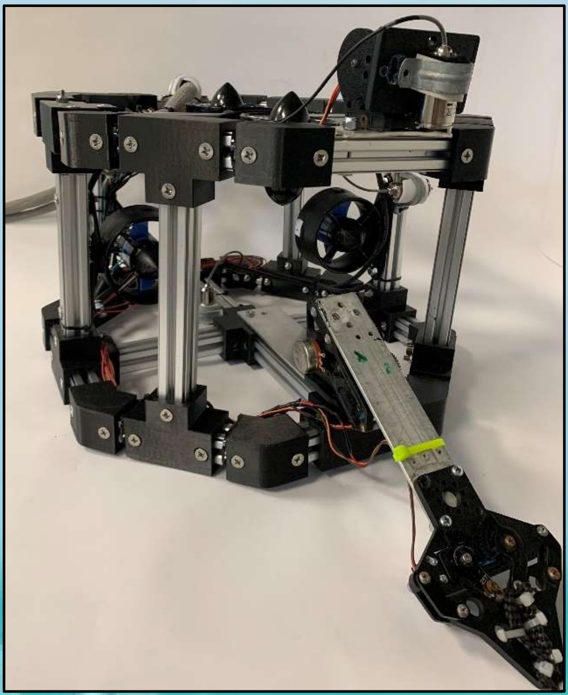
Sea Life Technology

Crush & Squirt



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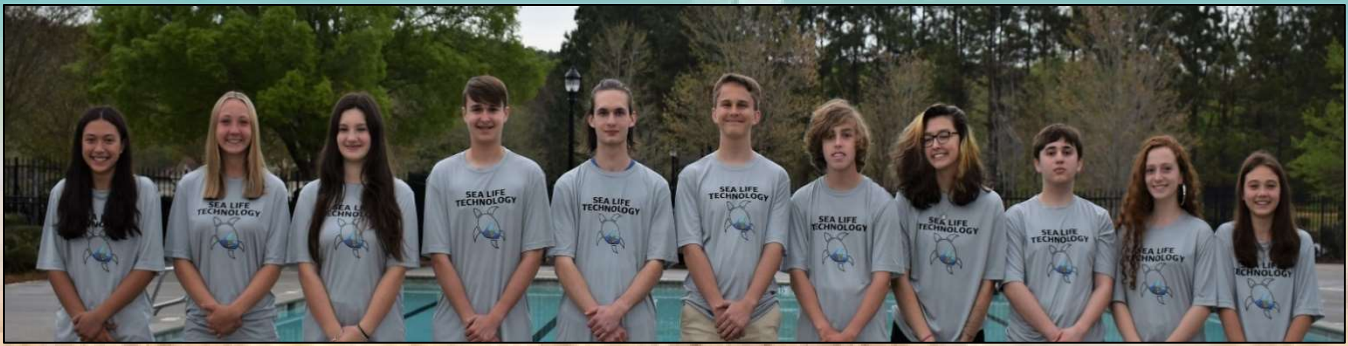

Abstract

Sea Life Technology (SLT) created a dynamic remotely operated vehicle (ROV) to assist in the maintenance of the health of both fresh and saltwater ecosystems. The ROV, *Crush,* has the capability to provide accurate data, images, and maneuver in aquatic environments while performing assigned missions. This includes removing plastics from oceans, decreasing the effects of climate change on coral reefs, and maintaining healthy waterways. *Crush* was distinctly designed with the versatile capabilities to accomplish each of these tasks. For example, the manipulator will pick up litter in environments to meet the requirements of managing the sea bin. *Crush* has a uniquely created program, polystyrene turtle shell for buoyancy, aluminum framing with custom 3D printed joints, manipulator, three cameras, four thrusters, and a 15-meter tether. In addition, an electrically powered micro ROV, S*quirt,* housed on the frame and can detach to assist in obtaining isolated samples.

SLT has spent approximately 550 hours throughout the engineering design process, designing, building, programming, testing, and finalizing *Crush* to accomplish the missions provided by the MATE Competition. The company strives to show how a positive impact can be achieved on the environment. The technical document lists the many steps we took to successfully accomplish the missions, system decisions, testing and troubleshooting, challenges, and improvements made throughout the past two years since inception.

Figure 1: Sea Life Technology Engineers

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Project Management

Sea Life Technology (SLT) was established in 2019 and continues to be a thriving program consisting of eleven engineers, eight 9th graders and three 7th graders. Seven of the company members were new to the robotics program; however, the members are critical thinkers, creative, academically strong, and ambitious in the design of the ROV and the micro ROV. Our team displayed strong teamwork and leadership during this course by working together to overcome the Coronavirus Pandemic shutdown in 2020, and diligent in making necessary changes when we returned in the fall of 2020. We have worked hard to create an ROV worthy of the competition and the real world, and are proud to present *Crush*, our 2019-2021 ROV.

Company responsibilities were assigned based on experience, member interests, and all new engineers were paired with mentors. Our team made a rigorous but manageable schedule to make progress in an organized way. We originally met on Tuesdays from 4-6pm, and in December of 2020 we moved the end time to 6:30pm. In January we began meeting on Tuesdays and Thursdays from 4-6pm, adjusting the schedule as needed, adding Monday meetings, and weekends. Each meeting goals were established, and company members worked diligently to accomplish these goal(s). A wall calendar was created to monitor our preparedness for competition, progress, due dates, and pool practice.

