# OOSTBURG ROV

## Technical Report

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TABLE OF CONTENTS

## Abstract

Oostburg ROV is an ROV Company composed of 30 students (19 attending the MATE International Competition) from Oostburg High School. Our company's mission is to create a world-class ROV and high-functioning engineering business while forming external connections and internal relationships with our high school company members solely completing all tasks Initially, our company split into two main groups: business and engineering. Some of the tasks completed by the business team include the following: establishing a budget, connecting with sponsors and community organizations, and sending out a weekly update. Our engineers began by reviewing and writing code, building the frame, and designing tools. Throughout the year, our company members displayed a high level of professionalism and a readiness to step out of their comfort zones in order to build the best company. This year, we decided to carry on the idea of having team leaders because we found it to be effective and beneficial for our company as a whole. These nine leaders had individual meetings prior to the practices every week to discuss progress, timelines, and goals. This setup increased the flow of communication and made it easier for all the groups to work with each other effectively. Currently, we have completed 20 practice runs which allow us to make modifications to the ROV. Our company has confidence in its function and the amount of time spent practicing to say that we are ready to offer our best services to the Eastern United States.

## Corporate Profile

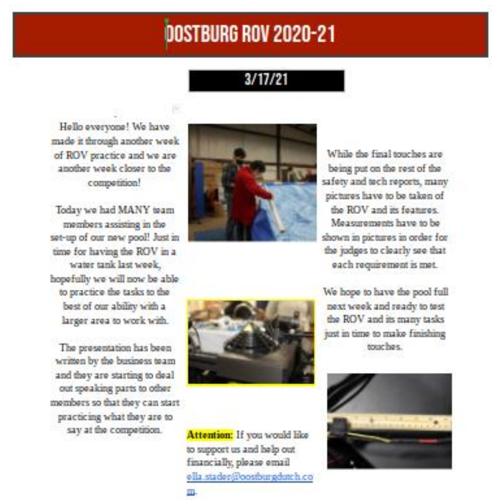
The Oostburg ROV Company is organized into two main departments in order to increase efficiency and communication. These departments, business and engineering, are subsequently separated into sub-teams. The engineering department is divided into four teams which include mechanical engineers, software engineers, tooling engineers, and electrical engineers. The business department is divided into marketing, technical writing, presentation, and accounting.  Each of these departments is managed by a student leader who is responsible for the productivity and quality of each project. The Chief Financial Officer (CFO) oversees all budgeting, purchasing, and accounting, and the Chief Executive Officer (CEO) is responsible for productivity and quality within the entire company. All in all, departments work together to create the highest functioning company with WALL-E, our robot, at the core of the team. The Oostburg ROV Company has devoted time, energy, and resources to help clean up the garbage that is polluting the oceans around the world. To stop the global issue of pollution in the oceans, our company took it upon ourselves to create a world-class robot that will solve various tasks underwater during the MATE Competition.

## Corporate Responsibility (Community Outreach)

Our business department has organized several events for community outreach, including mentoring our middle school company. Helping them understand how the ROV functions is key to the current and future success of our company. Our high school newspaper called *The OH-Say* featured two articles on the ROV team. With these articles, we could inform other students about ROV and convey our company's mission. Presenting to our school board was a unique opportunity to update them on what students are learning in ROV and how it has made an impact on our lives. In addition, we are working with our local newspaper, The Sheboygan Press, and they are working with us to write an article about the ROV team. Lastly, our marketing outreach coordinator created a pamphlet to distribute to companies in the community to educate them on our company.

## Communication

Our company understands that being large is our greatest strength and potential weakness, so our business department implemented three different strategies to increase communication between departments. First, we mounted a large whiteboard to our workspace wall to keep track of important announcements, deadlines, and brainstorming ideas. Displaying our tasks on this board significantly increased our productivity. Second, our company departments regularly use Facebook Messenger to communicate with each other about task-specific details and deadlines. This allows different teams to communicate easily without having to spend a significant amount of time making sure each member was informed of recent updates. Third, we communicate using a shared Google spreadsheet. This spreadsheet includes names, emails, deadlines, project notes, and other information that is needed during our season. Keeping our community sponsors, parents, and interested parties regularly updated is an important part of our business model. To accomplish this, weekly newsletters highlighting accomplishments and new updates were distributed.



OOSTBURG ROV 2020-21

3/17/21

Hello everyone! We have made it through another week of ROV practice and we are another week closer to the competition!

Today we had MANY team members assisting in the set-up of our new pool! Just in time for having the ROV in a water tank last week, hopefully we will now be able to practice the tasks to the best of our ability with a larger area to work with.

The presentation has been written by the business team and they are starting to deal out speaking parts to other members so that they can start practicing what they are to say at the competition.

While the final touches are being put on the rest of the safety and tech reports, many pictures have to be taken of the ROV and its features. Measurements have to be shown in pictures in order for the judges to clearly see that each requirement is met.

We hope to have the pool full next week and ready to test the ROV and its many tasks just in time to make finishing touches.

**Attention:** If you would like to support us and help out financially, please email ella.stader@oostburgdutch.com.

Figure 1: Oostburg ROV Newsletter

Figure 2: Oostburg ROV Company

## Design Rationale

### Design Theme

This year we made it one of our priorities to create a cohesive theme. The theme we pursued was “eliminating pollution to keep the environment, specifically the waterways clean.” Climate change and plastic pollution have plagued the planet for over a hundred years. The rivers, lakes, oceans, and waterways are being filled with immense amounts of plastic debris, causing water temperatures to rise, and damaging the health of coral reefs. Tennessee and the Delaware River and Bay are located in the Eastern United States and is a victim of these unhealthy waterways. Our ROV Company has focused on the remediation and cleaning up of the existing problems. With the task-specific tools on our ROV, we address the large impact of the cleanliness of the waterways and promote nursing marine life back to health. Using a high-tech gripper system, our ROV can remove debris samples and identify sediment samples. The ROV also contains a Garbage Collector that will remove six items of debris from the waterway. A second micro ROV will be used to retrieve and analyze a sediment sample from the waterways for hazardous chemicals. Our research towards removing plastic debris and identifying hazardous chemicals helps scientists make the best plan of action on how to keep waterways clean. In doing these things, we will be able to contribute to keeping the environment safer and healthier to better the Earth for future generations.

