camera.

Vertical Profiling Float

The R-Mateys were tasked with designing and constructing a float capable of accomplishing two vertical profiles. The company completes this mission with the use of a buoyancy engine. The float's outer enclosure is a polyvinyl chloride (PVC) pipe that is 60 centimeters long and has a three-inch diameter. The R-Mateys chose PVC over other materials due to its affordability, strength, and lightweight.
Within the enclosure is a Raspberry Pi Pico, a Blue Robotics Bar02 Depth Sensor, a linear actuator, a syringe filled with water, and three D batteries, with the battery pack located in a separate waterproof compartment for safety. The depth sensor communicates the depth of the float to the Raspberry Pi. When the float reaches a certain depth, the linear actuator pushes the water out of the syringe and into the external bladder. The bladder then expands, thus increasing the overall volume of the float while the mass stays the same. This means that the float's density is decreased to a level less than water's, allowing it to return to the surface.



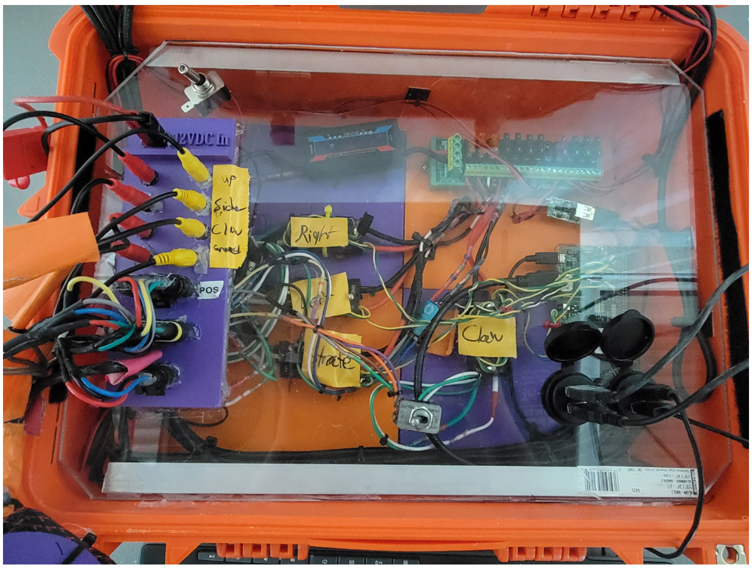
(Figure 8, Picture shows R-Mateys' Vertical Profiling Float, Photo Credit: Dawson Pendleton)

Code

The R-Mateys have coded a Raspberry Pi with the programming language Python to control Amphitrite's movement in the water as well as to complete autonomous tasks. The RPi sits inside the control box and controls the movement of the ROV's motors. The RPi takes the input from the joystick axis and applies it to each motor controller. These axes are from zero to one–representing no power to maximum power– which means that when the joystick position is moved, the power output is parallel. For example, when the joystick is moved halfway, this represents 0.5 or 50% power. The left and right motor are mapped to the controller's left and right joystick's vertical positions, respectively. Moving both of these joysticks together controls Amphitrite's forward and backward movement, and moving them independently allows the ROV to turn quickly. The horizontal axis of the left joystick is attributed to the strafe motor controls, letting the pilot move laterally with ease. The horizontal axis of the right joystick controls the vertical movements. Coding these inputs accurately was a vital part in fabricating the pilot's controls of Amphitrite. (See Appendix B for Logic Flow Diagram)

When visually docking, the onboard Pi takes a picture and sends it to the main RPi in the control box via an ethernet cable. The main RPi contains the more sophisticated software to scan the image for red RGB values and saves the position of each red pixel it detects. Averaging the red value's position and calculating the difference between the red and the center of the image, the main RPi then activates the left and right motor to steer Amphitrite until the scans indicate that the red is in the middle of the screen. The same is done for the vertical axis with the vertical motor raising and lowering the elevation of the ROV until any detected red is in the middle of the screen. Once red is detected within the middle of the screen, the ROV is propelled forward. (See Appendix C for Logic Flow Diagram for Docking)

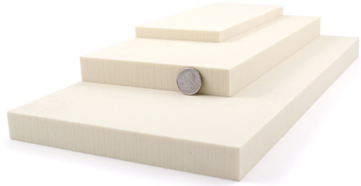
In cases where visual docking may be unable to be used. An example is water getting into the enclosure and compromising the onboard Raspberry Pi. This method will require the pilot to align the ROV with the dock. The pilot will then press a button on the keyboard attached to the control box Raspberry Pi, this button will activate the autonomous docking. The right and left motors will run at 50% power until the pilot chooses to end autonomous docking with a keyboard input.



(Figure 9, Picture shows close-up of the R-Mateys' Control Box, Photo Credit: Dawson Pendleton)

Buoyancy

Archimedes' principle is a crucial concept in determining an object's buoyant force. The principle states that the buoyant force on a submerged object is equivalent to the weight of the fluid being displaced by said object. If the displaced water weighs less than the ROV, the ROV will sink. This is known as negative buoyancy, meaning the vertical thruster would need to continuously propel the ROV upward in order to keep a consistent depth. Positive buoyancy occurs when an object is lighter than the weight of displaced water. Amphitrite is neutrally buoyant, meaning the ROV's weight is equal to the weight of water being displaced. This allows the ROV to stay submerged without using the vertical thruster.