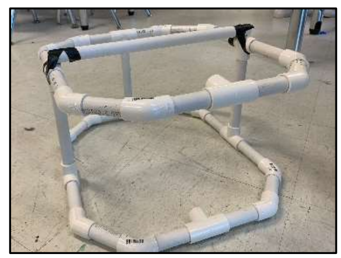


Figure 2: PVC Frame Model

Design Rational

Engineering Design Rationale

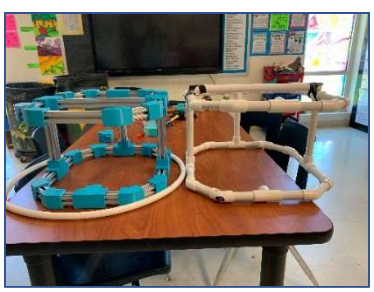


Figure 3: ROV Frames

The companies first step involved the engineering design process, identifying designs that would meet the mission requirements outlined in the Ranger Mission Manual. Factors considered were the needed size and weight requirements, timing, and maneuverability along the coral reefs without causing damage, obtaining pollution samples from rivers and pipes, and assessing the health of various waterways. This process allowed the individual members to communicate effectively with each other, avoid delays in production of parts and allowed the design and production of parts to be completed in the order of priority.

Sea Life Technology's design was inspired by the turtles (*Crush* and his son *Squirt*) from Finding Nemo. Initially to minimize design errors, the company designed a prototype using half inch PVC pipe and added payloads and thrusters to ensure placement. As modifications were needed the company reevaluated the design, adjusted, and made improvements before moving to the final stage of the 3D print and assembly.

The frame was designed and modeled using the 3D design program Solid Works, and the frame joints were 3D printed using ABS polymer filaments. These joints secure the aluminum framing for *Crush*. Two thrusters were attached to the side of the frame for forward and backward movement, and two were attached to the top portion of the middle frame for upward and downward movement. This resulted in an ROV that can maneuver in tight spaces, meet the size 60 cm and weight of less than 15kg requirements set forth by MATE.

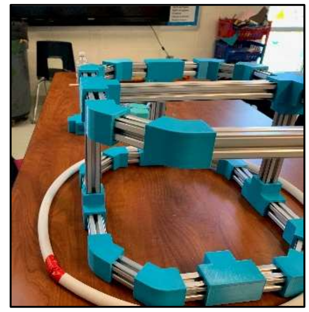


Figure 4: 3D-Custom Frame

Tether

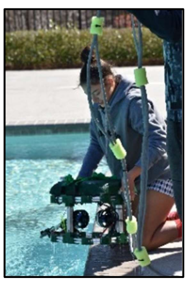


Figure 5: Tether

The tether is 15 meters in length, with an ROV circumference of 6cm and the camera tether has a circumference of 4cm. It consists of a gray mesh covering three groupings of wires from the control box to *Crush* itself. In each group of wires is found eight multicolored wires. The ROV required for the payloads, twenty-four wires, and the wires were braided together into three groups forming the tether. In total the tether circumference is 7cm.


Figure 6: Tether Restraint

Camera

Placed on the ROV were three 1200TVL underwater fish cameras for superior image clarity. Each camera has 12 super bright LED lights for night vision and areas with low light. The cameras measure 7cm in length, 3 cm in height, and has a 15-meter tether. The first camera is mounted to the front top portion of the frame with a tilt mount allowing the pilot to clearly see the manipulator and forward motion of the ROV. The baseplate camera allows the pilot under the ROV to complete missions such as the transect line during the autonomous mission on the coral reef. The third camera is mounted on the side of the ROV to allow for images to be captured and stitched together during the subway car autonomous mission. These cameras are


Figure 7: Control Box

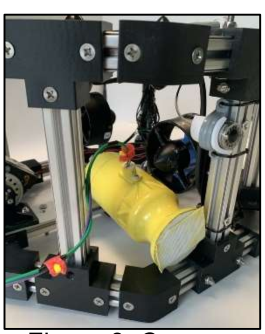


Figure 8: Camera

strategically placed on the ROV frame to assist in completing the missions successfully and allow to pilot to be able to see around the ROV from multiple sides.

Innovation

The frame is octagon in shape with two up/down thrusters mounted to the center bar and the two forward/backward thrusters mounted to each side. The frame is built using 2.54 cm by 2.54 cm aluminum bars. The aluminum framing was chosen for the grooves in the design of the bar. These grooves allowed for smoother movement and easier attachment of the different payloads. The frame is 24 centimeters in height, 41 centimeters in length, 35.5 centimeters in width, and weighs 4.53 kilograms. The aluminum bars are connected by custom 3D printed connector pieces. Although, this took more time than expected, it saved us money and helped to create a better ROV.

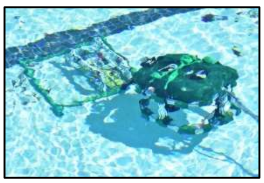


Figure 9: ROV

A custom program was created to use a mix of C++ and Python code languages that work in harmony to allow for solid output. A graphic user interface (GUI) was used to access the various codes to accomplish the missions such as the subway car and determining the health of the coral reef.

Systems Approach

Vehicle Structure

We decided to use aluminum framing and 3D printed joints over PVC because it looks more dynamic and would allow for improved areas to mount payloads on the ROV. For instance, three cameras were mounted to accomplish the missions involving the coral reefs, the subway car, and in general guiding the movement of the ROV. The arm is mounted onto a frame-mounted sliding mechanism that allows for protection and storage during transportation.