## Frame

In our 2020 season, our frame was completely reengineered with significant upgrades including reinforced 3D-printed corner shrouds, T-slot cross bracing, and hydrodynamic thruster guards. Because our 2020 season ended early due to COVID-19, we will utilize the newly upgraded and functional frame again. The final design also incorporates the motor shrouds to support the dry housing and frame corners. The dry mass of the bare frame is 2.13 kilograms which is 1.4 kilograms less massive than our frame from last year. The final mass of the completed ROV is 15.5 kilograms.

The dimensions of the frame are 40 cm wide x 40 cm deep x 27 cm tall and take up a total area of 43,200 cubic cm. Our engineers constructed the frame from size 10 plastic 80/20 because it is versatile and waterproof with a density near neutral buoyancy. This 2.5 cm x 2.5 cm plastic 80/20-type T-slot material is efficient because it easily allows tooling and cameras to be attached anywhere within the T-slots. The plastic 80/20 is also superior because it has a density of 1.05g/cm, rendering it significantly smaller than the traditional 3.7 g/cm aluminum.

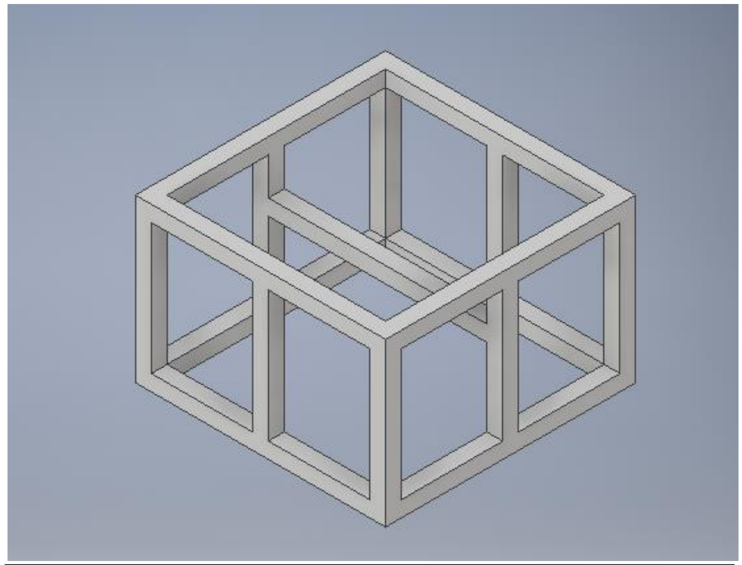


Figure 3: CAD Drawing of Frame

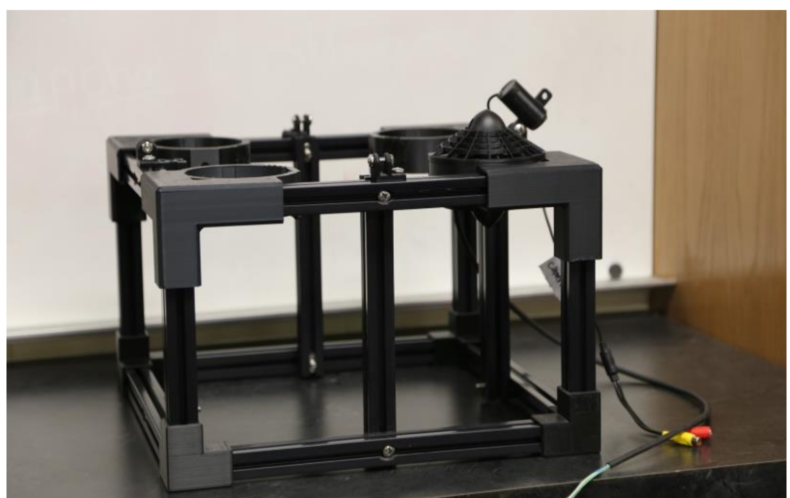


Figure 4: Final Frame

## Dry Housing


Figure 5: Dry Housing

The dry housing is an essential component of the ROV, providing both buoyancy and protection for underwater electronics. This year, we upgraded our dry housing to a 4400 $cm^3$, IP68 electrical box, generously donated by Integra Enclosures. The frame engineers, considering Archimedes' principle and Newton's 2nd Law, intentionally designed the ROV to have maximum stability by placing the buoyant dry housing near the top of the ROV with heavier components like tooling and motors near the bottom. This dry housing was selected because it provides perfect buoyant force while still providing ample space for all required electronics based on a calculated value of 13 cm x 16 cm x 21 cm = 4400 $cm^3$ of displaced water providing 4.4 kg x 9.8 m/s/s = 43 Newtons of buoyancy force.  In the end, our mechanical engineers had to add 640 cubic centimeters of foam to the ROV to achieve neutral buoyancy. To check the waterproofing, our engineers successfully pressure-tested the dry housing and bulkheads at 0.5 atmospheres of pressure for 15 minutes to represent a full pool run at 5 meters of depth. In the past, the electrical engineers struggled to fit all electrical components into the dry housing in an efficient way, so our electrical engineers designed a double shelf rack for the dry housing this year to improve the organization of electrical components.

## Bulkhead Connectors

Figure 6: Bulkhead Connectors

The bulkhead connectors have an extremely important job of serving as a barrier between the electrical components and the surrounding water. They allow power and communication to penetrate the dry housing while keeping the internal electronics dry. Initial research from previous electrical engineers identified the bulkhead connectors as a weak link in many ROV systems. If the design is not *completely* waterproof, a small leak could lead to thousands of dollars in damage to the internal electronics. For this reason, our engineers partnered with SubConn in the 2020 season. Their donation allowed us to use commercial-grade 300-volt bulkhead connector series for power distribution and two micro series 21 pin connectors for communication and motor power distribution. Our engineers feel confident with using these SubConn bulkhead connectors because the application is well within the power ratings and the 2900 m working depth. These professional-grade bulkhead connectors are expensive, but SubConn has made it possible due to their sponsorship.