(Figure 10, Picture shows Buoyancy Foam used, Photo Taken from Blue Robotics website)

To determine the amount of buoyant force needed to achieve neutral buoyancy, all components were individually weighed to find the mass in grams, which was 4.615 kg to calculate their force due to gravity. Then, the volume of the water being displaced by the ROV was measured to be 2,538.4 mL. In order to achieve the goal of neutral buoyancy, the ROV required 469.48 cm3 of Subsea R-3312 buoyancy foam. The foam is mounted on top of the ROV for stability when deployed in the water. For aesthetic purposes, the buoyancy foam was wrapped with purple and orange VViViD vinyl wrapping to match the company's ROV's color scheme.

Tether

(Figure 11, Picture shows Tether, Photo taken from Amazon website)

This year's tether is comprised of twelve color-coded, eighteen gauge wires, an Ethernet cable, and four camera wires that are encased in a 15-meter, 1-inch PET expandable, braided sleeving. Additionally, the tether houses a sealed 15-meter x 0.318 cm silicone tube to provide additional buoyancy to offset the mass of the tether. The R-Mateys chose this tether design for its flexibility, small size, and lightweight. The tether allows Amphitrite to move with a high level of agility in the water by reducing the amount of drag. This sleeving also allows for effortless field repairs and modifications. Where the tether attaches to the ROV, there is a one-inch wire clamp to provide strain relief. If the tether was pulled unexpectedly, the force would be applied to the frame of the ROV, not the tether itself. Topside, the tether is equipped with a custom 3D printed strain relief thimble to protect the control box connections.

To ensure the safety of the tether manager and poolside team members, tether care is treated with utmost importance. While in use, the tether manager keeps the unused section of the tether out of foot-trafficked areas to avoid trip or slip hazards. While not in use, and at the end of every pool practice, the tether is coiled and secured on top of the ROV to avoid entanglement, damage, or unnecessary strain.

Buy vs. Build

The R-Mateys are dedicated to bettering the world. A key way to accomplish this is the use of recycled materials in design and building. The R-Mateys have reused previous props and PVC for this year's missions. For the Appalachian Highlands Regional Competition, the housing for the control box was reused from last season, however, the inside has been reconfigured. The R-Mateys built the control box to customize the controls to the pilot's specific needs. The R-Mateys also reused frame materials from the previous season. Reusing materials helps not only the company's bottom line but also reduces the R-Mateys' environmental footprint.
e
However, some components cannot be reused, whether due to consumability or malfunction, and have to be bought new. For example, two new Logitech F310 gamepads were purchased for Amphitrite's system after complications with the previous controllers. New Raspberry Pi's, Zero and Pico, and cameras were also bought this year. Additionally, due to shipping constraints, the company's control box was rebuilt into new waterproof housing for the International Competition. These purchases will not only benefit the company this year, but can be reused in future years. Longevity is one of the most important steps towards sustainability, and the R-Mateys are dedicated to achieving this goal.

System Integration Diagrams

The R-Mateys have created two system integration diagrams (SIDs) and two software flow diagrams as a tool to explain the inner workings of the control systems. (See Appendix B, C, D, E, and F)

Safety

The R-Mateys' ROV, Amphitrite, was designed with safety being of utmost importance in both construction and usage. With the goal of zero incidents or injuries in mind, the R-Mateys have come up with multiple safety features and protocols. (For a breakdown of Amphitrite's safety features and company poolside and workspace protocols, See Appendix G and H)

Critical Analysis

Testing and Troubleshooting

Throughout the creation of Amphitrite, testing and troubleshooting were essential. The R-Mateys had to work through many different issues. Cameras have posed a unique challenge to this company. This season, the R-Mateys used four back-up cameras and one Raspberry Pi camera used for autonomous tasks. A big aspect of testing cameras for competition is ensuring the angles of each camera are to the pilot's needs and are able to complete all missions with ease. One person adjusted each camera to see different angles while the pilot watched the monitor on the control box. This confirms that all the cameras are in the correct position for the pilot to maneuver during practice and competitions. Another aspect that required plentiful testing was the addition of the T-200 thruster. Due to the novelty of the T200 thruster, the company underwent a slight learning curve. This thruster proved to be an excellent addition to the ROV as it was easy to work with and is highly effective.

Challenges

Meeting Space

A main challenge the R-Mateys faced was losing their meeting space for a second year in a row. The space they were using, which was owned by Kingsport City Schools, had to be accessed by a short hallway owned by the Kingsport Chamber of Commerce. The Chamber then said the company was no longer able to use the hallway to access the space. For the first part of the year, the R-Mateys met and kept their supplies in the school. Halfway through the year, a local business known as the Inventor Center, allowed the company to meet in their workspace and use their equipment. With much gratitude, the R-Mateys took advantage of the workspace and got to work fabricating Amphitrite.

Code

A consistent challenge the R-Mateys have faced in their competition years is learning how to code. This year, new members with backgrounds in coding, as well as members who had worked in the coding department in the past, rose to the challenge to bring the R-Mateys' code to an improved level. But, even with an added level of experience, coding was still a struggle to work with and complete. With hard work, trial and error, and lots of determination, the R-Mateys pulled through, gained experience, and were able to deliver working code to be used at competition.

Supply Chain Issue

Due to supply chain issues affecting the country, getting parts for the ROV in a timely manner became a problem for the R-Mateys. With shipping times slowed dramatically and various products unavailable, getting vital pieces and parts for the ROV sometimes took weeks, when in previous seasons parts could arrive in a couple of days. The R-Mateys stayed resilient, and even though some parts took longer to arrive, everything was still completed on schedule.