The aluminum framing is more expensive and increases the ROV’s mass. The company adjusted the design to accounted for this by using a polystyrene foam mixture to create a highly buoyant turtle shell reducing stress that the thrusters may experience during various missions, such as bringing the full eel trap to the surface.

Vehicle Systems

The first mission: Ubiquitous Problem of Plastic Pollution, involves the ROV needing to remove pollution from the surface (ping-pong balls), the Seabin, plastic from the bottom or the ocean, and releasing fishermen’s ghost nets. A net was created to gather ping pong balls from the water’s surface, and the manipulator holds the net while gathering the items. The manipulator can remove the power connector from the Seabin, retrieve and replace the mesh catch bags, and reconnect the power connector. Additionally, the arm can retrieve the plastic bag from the bottom of the ocean and release the pin from the ghost net. Shrouds have been attached to the front and back side of each thruster to help prevent items such as the ghost net from being sucked into the thrusters causing damage to the ROV and decreasing its functionality.

The second mission: Catastrophic Impact of Climate Change on Coral Reefs, requires flying over the coral reef using image recognition to determine the health of the colonies, transplanting coral from the nursery to the reefs, culling sea stars, and collecting sponge samples. Cameras attached to the ROV in multiple locations help accomplish the various aspects of the mission. The bottom camera gathers data on the different marine species within the reef by captures images as it flies the transect line. The top camera and manipulator cofunction to help to remove the invasive species of sea stars from the reef and gathering sponge samples for pharmaceutical research.

The third mission: Maintaining Healthy Waterways, includes gathering sediment samples to analyze contaminants, estimating mussels within a mussel bed, removing eels from the ecosystem, and creating a photomosaic of a subway car to create an artificial coral reef. The micro ROV and reel will gather the sediment sample from the pipe and identify the contaminant. Next the manipulator will carry the quadrat to the mussel bed, and using the cameras allow for an accurate count of the mussels to estimate the total mussels in the bed and their filtration rate each hour. The manipulator will also remove the full eel trap and replace it with an empty one, and the multiple cameras will capture photos of the subway car and allow for a mosaic to be created.


Figure 10: Robotics Room

Control/Electrical Systems

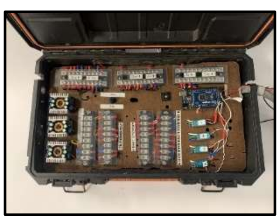


Figure 11: Labeled Control Box

Control box is the communicator between programming and our ROV during the missions. The tether connects the ROV to our surface control box where the kill switch holds the life of our whole operation. Power is first directed to our twelve-volt power bus, where it is then distributed to three separate step-down transformers or voltage regulators to transfer those twelve-volts into 7.4, 6, and 5-volts. After voltage is regulated, it travels back to our remaining power buses, each one connecting to our four signal buses. Wires from the tether connect to the opposing sides of the signal buses allowing the power to reach the necessary requirements on the ROV. In addition, the control box holds a four-way USB video splitter for our three onboard cameras. Another component that our control box powers is four Electronic Speed Controllers (ESCs). The ESCs provide information (power and signal) to each of


Figure 12: Control Box

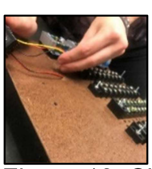
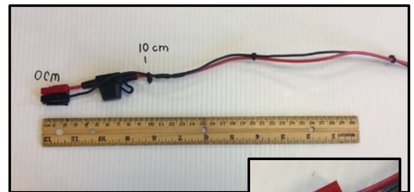


Figure 13: Signal Bus

our thrusters. Overall, the “brain” of our ROV, Crush, has three power buses, four signal buses, three step-down transformers, four ESCs, one Arduino IDE, and one kill switch.

Anderson connectors were used because of their ease in connecting multiple wires securely and allows for a quick disconnect from the power supply if an electrical problem were to occur. It connects the wires from the control box to the power supply and includes a fuse that is within the 30cm requirement from the connection.



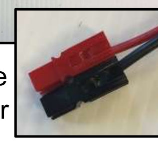


Figure 14: Connector and Fuse
Figure 15: Anderson Connector

Programming

Crush is piloted using various code created in both Arduino and Python programming languages. Arduino was used to send the required signals within the control box to allow the ROV to move and complete the various missions. Python was used to read the data from joysticks and convert it so that it may be read by the Arduino via a serial communication line. Python was also used to create a custom graphical interface (GUI) which allows us to run the various programs required for the autonomous tasks such as the transect, subway car, and image recognition missions.

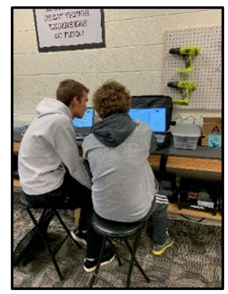


Figure 16: Programming Tutorial

The autonomous transect code was created to fly the ROV above the transect line while remaining at the same height. This was accomplished by measuring the distance from the pool floor to the onboard camera and adjusting vertically to keep the ROV at the appropriate height as the ROV moves horizontally over the transect line, stopping when the end of the transect line is reached.

The program for the subway car task was created using image stitching to create a complete photomosaic of a submerged subway car. The code first pulls images that have already been taken and cropped by the pilots of the ROV and resizes them to the appropriate height and width to be stitched together. The program then stitches both the top and bottom rows of images together to form two images which are then stitched on top of each other to form the complete photomosaic which is then displayed on screen.