## Electronics and Internal Wiring

The navigational system is controlled with eight Blue Robotics Electronic Speed Controls (ESCs) powering eight Blue Robotics, brushless T200 Thrusters. Our ROV utilizes four thrusters for up and down, two thrusters for forward and reverse, and two thrusters for strafing. Together, all six thrusters at full capacity consume around 20 amps of current at 12 volts. We also are using two DC-to-DC step-down voltage converters in order to provide 5.0 volts to power the Savox SW-1210 digital, waterproof servos which we use to run our tools. We created a 3-layered circuit board that includes a top layer made up of Arduino, Arduino out pins, and DC-to-DC converters; a second layer of motor drivers, eight basic ESC's, eight Pololu motor drivers, and a third layer of input wires.

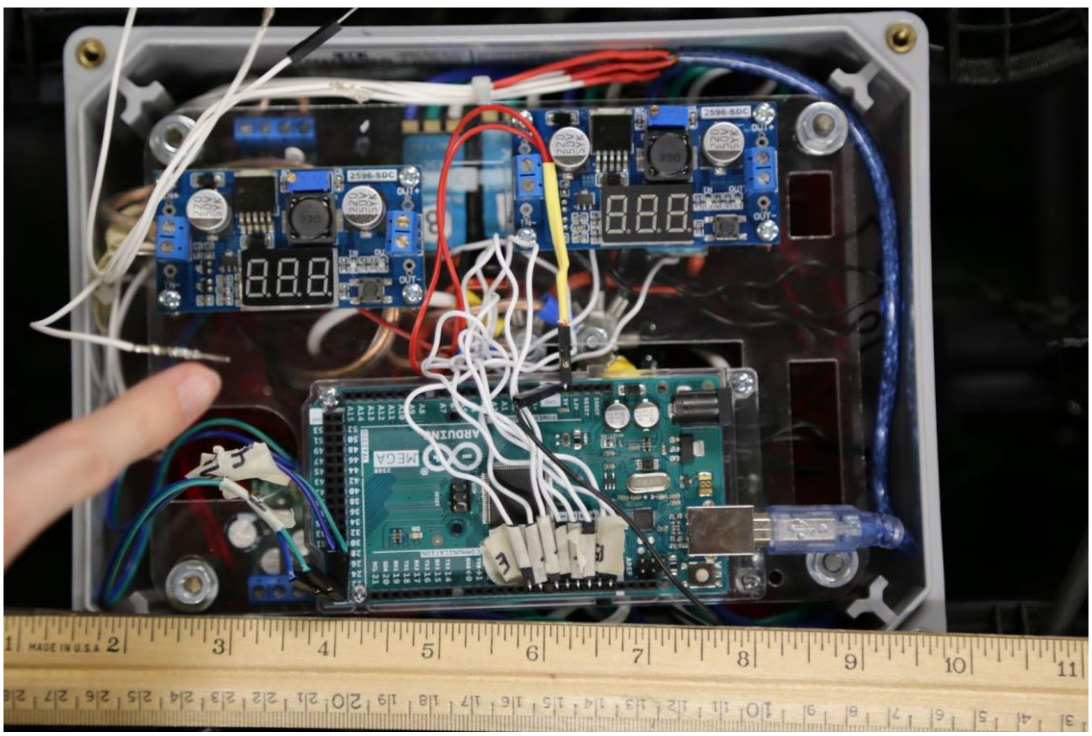


Figure 7: Wiring and Electronics Inside Dry Housing. Photo by Caris Dirkse

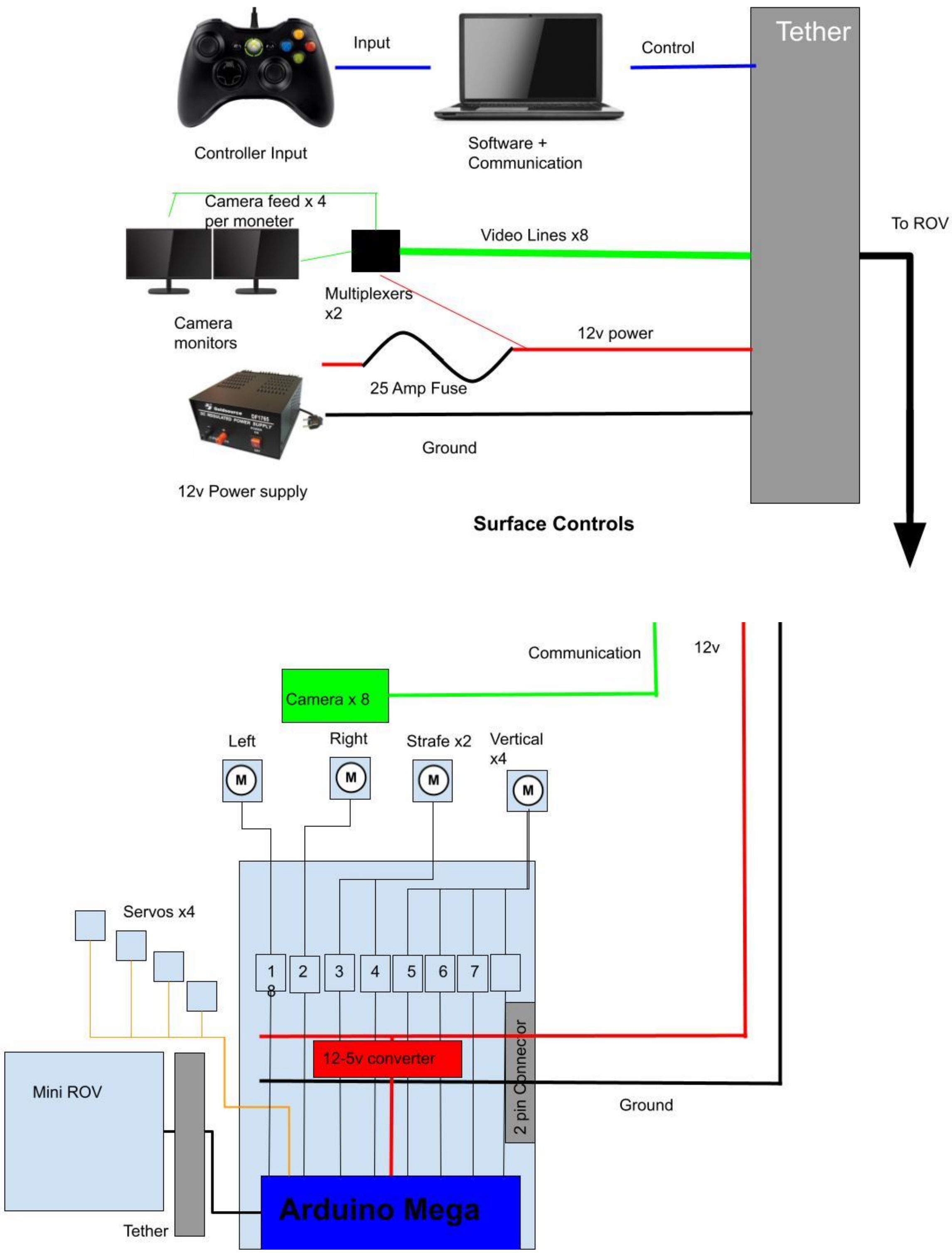



Figure 8: Electrical SID showing 25-amp fuse by Jason Becker

## Microcontroller and Software

Our engineers decided to use an Arduino MEGA microcontroller which is well known for its open-source platform. The Mega was also chosen because of its large number of both PWM and Digital pins which are vital in powering and controlling the ROV navigation and tooling electrical needs. This microcontroller is connected by serial communication through a 16.25-meter tether to a topside laptop which runs Processing, a program used to communicate with the ROV Arduino.

The ROV navigation and tooling software was written by our software engineers and operates in C/C++ and works with the JAVA-based Graphical User Interface (GUI). Because WALL-E has been completely rebuilt to include brushless thrusters and servo-based tooling, our software engineers rewrote the software code from scratch. As the code is currently written, our pilot utilizes tank steering through an XBOX 360 controller and is able to switch the “front” side of the ROV with the push of a button. We designed the ROV to have four front-facing sides which has helped to accomplish tasks quickly and efficiently. Another aspect of our ROV’s capability is the “Hover mode” which allows the ROV to actively remain in its vertical position. This is an extension that can use the information gathered from the depth sensor to automatically turn on different motors to keep the ROV flying at the same depth. Despite the Graphical User Interface being crude in years past, our software engineers have spent considerable time upgrading it to accommodate our needs for WALL-E. The GUI is Java-based, and it modifies calculations that appear on the screen of the laptop to be more user-friendly. Overall, the GUI--paired with the updated software coding--makes driving the ROV easier and more efficient.

## Tether

The tether is a 16.25-meter long umbilical responsible for transferring power, communication, and video between the ROV and topside controls. Within 10 cm of the power supply and complying with MATE regulations is a 25-amp fuse installed on the positive power, which was selected based on power calculations. The ROV uses eight 1.41-amp thrusters (11.28 total amps), eight 0.25-amp cameras (2 total amps), two 0.5-amp servos (1 total amp), and an additional 1 amp for various controls. In total, the ROV consumes 15.28 amps; and when multiplied by 150% overload, a 22.88 amps overcurrent draw is calculated**.