Cameras

The company had issues transmitting USB camera signal last competition and decided to fix it this year. The main issue was that USB can only run for five meters reliably, despite needing the signal to reach to the end of the 15 meter tether. To address this, the company decided to utilize an onboard Raspberry Pi that can send camera feed via an ethernet cable.

Lessons Learned

Vex V1 Claw

One major problem faced by the R-Mateys is the gears in the Vex V1 claws. The plastic gears in the claws are easily stripped. When the gears strip, the edges come off the gear and render it virtually useless. This is a problem when the claws are essential for grabbing things underwater. The solution to this problem is to have metal gears. However, due to supply chain shortages, this is not only expensive, but also lengthy to have delivered. The solution for this season was to have extra gears to replace the broken ones when they strip. The team has learned the lesson of longevity with this problem. Getting a more sustainable way to replace the broken gear would prevent waste. Another solution would be to use a different claw that would prevent gear stripping in the first place.

Wire Management

A consistent struggle the R-Mateys face is proper wire management from the beginning of wiring the ROV. After soldering all the wires needed inside the tether, the company discovered that some wires were too short or too long to manage the wires properly. In the future, the R-Mateys will make a list of all the wires needed on the ROV, and a map of their locations and how they will move prior to beginning wiring. This will allow for soldering and adjustments to be done with ease.

Post-Regional

After the Appalachian Highlands Regional competition, several improvements were made after the advancement to the 2022 World Championship.

Control Box

Due to shipping constraints, the R-Mateys made the decision to redo their entire control box to fit into a smaller case. Previously, the case they used to house all their poolside-electronics was rather large. The case was too large to ship from Kingsport, Tennessee, to Long Beach, California. The new case is much smaller which in turn makes it easier and cheaper to ship. The internal components are wired and function the same way as before in the larger housing.

Additional Camera

Additionally as a part of the company's post-regional changes, the company decided another sideways-facing camera would benefit manually performing task 2.1 "Inspecting an Offshore Aquaculture Fish Pen" in future product demonstration runs. Previously, this task took an extensive amount of time using a combination of the strafe motor and forward facing camera. Using this new sideways camera, the R-Mateys now minimize the time expended by using the two faster and more powerful forward motors to fly the transect with ease.

Various Changes

In addition to the previously mentioned changes, other tweaks were made to enhance the performance of Amphitrite. The strain relief for the tether was improved to be easier on the wiring used on the ROV. Better wire management was implemented in the new control box. This change allows for easier fixes, as well as others' understanding of the R-Mateys' wiring. Finally, new custom-fit pieces were 3-D printed for our motor shrouds and for our control box. The new 3-D printed motor shrouds maximize their potential. The 3-D printed piece was specifically designed for the control box and fits in the plexiglass covering. This allows the tether to be connected from the top as opposed to the side, as in the previous rendition of the R-Mateys' control box. This change allows for better strain relief topside, as well as easier and more efficient plugging in of the tether to the control box.

Future Improvements

With any project, there is always room for improvement. Below are some improvements that the R-Mateys would like to further expand upon in future years of competition:

Shielding the camera
The R-Mateys would add metal shielding around the camera wires. This would potentially fix any interference on the monitors, allowing for a clearer image. The metal shielding would help to deflect the magnetic waves created by the current of other power wires.

All T-200s
In the future, the company would like to look into using T200s for all thrusters. The main problems would be the increase in size for the motors compared to bilge pump motors and an increase in amp usage; however, it would give the ROV more power for maneuvering.

Upgrade RPi
The R-Mateys hope to upgrade the RPi in the control box and onboard next year. This year, the company was unable to get new versions of Raspberry Pis because of supply chain disruptions. The company would like to upgrade the control box Pi from a Version Three B+ to a Version Four 8 Gigabyte and the onboard RPi from a Raspberry Pi Zero to a Raspberry Pi Zero W 2.

Accounting

Budget

Budgeting is an important part of any project and was vital to this season. The Chief Financial Officer (CFO) and the Chief Executive Officers (CEOs) looked over existing materials and made a projected cost for Amphitrite. See Appendix G for the R-Mateys' 2021 - 2022 season budget created at the start of the school year. The following includes the starting account balance, grants, budgeted amounts, and actual cost. There are two areas important to note. First, fundraising is primarily obtained after the regional competition and before the start of the next competition year. Second, the R-Mateys' CFO calculated an estimate of the combined company hours donated to the project at 2500 hours.

Cost Accounting

The R-Mateys' CFO kept meticulous records of what purchases were made over the course of the project. All proposed purchases were run through the CFO before approaching the company sponsor for official purchase.

To calculate the expenses of travel for the regional competition, the CFO took the total miles to be traveled (round-trip), the average gas price for Northeast Tennessee and Long Beach, California, the estimated fuel efficiency for the district-supplied and rented vehicles, and ROV transportation to determine the projected cost for the company travel. Additionally, the R-Mateys had to purchase airfare to Los Angeles and team lodging for the International competition.

Conclusion

To address the missions put forth by the MATE ROV competition for the 2022 season, the R-Mateys worked tirelessly, thoughtfully, and with boundless amounts of collaboration to bring Amphitrite to life. This company, as well as this ROV, is founded on friendship, hard work, and dedication. Amphitrite gets her name from the Greek goddess of the sea, and this ROV is designed to help protect the seas, the world, and the future. Amphitrite is equipped with the necessary tools and technology to tackle the missions and challenges set by MATE to aid in the fight against climate change for our future.