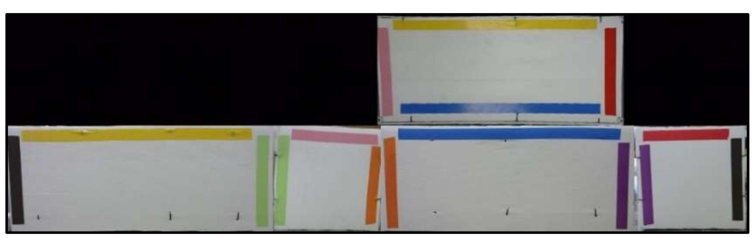
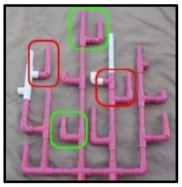


Figure 17: Subway Car Photo Mosaic



The image recognition program was created to compare an image of a coral reef from the previous year to an image of the current coral reef. After the pilots take a picture of the current coral, the code compares the current image to the image from a year ago. The code then outlines any areas of change that it has successfully identified.

Figure 18: Coral Health Assessment

Thrusters

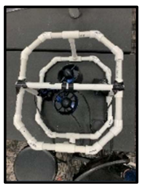


Figure 19: Model Frame with Thrusters

Crush is mounted with the same T-100 thrusters as last year's ROV because of its success, and it draws less amps than the T-200 thrusters. We have a total of four thrusters. Two of the thrusters are mounted on the top bar of the ROV for vertical maneuvering. The other two thrusters are mounted on the two side bars for horizontal movement. When deciding the best placement for the thrusters, we decided to place them on the inside of the ROV, remaining within the size requirements, protection of the thrusters, and quick directional changes.

Figure 20: Thruster

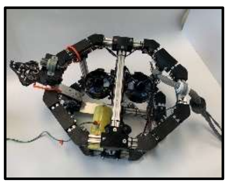


Figure 21: Frame and Thrusters

Buoyancy

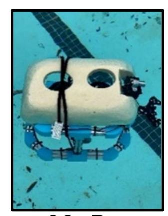


Figure 22: Buoyancy

The buoyancy of an ROV is vital in the completion of the competition as the company needs to be neutrally buoyant to complete the tasks given. We decided to use polystyrene foam to create the buoyancy by mixing part A and part B into a mold and then shaping it into a turtle shell buoyancy. As our company's logo and ROV name represents a turtle, *Crush,* the design was made to look like a turtle. This is attached to the frame using bolts and repurposed plastic dividers into straps to secure the buoyancy. Payloads and Tools

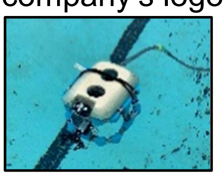


Figure 23: Original Buoyancy
Figure 24: Turtle Buoyancy Design

Micro ROV

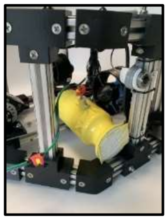


Figure 25: Micro ROV

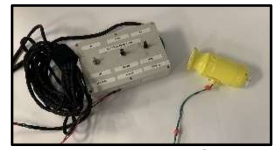


Figure 26: Micro System

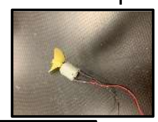


Figure 27: Micro Propellor

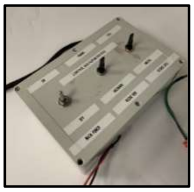


Figure 28: Control Box

The Micro-ROV, Squirt is made from a recycled plastic water bottle. Our first prototype consisted of a metal mesh torpedo, and two cylindrical plastic containers. The water bottle was the best option as it can easily fit all parts necessary inside and it was the lightest. The dimensions are 19 centimeters long and 6.3 centimeters in diameter. The fundamental purpose of the Micro-ROV is to go down a drainage pipe that is 3.2 meters long. At the end of the pipe, it will collect a 1-inch PVC pipe sediment sample. Our 3V Hobby Motor 6600 RPM has a plastic propeller attached at the end to help it speed through the water, and a Velcro piece attached to the front to assist with the sediment sample retrieval. The Micro-ROV is powered by a separate control box, with a 15-meter tether, that will be recoiled around the reel on the ROV.

Figure 29: Tether Restraint

Payload Tools

Manipulator

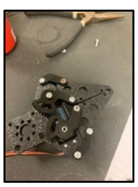


Figure 30: Claw


Figure 31: Building the Arm

The manipulator consists of a claw, two servos, rotation, and a tilt mechanism. The manipulator measures in 24.89 centimeters long and 11.43 centimeters tall and is mounted in the front of the ROV allowing the pilot to maneuver the manipulator in the view of the top camera to complete the missions effectively, without error. The company chose to use two Savox servos to operate the gripper and tilt mechanism. Allowing the manipulator to move up and down when completing the tasks. The company selected to purchase the gripper and tilt mechanism that was used to assemble the manipulator instead of 3D printing, due to time constraints and printer back-log at the time. An aluminum bar was used to attach the gripper to our tilt mechanism, ensuring that the manipulator did not extend to far out of the ROV frame and would not violate size requirements.