** The multiplexers were previously potted and attached to the ROV frame which was advantageous in reducing tether size but exposed the multiplexers to failure. This season, our engineers decided to trade tether size for functionality by moving the multiplexers to the surface. Because of this change, our engineers increased the video cables in the tether from two to eight. In addition to the eight RCA video cables, the tether also includes USB communication and two marine-grade, 12-gauge, braided cables that provide 12-volt topside power to the ROV. The entire tether is organized in an expandable, mesh cable sleeve and maintains neutral buoyancy with pipe insulation. When handling tether, our protocol includes: inspecting all parts to make sure there are no fray wires and making sure the tether is laid properly (meaning not twisted). These things allow for efficient releasing and retracting of the tether from the pool.

## Propulsion

Propulsion is achieved by the Brushless Blue Robotics T200 Thruster that we purchased in 2019. The thruster body and propeller are made from tough polycarbonate plastic, and exposed metal components are made from marine grade 316 stainless steel. This allows the motor to be water-cooled to allow for safe operation for extended periods of time. There is one motor in each corner with the propellers facing up to allow the ROV to move up and down with 3 kgf. The motors next to each other spin in opposite directions in order to reduce torque on the frame. There are four more motors mounted onto each side of the frame to allow the ROV to turn and maneuver laterally. All four of these motors are mounted the same because the code we have allows for any of the motors to move the ROV in any direction.  This, theoretically, allows any side to be made the "forward" side, with the "forward" direction able to be changed while in the water. Additionally, this allows the pilot to turn the ROV at a standstill by running two motors in opposite directions. This ability to rotate the body while remaining still along the x-axis creates efficient movement for the ROV, as we can propel and steer the robot in whichever way the task at hand requires. For example, in Task 1, we are able to carefully maneuver the ROV in order to precisely remove the electrical plug and trash rack. Without this placement of motors, precise movements would be very difficult.

## Motor Shrouds

Figure 9: Right Motor Shroud

ROV navigation is achieved through input from an Xbox 360 controller. The software engineers have chosen to use a software application called "Processing" to send and receive commands from the topside laptop and Arduino microcontroller. Due to the Arduino's low current, ESC's and motor control must be used between the Arduino and the motor themselves. The Arduino sends out a PWM (pulse width modulation) signal to the ESC or motor control which boosts the current to up to 12 volts and increases amperage before sending the signal to the actual motors. The signal instructs the motors when to turn on and off (hence "pulse"). The longer the motor is instructed to be "on", the more power it receives and the faster it runs, and vice versa. The analog joysticks allow us to have a variety of speeds based on how far the stick is tilted. The left stick controls the forward/backward movement of the left side motors while the right side controls the right-side motors. The controller is able to switch the “forward” side of the ROV very easily which allows them to accomplish tasks faster. The triggers will be assigned to up and down movement. The directional pad makes the ROV multi-directional, and the ABXY buttons and back bumpers control the gripper and other tools.