References

2022 Ranger Manual. (2021). 2022 MATE ROV Competition: Ranger Class Manual, 8–14.

T200 thruster. Blue Robotics. (2022, May 21). Retrieved May 21, 2022, from https://bluerobotics.com/store/thrusters/t100-t200-thrusters/t200-thruster-r2-rp/

Subsea buoyancy foam: R-3312. Blue Robotics. (2022, May 21). Retrieved May 21, 2022, from https://bluerobotics.com/store/watertight-enclosures/buoyancy/float-r1/

Acknowledgements & Sponsors

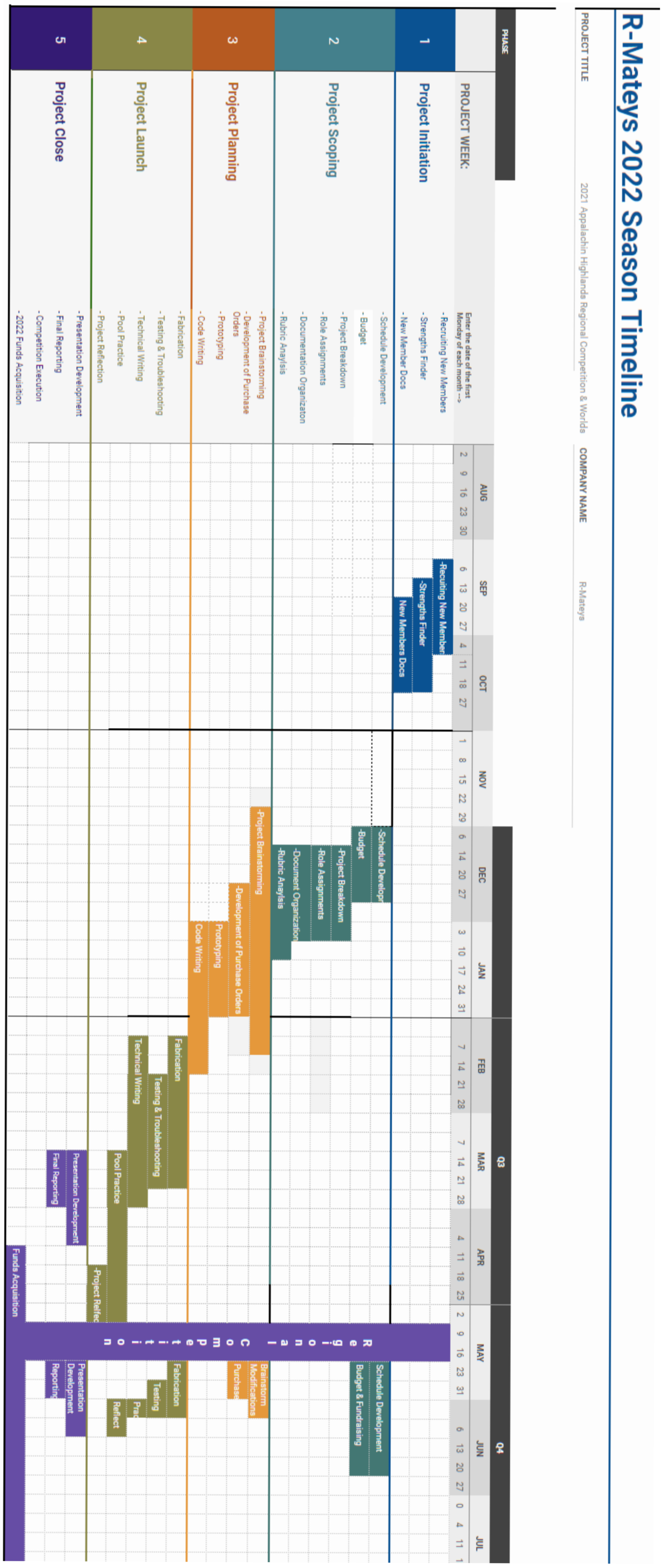
The R-Mateys would like to thank the following mentors for their guidance and support through the 2021-2022 competition season.
Erica Gardner, D-B EXCEL Teacher and R-Mateys coach and sponsor.
Zachary Gardner, Eastman Chemical Company-Chemical Engineer and R-Mateys lead mentor

The company would also like to thank the following sponsors for their monetary contributions. Without their help, the R-Mateys would not have been able to fabricate the ROV, Amphitrite.