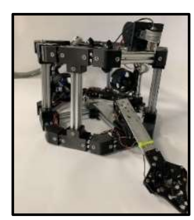


Figure 32: Manipulator

Seabin

Our Seabin is a 5-gallon Home Depot bucket with a ½ inch PVC frame secured inside it. We have a 3-inch PVC pipe sticking out of it to act as our power port, and we also have a brick tied to the bottom of it to add extra weight to sink it. We built an 18cm power connector to put in the power port so that we can power the indicator light when placed correctly. A 5-amp fuse was used with in the power connector. The ROV is required to descend to the Seabin and replace the old power connector with the brand new one. It then must take out the old mesh bag and put a newer one in. We need the Seabin to clean up waste in the Ocean so we can have cleaner waters.

Figure 33: Completed Power Connector

Figure 34: Power Connector

Ping Pong Retrieval Tool

The ping pong retrieval tool was a payload designed early on that was made with PVC framework and was entirely too large and far too heavy for our claw. Later in the season, we redesigned the payload to have a 3D printed frame that is attached to a CVC pipe in which the ROV will hold to scoop the ping pong balls. Within the net, there is a circular disk that goes around the middle of it. This was purposely put into the design so that once a ping pong ball goes into the net, it is unable to fall out.

Figure 35: Ping Pong Net

Figure 36: Gripper Coated Handle

Figure 37: Quadrant

Mussel Bed Quadrant Tool

The mussel bed quadrant is used to estimate the number of mussels in the mussel bed. This payload is a 50cm x 50cm PVC quadrant. Our ROV brings the quadrant down to the muddle bed and places it onto the bed. Once this task is completed our company must count the number of mussels in the quadrant area and use that combined with the dimensions of the mussel bed provided to calculate the total amount of mussels inside the bed. We will also be provided with the mussel filtration rate and use the data gathered to determine the total amount of water filtered by the mussel bed.

Build vs Buy Components

One major decision that our team had to make at the beginning of the year was whether we wanted to build most of our robot or buy parts to construct the ROV. Some items needed to be bought such as the manipulator, aluminum framing bars, color image with LED light cameras, filaments, and smaller items to complete the ROV. 3D printed corner and connector pieces of the frame were designed and printed using the 3D printer. Our team also used a thin aluminum bar to connect the grip mechanism of the manipulator to the tilt.

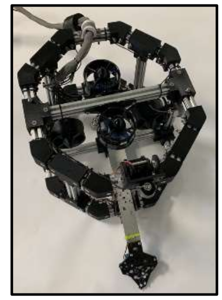


Figure 38: Build vs Buy Components

New vs. Reused Components

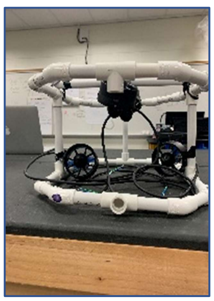


Figure 39: Reused Thrusters

This season we decided to reuse four T-100 thrusters from previous company ROV’s. During the testing phase outside of the pool, one of the thrusters stopped working properly. This meant we needed to replace this thruster; however, the company who manufactures this type of thruster had retired the T-100 model. We then reused one more T-100 thruster from one of the previous ROVs. The box used for the control box was also reused from a previous team. These two decisions were made and were the more cost effective for the company budget.

As a company we tried to model environmental responsibility and reuse where possible, buy components that are environmentally friendly, and decrease possible waste.

Company Safety Philosophy

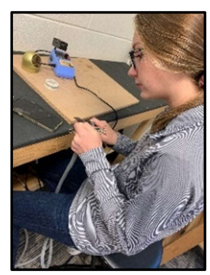


Figure 40: Safety while Soldering


Figure 41: Safety

At Sea Life Technologies, we strive to make safety our top priority. Students' safety comes before everything else to ensure no injuries occur. Some examples of precautions we use when working with equipment is always wearing safety googles to block small objects, such as metal shavings, so they do not enter the eyes. We also have a plastic sheet that protects people in the same room who are not working with machines. To make sure that we are working safely and swiftly, we always have a teacher or mentor in the room. To ensure proper use of devices, we have an older member model the first time use of any heavy machinery to new members and supervise students until the new members demonstrate proper use and then can use the equipment individually. In accordance with the CDC guidelines masks were strongly encouraged to be worn, stay home if exposed or feeling sick, and maintain social distance as much as possible. Within our company we aim to create a safe environment for all members. These are some other examples of the rules we instituted to keep our company's employees safe.

Hazard	Safety Precaution	Reasoning
Debris can get into the eye from using carious tools needed to work on the ROV.	Safety Goggles	The goggles, when worn properly, can help reduce the chances of having harmful debris in the eye(s).
Incorrect use of power tools can lead to injury of oneself or others.	Proper training	Proper training on the equipment from a mentor. Be sure to keep the safeties in place until ready for usage.
Serious burns or injuries from soldering irons.	Proper placement and training	Proper use of the soldering iron and returning the soldering iron to the holder to keep from accidental burn.
Respiratory and eye irritations from chemicals.	Safety goggles and proper ventilation	Use glue (PVC pipe and epoxy) and paints in well ventilated areas to prevent eye and respiratory irritants.
Serious injury or drowning from falling into the pool.	No running, keep all electrical equipment away from the water, and pay close attention to all wiring.	Exposed wiring can send electrical currents through the water, causing electrocution. Once can slip and fall when running around the pool and can cause serious injury or possible drowning.