## Cameras

Nothing could be accomplished in competition without the ROV’s eyes: the cameras. In 2019, the ROV was equipped with 8 Paayoo cameras. To improve last season's cameras, our engineers tested numerous cameras under 10 PSI pressure, which has not been done previously by our company. This allowed us to test the pressure the cameras would face at 25 ft underwater even though the pools WALL-E will be servicing would be at significantly less depth. We wanted to ensure that the cameras could handle the pressure and be a reliable asset to the ROV. Engineers then rated the functionality of the 12 various tested cameras to decide which cameras would act as WALL-E’s eyes. From there we ordered the highest-rated cameras to start potting and attaching to the ROV. As a result of testing multiple cameras, WALL-E’s efficient performance was guaranteed. We ordered and extensively tested CNDST CCTV ⅓ Sony HD Mini cameras. One of our engineers designed and 3D-printed waterproof housing for the cameras. From there the wires were nicked and potted with epoxy to fully waterproof the cameras. The cameras are color and have a field view of 150 degrees. We created a multiplexer box that will be kept poolside, allowing for easy exchange of RCA cords if needed. The final pieces of the camera system include two 82 cm screen TVs, a setup that allows the driver to have a 360-degree view of the pool and the tasks.

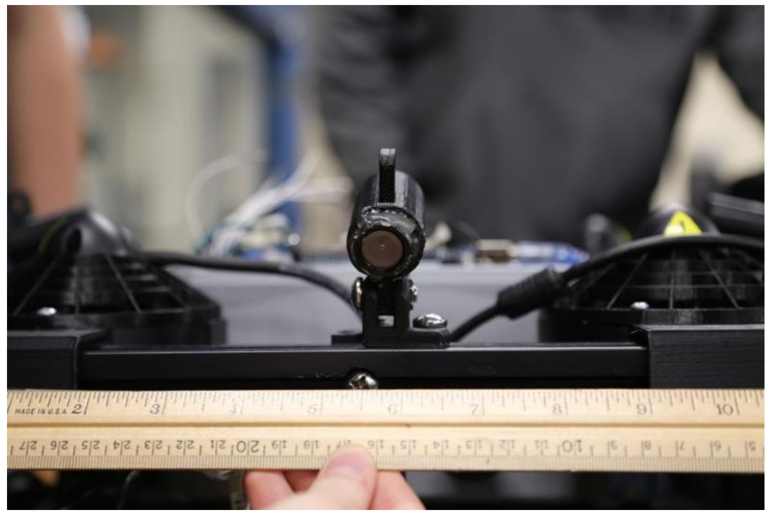


Figure 10: One of eight ROV Navigation Cameras

## Tooling

### Gripper

Our gripper from the 2020 season did not function as designed; so, we set out to redesign three new, practical designs fitted for each task. This decision was established by our tooling team to minimize grabbing difficulties as well as to provide maximum time for WALL-E's performance. Our primary gripper is fabricated for objects placed on the ground such as removing the plastic debris from the bottom bag. Our engineers used the KISS philosophy (Keep it Simple) in designing the gripper composed of two 3D printed pieces: a casing for the servo with the stationary arm and the moving arm that is directly attached to the small servo arm. With the narrow 13 cm fixed probe and a 13 cm tooth, we can successfully grab and secure smaller items. In addition, our designers constructed the gripper of PLA and Savox SW-1210 so it can lift heavy objects like the trash grate and easily hold it secure with the 68 kilopascals of pressure provided by the servo. Unique to our mechanical engineer's design this year, a uniform mounting system was developed, allowing tools to easily be switched with each other. This system works by having a magnet mounted on to the frame as well as on each gripper. It allows for a quick and easy change between grippers to efficiently complete all tasks. Our engineers altered the design to have a magnetic dual mounting system to switch out on the surface for both vertical and horizontal props. The added a servo horn on the digit 4096 servo allows for maximum security. Instead of teeth on the servo, there is a divet on both the moving and fixed probe, specifically for the PVC power connector in task one. Overall, the complex design of each gripper model is what makes our ROV as reliable as it is.

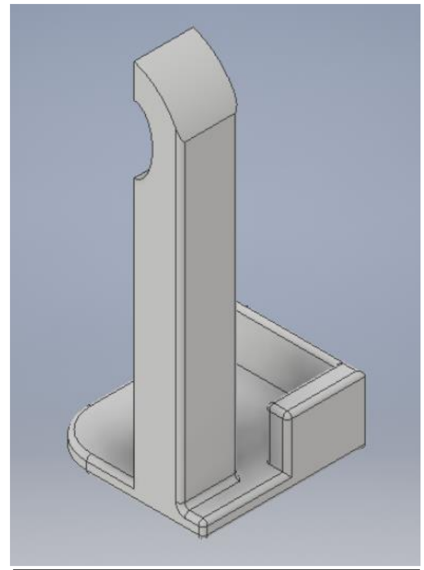


Figure 11: CAD Drawing of Gripper

### Power Probe

The power probe is the simplest yet most noteworthy tool our engineers have utilized since the beginning of our participation in the ROV program. It is a 20 cm long threaded, stainless-steel rod that is attached to the frame with the uniform, magnetic attachment system. The power probe is as trustworthy as a MATE judge and ensures components of simplicity on our complex ROV and a "safety net" to complete tasks if grippers or other tools were to fail.

## Floating Plastic Debris

The Floating Plastic Debris Extractor does not use a servo or any other electric device, allowing for a high level of functionality without raising any electrical current from the ROV. This basket-shaped contraption was designed and 3D printed with PLA due to it being lightweight as well as sturdy. The extractor also takes advantage of the physics of water as the ROV forces itself forward, Newton's third law causes the water to flow back into the gate. This results in a swinging motion as the door opens when water moves past, allowing it to collect floating debris (floating ping pong balls), ensuring a quick clean-up of the waterways.