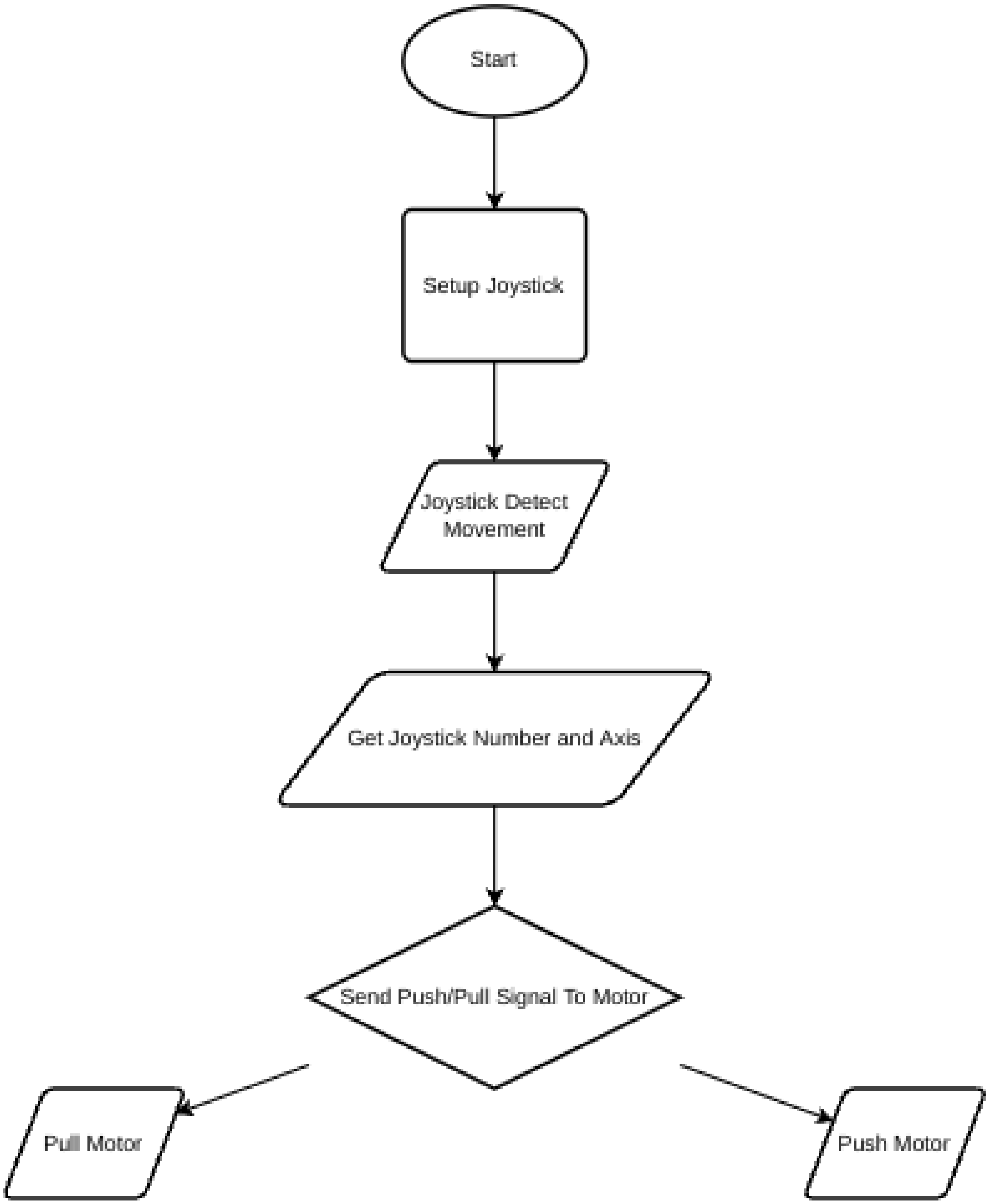
The Inventor Center
Eastman Foundation
Baker's Jewelry
Kingsport City Schools
Martin Transport Inc.
Zion Marine
Chef's Pizzeria
Cumberland Marketing
Merrill
Tribe Nutrition
O'Reilly's
Fizzy Fairway Mini Golf Bar
Signature Properties
Mattern & Craig
Gray Builders Inc
GRC Construction
Mac's Medicine Mart
Pinney's Prescription Shop
Integrity Capital Management
Town & Country Realty
First Bank
Eric Fugate
Martha and Coble Ramsey
Brandie Godsey
Penny Parker
Honda of Kingsport