Testing and Troubleshooting


Figure 42: Original SLT Company

An early challenge during the building process was the design and construction of the frame. The first set of 3D printed joints were printed with measurements that were larger than the aluminum framing 2.54cm square ends. The novice engineers assigned to framing were unfamiliar with Solid Works and did not fully understand the relationship between the needed measurements for the frame pieces and scale within Solid Works. This set the company back

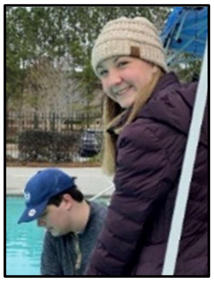


Figure 43: CEO Poolside

several weeks in completing the frame, but our frame engineers were able to learn, make necessary adjustments in Solid Works, and finalize the joints for printing.

Initially identifying the Arduino pin numbers so we could successfully send signals from the code to the ROV. Some of the pins were misplaced within the Arduino and it took lots of testing to rewire and understand which wire went to each pin number. We also had to change the way we connected the Logitech Extreme 3D Pro Joysticks because Arduino cannot process images. This meant we had to alter the code to operate the joysticks and the mounts had to be modified for better camera functioning and use. While testing the control box we had to rewire a few wires because they were not connected correctly.

While testing the thrusters we discovered one of the thrusters was defective, not responding and was quickly replaced. There was also an electrical issue that we had to locate and correct for the thrusters to operate. After multiple testing phases we fixed all our surface level issues and moved on to testing in the pools.

Figure 44: Mission Practice

The original buoyancy had to be replaced as it cracked and began absorbing small amounts of water during the pool practices, effecting the buoyancy, and putting strain onto the thrusters. It has been replaced with a more durable material that is not water absorbent.

During mission practices in the pool several of the 3D printed joints cracked due to stress and weight of the payloads attached to the frame. This required us to reprint the joints and reconstruct the frame. The newly printed frame pieces are larger in size, thicker in width, and the aluminum bars meet within the joints. Screw holes were preprinted within the pieces to prevent cracking when securing joints to the frame. This allowed for greater strength and stability throughout the frame.

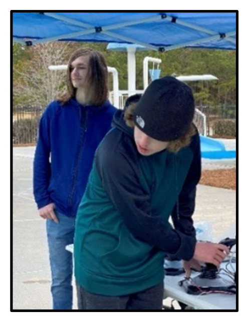


Figure 45: Mission Practice

Reprinting the pieces created a secondary issue where the ROV manipulator extended beyond the allowed frame size. Therefore, we added a sliding mechanism to be able to move the arm backwards and forwards as needed. This also protected the manipulator and claw from damage during transportation and storage.

Figure 46: Company Member

Unfortunately, we were unsuccessful in getting the micro ROV and reel to correctly work during earlier pool practices. This led to several of the engineers working together to create a design that was better suited to carry out the missions. This improved the design by decreasing weight, and drag, improving the water flow through and around the micro ROV.

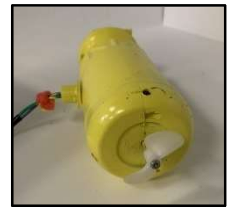


Figure 47: Micro ROV

Our company, as well as the entire world, experienced unprecedented times during the Coronavirus Pandemic shut down and quarantine during the spring of 2020. This resulted in our school and program being shut down. We were disappointed when we learned the MATE ROV competition in Savannah for 2020 had been cancelled. Thankfully, during the fall of 2020, Robotics was able to begin meeting again and continue working on the ROV.

Budget

Sea Life Technology is a company that relies solely on fundraising, donations, and members fees. SLT operates on a strict budget and cannot afford to waste or misuse funds due to errors in design practices or electrical malfunctions. The company met at the beginning of the build year, assessed what the new MATE competition requirements stipulated, what the ROV would need to complete the missions effectively, and what materials were already available on hand to reuse saving costs and minimize waste. All purchase requests are submitted by each engineering department, agreed on as a company and then approved for purchase. Receipts are collected and documented, allowing the company to keep track of expenditures and to avoid overspending. The company collected $2,300.00 to start the 2019-2021 build year, allowing $200.00 for contingencies such as thrusters or servos needing to be replaced. The ROV total expenses for the 2019-2021 year totaled $2,095.47. This left the company with a surplus of $204.53 to be used if needed.

Figure 48: Sea Life Technology Company Members

References

Blue Robotics. (2019, August 9). *T100 Thruster Usage*. https://bluerobotics.com/learn/t100-thruster-usage/

MATE Center & MATE II. (2020, October 27). *2021 Ranger Competition Manual*. MATE ROV Competition. https://files.materovcompetition.org/2021/2021_RANGER%20Manual_27Oct2020.pdf