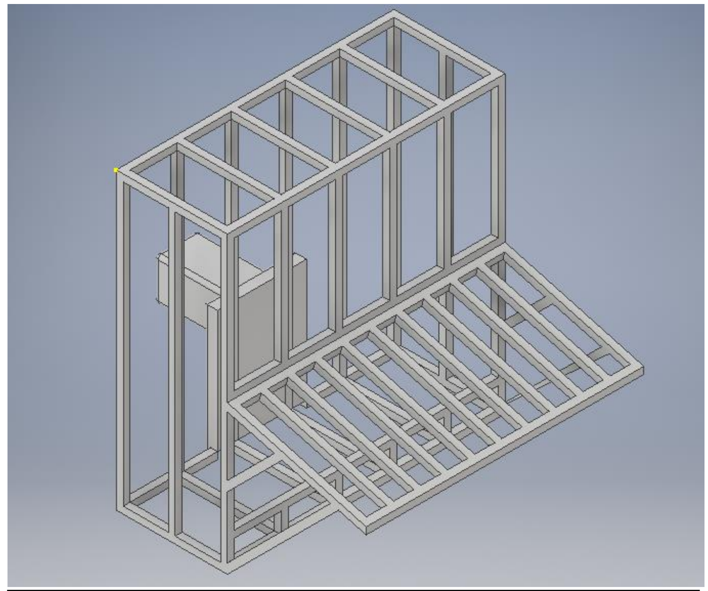


Figure 12: CAD Drawing of Floating Plastic Debris Extractor

## Coral Identification Calculations

A new challenge our company encountered this year was creating codes to map points of interest on a coral reef, as required in task 2. One of our software engineers created coding for coral identification where the image of the coral reef is scanned and different pixel ratings are compared to past data. Java and C# were utilized due to a high level of versatility and tons of information on how to properly code being at our disposal. In identifying the health of the coral colony, WALL-E limits the impact our climate has on the waterways. Although we do not have the working version of this, our team is working hard on the software, and we hope to have it functioning by our world competition.

## Micro ROV

In the 2019 season, our engineers were faced with the new and unique challenge of creating not one but two ROVs for the competition. Although the micro ROV was completed, it never made it past the troubleshooting phase, and it was not used for the actual competition. This year, to increase efficiency and functionality, our design of the Micro ROV was updated through the use of a circular frame instead of an octagonal frame, allowing it to fit inside the drainpipe smoothly. The objective of the Micro ROV is to complete task three by retrieving the sediment sample from the drainpipe to analyze if it has contaminants that could harm the Delaware River. To prepare for low light levels, the Micro ROV is equipped with a Sony CCTV Mini Camera an LED light on the front for maximum visibility. The design has an elongated laminar flow to better propel the ROV to the end of the Corex drain pipe. The final component to the Micro ROV is a micro-servo for a gripper which enhances our ability to pick up the sediment sample. We designed the Micro ROV to be as simple as possible to minimize failures while still being effective.

Figure 13: Micro ROV

## Control System and Software Coding

ROV navigation is achieved through input from an Xbox 360 controller. The software engineers have chosen to use a software application called "Processing" to send and receive commands from the topside laptop and Arduino microcontroller. Due to an Arduino's low current, a motor control must be used between the Arduino and the motor themselves. The Arduino sends out a PWM (pulse width modulation) signal to the electronic speed controller (ESC) which boosts the current to up to 12- volt, 15-amp before sending the signal to the actual motors. The signal instructs the motors when to turn on and off (hence "pulse"). The longer the motor is instructed to be "on", the more power it receives and the faster it runs, and vice versa. The analog joysticks allow us to have a variety of speeds achievable based on how far the stick is tilted. This added sensitivity helps our pilot complete complicated maneuvers like removing the Seabin power connector. The left stick controls forward/backward movement of the left side motors, while the right side controls the right-side motors. The ABXY buttons control which side of the ROV is the front. These controls make the ROV multi-directional. The controller is able to switch the "forward" side of the ROV very easily, which allows them to accomplish tasks faster. Further, an overdrive feature was added to the ROV which allows the ROV to move at double the speed as usual, and is useful for traveling across long distances. The triggers will be assigned to up and down movement. The directional pad and back bumpers control the gripper and other tools. All original software was coded from scratch by a previous ROV member that graduated last year, and all new additions were created by our current software.