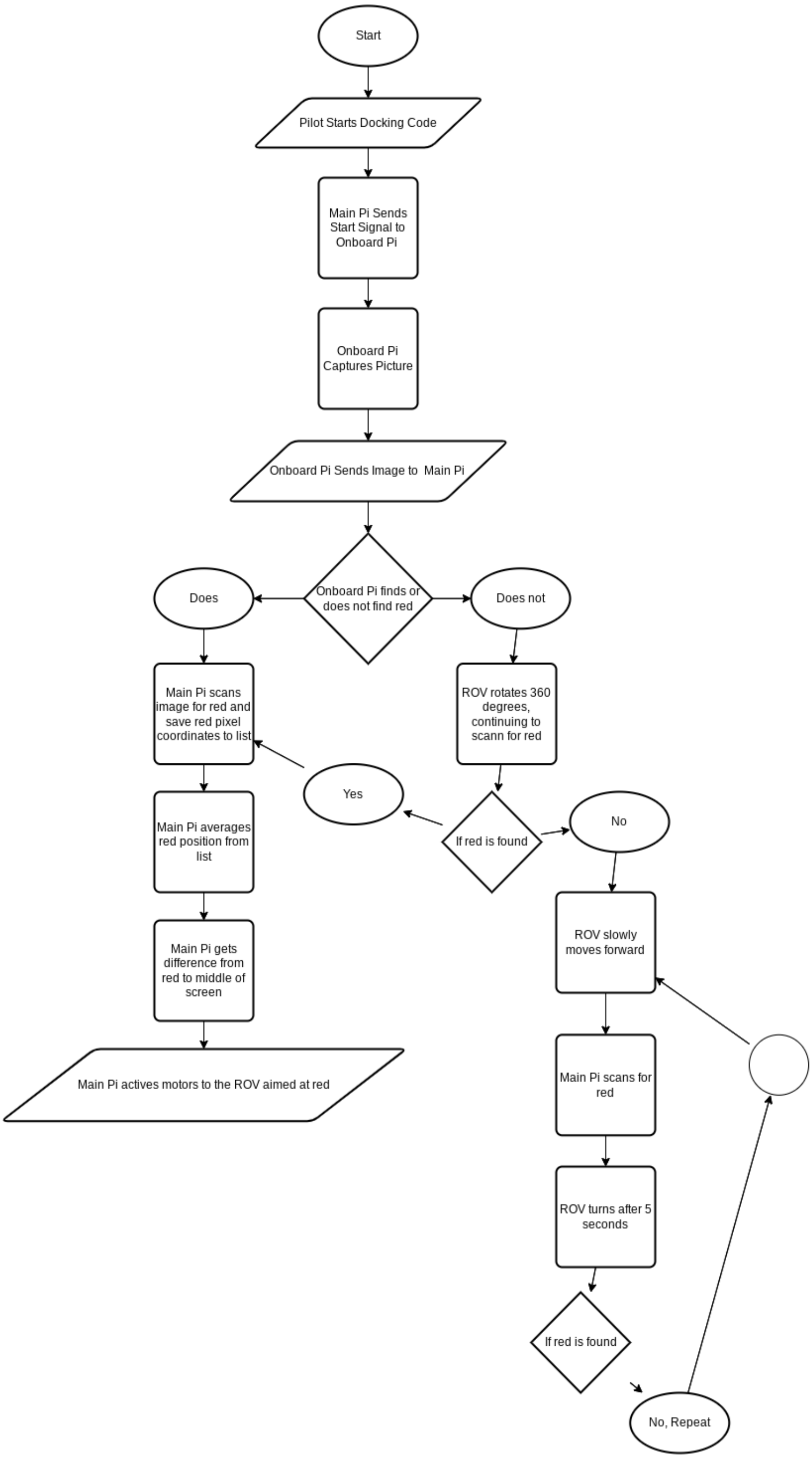
Appendix

Appendix A: 2021-2022 Project Timeline



Appendix B: Motor Controller Logic Diagram





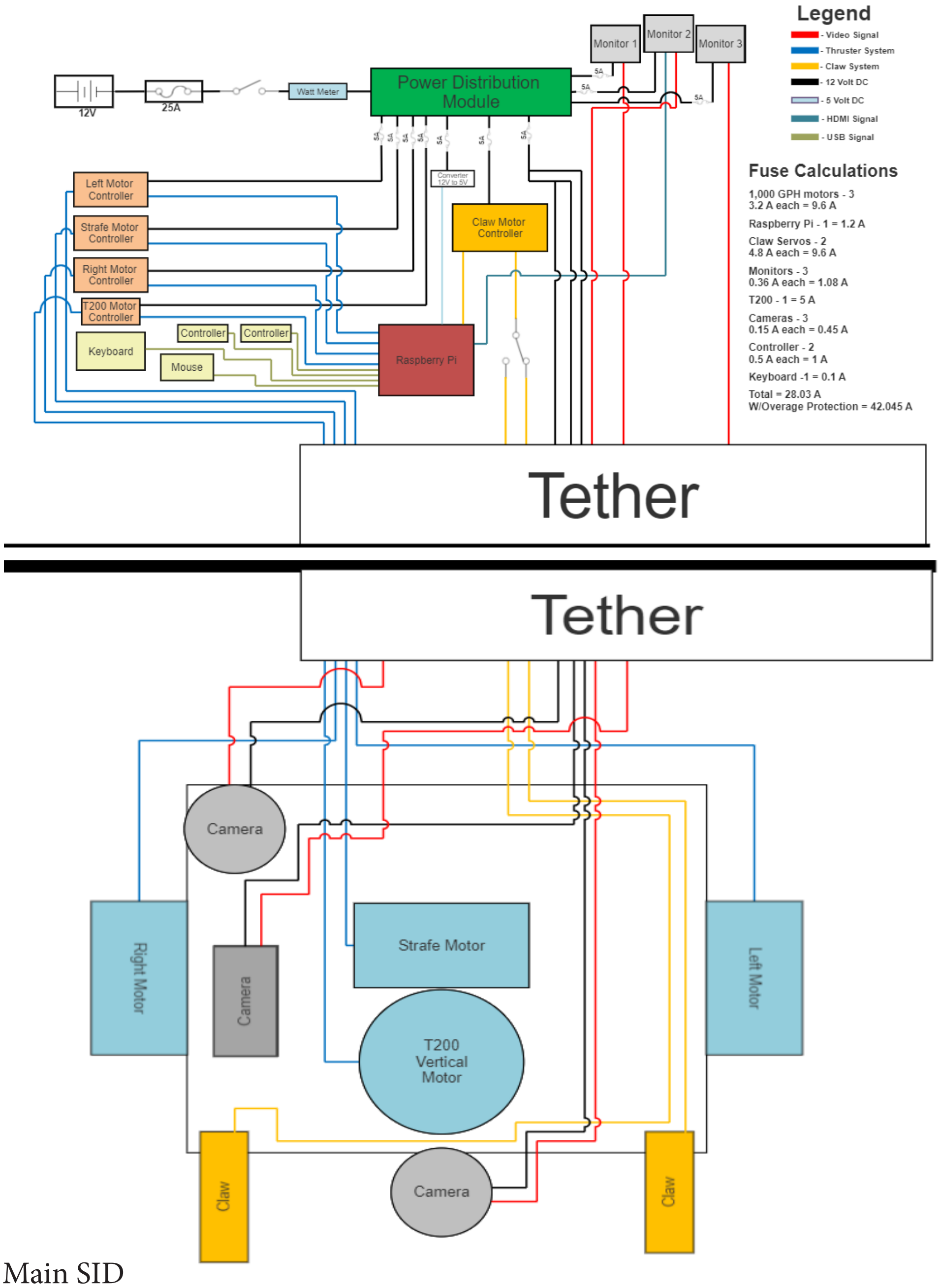
Appendix C: Autonomous Docking Logic Diagram