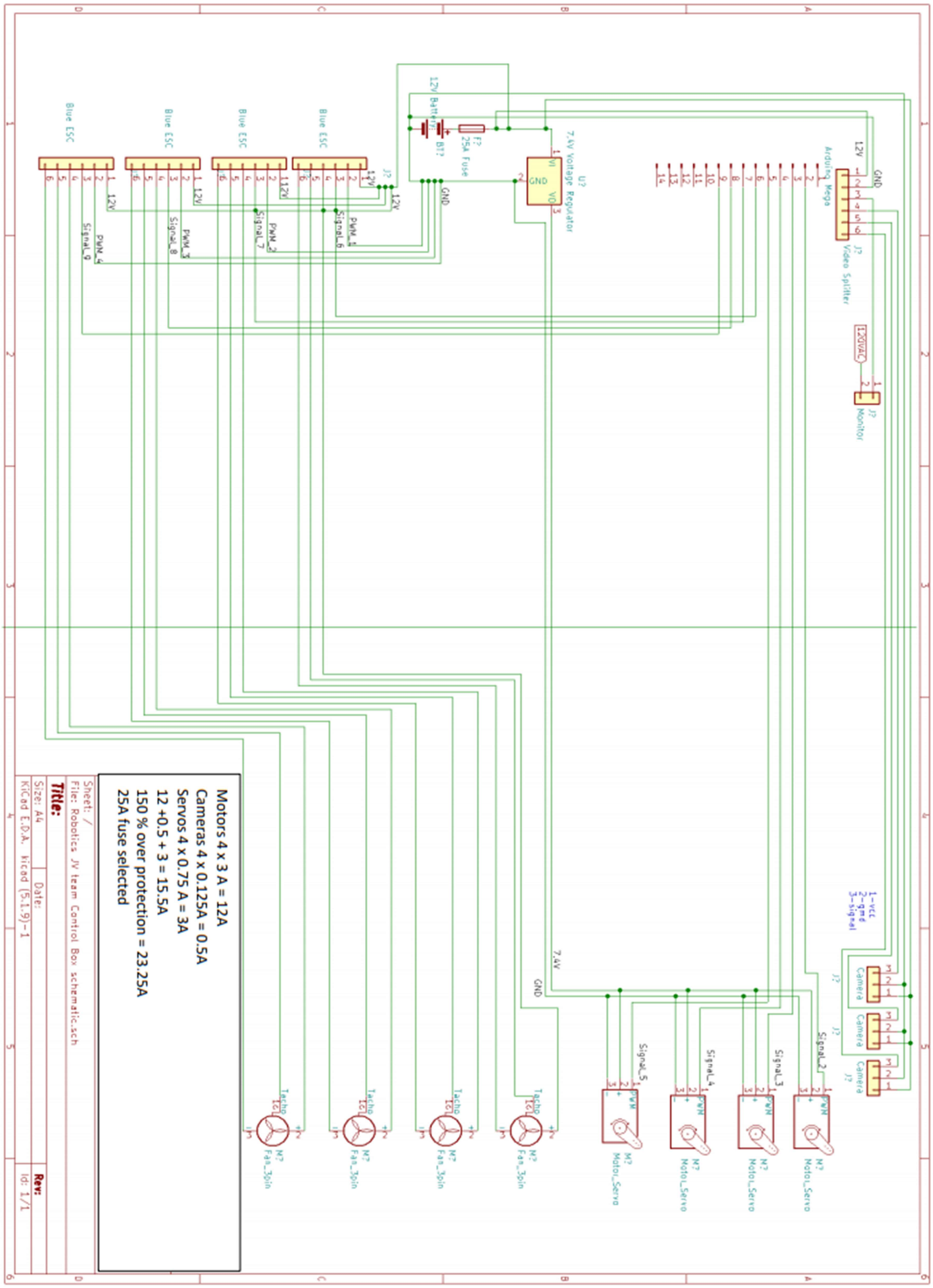
Acknowledgements

Over the past two years as we have prepared for the 2021 competition individuals and businesses have provided support to our team through donating money, time, and expertise. North Paulding Robotics JV Ranger team would like to thank the following for their continuous help and support.

- MATE ROV Competition for hosting our company.
- Gold Level Financial Sponsors:
  - Earnst & Young (EY)
  - Evans Structural Engineering Inc.
  - Deka Batteries
  - BLD Rolloff Containers
  - Floor Décor & More
  - Think GA Homes
- Financial Sponsors:
  - OCH Construction & Remodeling Inc.
  - Pearson Packaging Systems
  - Quality Cuts Complete Lawncare, LLC.
  - RE/MAX Unlimited
- Mentors:
  - Glenn Lewis for technical and mechanical support.
  - Michael Lees for coding for the ROV and Solid Works 3-D Printing Software program and design tutelage support.
- Parents of company members who aided with snacks and transportation for our weekly meetings.
- Mrs. Lees, Mrs. Anderson Fritsche, Mr. Gardner, Mr. Loomis for continuous help and support.
- Senators Ridge for allowing us to use the pool to prepare for the competition.
- Longhorn Steakhouse and Out of Town Orders for fundraising events.