# Oostburg ROV Software Flowchart 2021

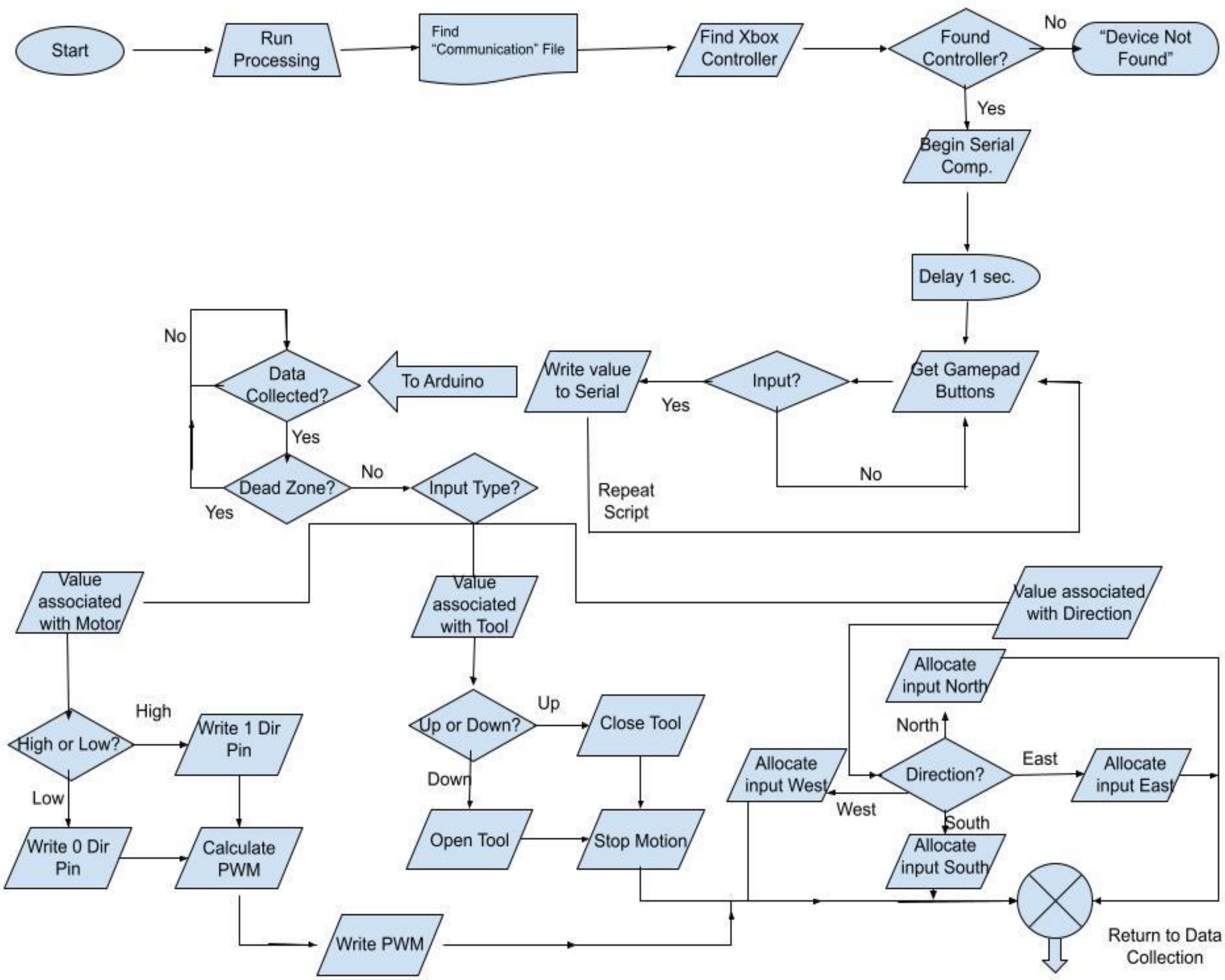



Figure 14: Software Flowchart

## Safety

For the Oostburg ROV Company, safety is a top priority. Thus, many safety precautions have been utilized over the course of the year to ensure that all members are completing their jobs as safely as possible. During this season's unprecedented times due to COVID-19, we prioritized implementing precautions that included wearing masks and social distancing to keep our members safe. We met in smaller groups in four different workrooms, and monitored one another to make sure masks were being worn properly. Safety glasses are always used when working directly with the ROV or any of its parts, especially in the shop and whenever working with or near power tools. Finally, our pool deck personnel implement a safety protocol and follow a safety checklist before each practice at the pool. (Figure 15)

| **Safety Checklist** | **Safety Protocol** |
|---|---|
| • All equipment attached to the ROV is secure<br>• Electronic components are properly waterproofed<br>• All propellers are protected<br>• Tether is insulated and secured at all ends<br>• The on-deck team is wearing proper safety attire (eye protection, closed-toed shoes, etc.)<br>• All fuses are installed and functional | • Uncoil tether and organize the area<br>• Ensure safety checklist is observed and complete<br>• Turn power on<br>• Check camera feed and position<br>• Test all systems for full and safe functionality |

Figure 15: Safety Checklist and Protocol

## Troubleshooting and Testing

The Oostburg ROV Company relies heavily on the power of perseverance and determination to solve problems. One large factor that can determine the whole season's success is time. At the beginning of the year, our company collectively agreed to extend our practices and meet 2.5 hours each Wednesday. Our company then created a schedule (figure 18 below) that allotted enough time for the engineers to test and troubleshoot everything long before the competition. A key step that leads to our team's success is 20 practice runs. Completing 20 practice runs before the regional competition allows the time needed to troubleshoot and perfect our services to the Delaware River and Bay. For the world competition our team continued to meet for at least 3 hours per week, and complete 20 more practice runs. In past years we have not met deadlines efficiently; however, this year, we were able to learn from our challenges and successfully met most deadlines for all aspects of the business and engineering teams.

## Challenges and Lessons (Technical)

Some technical challenges our company faced this season were with designing and coding the navigation and image recognition software. With an abrupt end to our last season, the lead software coder graduated without being able to pass on his knowledge to this year's software engineers. This proved to be difficult in figuring out how to complete the software and use the processing code to operate the ROV. After weeks of troubleshooting, we asked our graduated lead programmer to come back as a consultant, teaching our new engineers how to write code and manipulate the software. After this, engineers spent time understanding and improving upon last year's code. From this experience, our engineers learned how the processing code works with the ROV and developed a system to pass the information on to younger classmen.

## Challenges and Lessons (Non-Technical)

One organizational challenge our large company encountered early was inefficient communication. On several occasions, essential projects were overlooked and a lack of communication created confusion, which slowed down productivity. However, our managers quickly identified and resolved this issue by having weekly meetings to discuss what needed to be done prior to our practices, sending out weekly updates, and using a Facebook group chat to improve communication throughout the team. Also, our engineering team decided to give each engineer a specific role so everyone had a job each practice and all of the tasks were completed on time. What seemed at the time to be a weakness of our company, communication has now become a strength of our company. We now utilize things like spreadsheets, email, Snapchat, and a designated whiteboard turning into lifelong skills our company will utilize.

## Prototyping

Our engineers are very invested in testing and prototyping, especially in our plastic debris catcher. Keeping plastic debris out of waterways is a crucial piece in facilitating a thriving waterway. One of our mechanical engineers spent over five months designing and testing several **Floating Plastic Debris Extractor (FPDE)** debris catchers to quickly and efficiently collect and secure all floating plastic. During this process, 10 prototypes were created, starting out with one made of straws and hot glue. Our engineer soon realized that the design was not efficient, and continued to manipulate the design to maximize efficiency. From there, the FPDE was put through rigorous testing in a bin filled with water and plastic debris, allowing the engineer to create the final 3D-D printed design made of PLA plastic.