Appendix D: Buoyancy Calculations

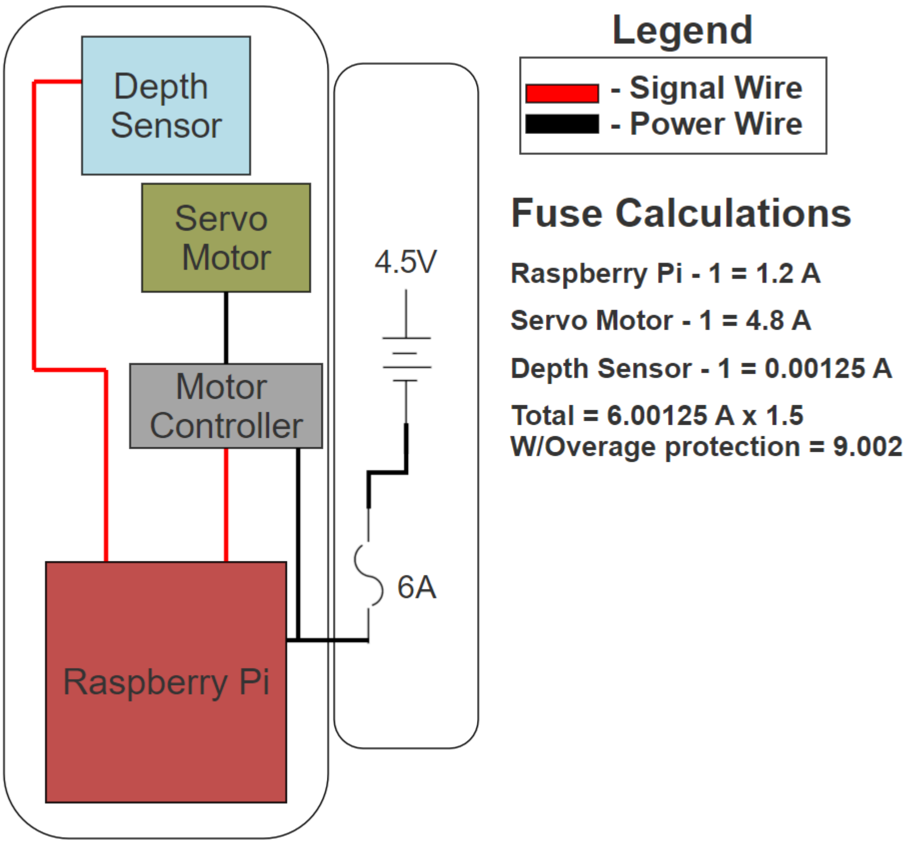
Items	Mass (Grams)	Quantity	Total Mass	Volume (cm^3)
ROV	4615.00	1	4615.00	2538.40
TOTAL			4615.00	2538.40

Kg	4.61500	
Fg	45.22700	Newtons
Buoyant Force No F	13160.91000	g*m/s^2
	13.16091	Newtons
Apparent Weight N	32.06609	Newtons
Foam Density	12.00000	lbs/ft^3
	192.21600	kg/m^3
	192216.00000	g/m^3
Mass of Foam	469.48000	g
	0.46948	kg
Volume of Foam	0.00244	m^3
	2442.46057	cm^3
	148.99009	in^3
Grav. Force Foam	4.60090	Newtons
Buoy Force Foam	23.86431	Newtons
App Weight Foam	-19.26340	Newtons
Total App Weight	12.80269	Newtons

Foam Thickness	1
Foam Width	74.49504724
Foam Length	2
	7.094766404



Appendix E: Main SID



Appendix F: Vertical Profiling Float SID

Workspace Protocols	Description	Y/N?
Safety Glasses	When working on/with the ROV, tether, or control box, company members are required to utilize proper Personal Protective Equipment (PPE) in the form of safety glasses at all times.	
Hair Entanglement	When working on/with the ROV, tether, or control box, or when working with power tools such as drills and soldering irons, company members with long hair are required to tie back loose hair to avoid entanglement or potential fire hazards.	
Hand Injuries	To avoid hand injuries, company members must carry, deploy, and retrieve the ROV by the metal frame. This ensures hands are away from motors and other moving parts.	
Closed Toed Shoes	All company members are required to wear close-toed and non-slip shoes, especially those on poolside positions.	

Appendix G: Workspace and Poolside Protocols

Poolside Protocols	Description	Y/N?
Non-slip Shoes	Non-slip shoes are required for all company members when participating in poolside events to mitigate chances of an accidental fall.	☐
Tether Management	The ROV tether is always properly detached from the control box, then neatly coiled after poolside events. This is carried on the shoulder of a company member to prevent damage and falls. Another company member carries the ROV.	☐
Control Box Safety	Upon set-up, the main fuse is checked. Then the kill switch is verified to be OFF. Then the power supply is connected, and the kill switch is turned ON. Then the watt meter is checked and all fuses on the power distribution module are checked by the pilot. Upon breakdown, the kill switch is turned OFF before disconnecting the power supply.	☐
Power Supply Safety	Upon set up, the power supply is verified to be OFF before connecting to the control box. Upon breakdown, the power supply is switched OFF before disconnecting from the control box.	☐
Controls Check	Once power has been safely introduced, the pilot will run a controls check. He will check the port motor, then starboard, vertical, and strafe. Then the team will check that combinations of motor movements are possible and picked up on the Watt meter. Then he will test the claw, lights, and cameras before giving the all clear to enter the water.	☐
Mission Tools & Prop Management	All mission tools and props will be stored safely away from the immediate path of company members working at the poolside. This will prevent accidental trips and water entries.	☐