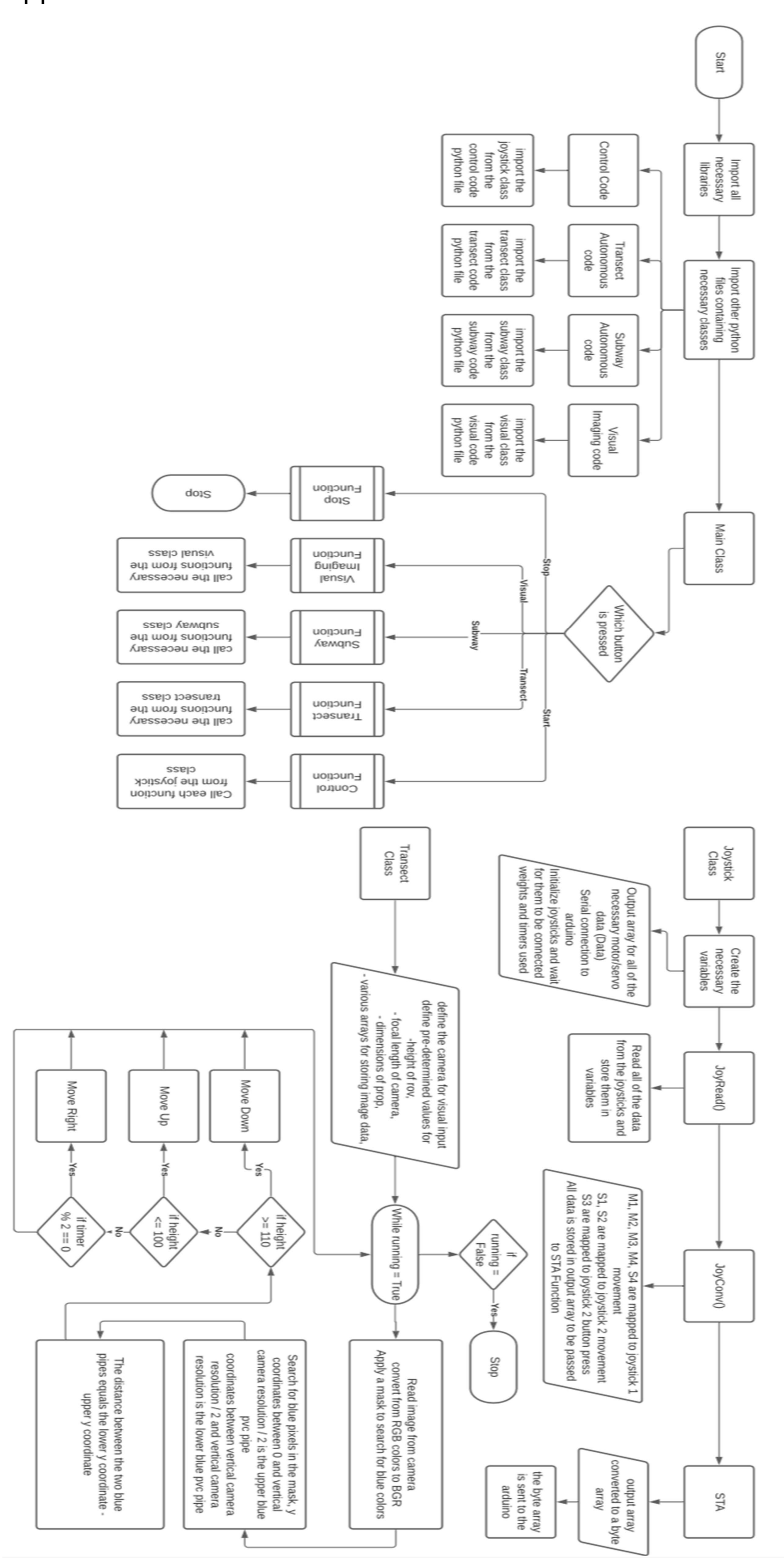
- MATE 2021 Challenge Sponsors: Monterey Bay Aquarium Research Institute (MBARI), Microsoft Azure, National Science Foundation (NSF), Bulgin, National Marine Sanctuary Foundation, Parley and Coral Morphologic.

Appendix 1: SID Main ROV



North Paulding High School
Sea Life Technology
SID

Appendix 2: Flow Chart



Appendix 3: Budget
Figure: Project Budget Table

Company Name:	Sea Life Engineering	Reporting Period	From:	01/10/2020
CFO:	Genevieve Lang		To:	01/05/2021
Income				
Source				Amount
Fees				$1,800.00
Fundraiser				$250.00
Donations				$250.00
Total Income:				$2,300.00

Figure: Project Costing Table:

Company Name:	Sea Life Engineering	Reporting Period	From:	01/10/2020
CFO:	Genevieve Lang		To:	01/05/2021
Category	Type	Quantity	Amount	Running Balance
Control Box				
Case and base plate	Reused	1	35.00	0.00
Arduino	Purchased	1	15.99	15.99
Bus bar	Purchased	3	18.00	33.99
ESC's	Purchased	4	100.00	133.99
Transformer	Purchased	2	23.98	191.94
Wire 16, 18 AWG	Purchased	8 rolls	45.00	236.94
Manipulator				
Savox SW servo	Purchased	3	269.97	506.91
Tilt mechanism	Purchased	1	45.00	551.91
Claw	Purchased	1	13.00	564.91
Pilot System				
Logitech controllers	Purchased	2	68.00	632.91
TV	Purchased	1	120.00	752.91
Laptop	Purchased	1	650.00	1402.91
Buoyancy				
Polyurethane Foam	Purchased	2	86.58	1489.49

Paint	Purchased	1	3.99	1,493.48
Frame				
Aluminum channel	Purchased	10	179.99	1,673.47
Nuts and bolts	Purchased	5	35.00	1,708.47
3D connectors	Printed	17	45.00	1,753.47
Tether				
8 stranded 16 AWG	Purchased	1	120.00	1,873.47
Techflex cover	Purchased	1	35.00	1,908.47
Cameras				
Fish finder cameras	Purchased		76.00	1,984.47
Tech flex covering	Purchased		30.00	2,014.47
Micro ROV				
3D printing material	Printed		25.00	2,039.47
Motor	Purchased		7.00	2,046.47
16 AWG wire	Purchased		14.00	2,060.47
Ping Pong Device				
3D printing material	Printed		15.00	2,075.47
Netting	Purchased		10.00	2,085.47
Quad payload				
1.27cm PVC	Reused		7.00	2,092.47
90^0 connectors	Reused		3.00	2,095.47
Total				2,095.47