Appendix H: ROV Safety Features

ROV Safety Features	Description
Motor Shrouds	To reduce the chance of injury as a result of fast-spinning motor propellers, there are durable, 3D printed covers and enclosures to limit contact with the blades. Moving parts are clearly labeled as such to avoid any confusion.
Filed Edges	Sharp objects, such as corners of aluminum framing or 3D printed parts, can cause cuts. This is avoided by rounding corners with a file.
Electric Hazards	Painful shocks and burns may occur even with the limited voltage running through the ROV. To avoid this, features such as insulated wires, heat shrink or hot glue covering wire junctions are always utilized and double-checked for accuracy. The control box is equipped with a plexi-glass cover to keep any hazardous wires out of reach. It is also equipped with fuses and a kill switch so the pilot can shut off all power at once in an emergency situation.
Fuses	The entire control box is protected by an inline 25 amp fuse. In addition, each branch of the power distribution module is protected by smaller, appropriately sized fuses.
Kill Switch	The ROV is equipped with a kill switch to shut all electronic functions down at the chance of electronic malfunction.
Safety Labeling	All functions of the ROV, specifically in the control box, are labeled with cautions if necessary.
Strain Relief	With all the wires in Amphitrite connecting to one tether, a slight jerk or pull could cause separation in the wires. This may increase the chance of electric shocks. To avoid this, a strain relief system gathers the tension at one point to reduce tension on the ends of any individual wires. The strain relief is located in two areas. One is at the connection of the tether to the control box, while the other is located at the rear of the ROV.
Zip Ties	When cut, zip tie ends may be sharp. This is easily solved with a protective coat of hot glue on top, which fully encloses the potentially sharp tip.

R-Mateys Budget 2022

CEO: *Jasmine Monroe & Quintin Bentley*
School Name: *D-B EXCEL*
CFO: *Kerrigan Bentley*
Instructor/Sponsor: *Erica Gardner*

Reporting period
From: 8/10/2021
To: 4/22/2022

Account Balance				Amount
R-Mateys Activities Account				$ 4,684.30

Budgeted Expenses				
Category		**Description/Examples**	**Budgeted Cost**	**Actual Cost**
ROV Components	Purchased/New	Motors, Claw, Cameras, Propellors, etc.	$ 700.00	$ 672.76
ROV Components	Re-used/Built	Frame, Motor Shrouds, etc.	$ 150.00	
Control Systems	Purchased/New	Raspberry Pi, Plexi-glass, etc.	$ 100.00	$ 189.44
Control Systems	Re-used/Built	Motor Controllers, Control Box Enclosure, etc.	$ 150.00	
User Interface	Purchased/New		$ 200.00	$ -
User Interface	Re-used/Built	Monitors, Keyboard, Game Controllers, etc.	$ 100.00	
Electrical Systems	Purchased/New	Wires, Heat Shrinks, Solder Seal Wire Connectors	$ 150.00	$ 138.37
Electrical Systems	Re-used/Built	Wires, Heat Shrinks,	$ -	
Tools	Purchased/New		$ 75.00	$ -
Tools	Re-used/Built	Drills, Screwdrivers, Allen Keys, etc.	$ -	
Team Expenses	Purchased/New	Registration, travel, etc.	$ 15,000.00	$ 13,634.61
Team Expenses	Re-used/Built	Old Member Shirts and Polos	$ -	
Props	Purchased/New	Rubber Fish, PVC, etc.	$ 175.00	$ 269.87
Props	Re-used/Built	PVC, String, Spray Paint, etc.	$ -	
Vertical Profiling Float	Purchased/New	Depth Sensor, Raspberry Pi (pico), Linear Actuator, etc.	$ 300.00	
Vertical Profiling Float	Re-used/Built	Raspberry Case	$ -	$ 310.71
			$ 17,100.00	**$ 15,215.76**

Appendix I: 2021-2022 Budget

R-Matey's International Travel Calculations

School Name:	*D-B Excel*	**CEO:**	*Quintin Bentley & Jasmine Monroe*
Coach/Sponsor:	*Erica Gardner*	**CFO:**	*Kerrigan Bentley*
Avg. Gas Cost Per Gallon (TN)	$ 4.30	**Avg. Gas Cost per Gallon (CA)**	$ 6.07
Distance from DBE to CLT	129 miles	**Distance from LAX to LBCC**	22.5 miles
Avg. Van MPG	14mpg	**Avg. Rental Car MPG**	30mpg
Gallons Needed per Vehicle	9.21	**Gallons Needed per Vehicle**	0.75
Gas Cost from DBE to CLT	$ 39.60	**Gas Cost from LAX to LBCC**	$ 9.10
Van Cost Roundtrip (DBE-CLT)	$ 466.00	**Rental Car Cost**	$ 1,500.00
Plane Ticket Quantity	9	**Cost per Hotel Room**	$ 219.00
Cost per Ticket	$ 716.70	**Room Quantity**	3
Total Cost of Airfare from CLT LAX	$ 6,450.30	**Length of Stay (days)**	5
Flight Insurance	$ 510.00	**Total Cost of Hotel Stay**	$ 3,817.17
Cost of ROV Shipping (Fedex)			$ 500.00
Cost of Registration			$ 100.00
Total			**$ 13,392.17**

Appendix J: Travel Cost Calculations