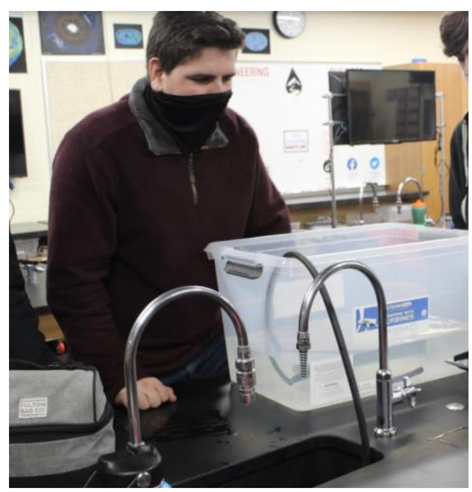


Figure 17: Engineer Testing FPDE

## Senior Reflections

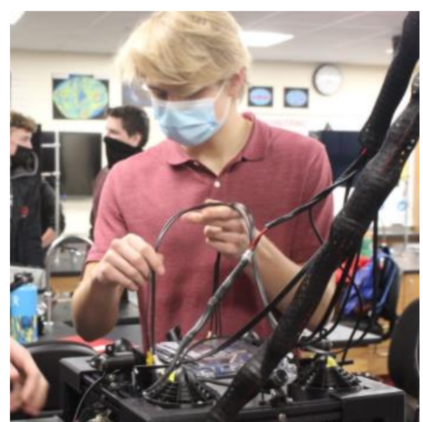
“When I was a freshman, my parents forced me to do ROV. I hated it at first because I didn’t feel like I was smart enough to be on a robotics team. But as the years have progressed, I have learned to love it, and it is now one of my favorite extracurricular activities. I learned that I don’t have to be good at engineering and that there is a whole other business side to ROV. This year, I have the privilege of being the team CEO, and although it can feel overwhelming at times, I like having responsibilities and being a leader for younger members. ROV has helped me grow in many areas including my communication skills, my leadership skills, and my work ethic.”

Ella Stader, Lead Business (Regional CEO)

Sabryn Bley, Lead Camera Manager (International CEO)

“ROV is where I've felt my calling to become an engineer. It has challenged me to further develop my problem-solving skills as well as where I have been able to fine-tune my leadership and work ethic. After only a week of joining the team I was coming in outside of practice to experiment and learn. This extensive work earned me a leadership role in the electrical engineering department where I'm responsible for researching, testing, and engineering an eight-camera system. ROV has presented to me how engineering is constantly evolving to create solutions to current world problems. In my career as a data engineer, I wish to be creating solutions that make the community a better place just as ROV has taught me to do.”

“Originally, I thought that ROV would be your stereotypical nerd club, consisting of all people working on a robot. However, I found out that there are really cool people in ROV with a variety of interests and personalities. Also, I thought that ROV would be as “simple” as building a Robot. What I didn't know is how ROV is run like a business, and there are roles on the team for people not heavily focused on an engineering aspect. A business needs a business team and building the ROV is only half of the problem. This allowed all different types of people with different interests and abilities to be big contributing members to the team.



Caleb Krueger, Lead Electrical Manager

## Mentor Reflections


Terry Hendrikse, Mentor

“It is awesome to be able to share my skills and knowledge with students and help them learn and grow in their skills and knowledge to help them out in their futures. I think ROV is just one more place that can help me do that. There are so many areas and skills that can be acquired through the program, no matter what a student's interests are. The most rewarding part is seeing all of the students grow in their skills and knowledge throughout the process and seeing the ROV come together and function come competition time.”

“This year has been like no other presenting many new problems and challenges for our students, but I will confidently say that I am proud of our ROV teams both in middle school and high school. Every challenge that was presented provided more opportunities for growth. As a result of last year's competition being canceled, a lot of things were left unfinished. Most importantly we lost the opportunity to transfer knowledge to the next year's team. However, to overcome this we had graduated students willing to come back while on Christmas and Spring break to mentor the high school team. We have had high school team members mentoring and providing their knowledge to the middle school team. When a student was quarantined, they met with their department on zoom. This year proved that we have accomplished the most important learning objective of ROV...teamwork. Thanks for a great season!”


Robert Boenisch, Mentor

## Company Effort

In order to ensure maximum communication while constructing the ROV, the team had to establish a company-like routine. Although the whole team was split into smaller committees, each team worked with the others to complete the ROV. For example, the mechanical engineers who were in charge of building the frame worked closely with the engineers designing the motor shrouds that attach directly to the frame. The open flow of information between the engineers and the business members is also essential to our overall success. Team members are very diligent about reporting orders to our finance directors and answering questions for the technical report thoroughly.

## Build a Schedule

| Date | Build Schedule |
|---|---|
| 1/8/20 | Complete frame and begin mounting, test mini ROV |
| 12/9/20 | Create camera mounts and test cameras, 3D print prototype mini ROV |
| 12/20/21 | Finalize TV system |
| 1/13/21 | Complete gripper |
| 3/3/21 | Finished presentation outline and poster design |
| 3/17/21 | All tooling mounted |
| 3/17/21 | Finished technical report rough draft |
| 4/7/21 | Setup pool and begin testing |
| 4/7/21 | Begin poster proofreading |
| 4/9/21 | Practice, practice,practice! |
| 4/28/21 | Completed mini ROV |

Figure 18: Company Schedule

## Budget Cost

Our company strives to be thrifty and efficient in our spending and product ordering. Our purchasing department tried to cross-reference various suppliers and find items on sale. Fortunately, our ROV team has gained the interest and support of our community and several local businesses. In addition to our school district funding of $500 and the State robotics matching grant of $3000, our team received several anonymous donations adding up to $806.55. Acuity Insurance has been a crucial partner in our company's history, and decided to support us again this year with a donation of $2,500. Because of this wide level of support, our team had enough funds to purchase everything needed to complete the ROV in addition to purchasing new team tools and toolboxes. Engineers filled out Google Forms with links to what needed to be ordered and the quantity so the financial advisors could make the purchase and record information efficiently.

**Expenses**

| Expense | Type | Examples | Amount | Running Balance |
|---|---|---|---|---|
| Cameras | Purchased | Security Cameras and digital cameras | -$209.56 | -$209.56 |
| | Reused | Quad view multiplexers and RCA Cables | -$766.89 | -$976.45 |
| Electrical | Purchased | Arduino Mega, wiring, power supply | -$155.26 | -$1,131.71 |
| | Reused | Subconn Bulkhead Connectors, braded teather wire | -$300.00 | -$1,431.71 |
| Software | Purchased | Levono Control Laptop | -$450.99 | -$1,882.70 |
| | Reused | Alianware laptop | -$200.00 | -$2,082.70 |
| Thrusters | Purchased | Blue Robotic ESCs | -$253.52 | -$2,336.22 |
| | Reused | Blue Robotics Thrusters | -$1,500.00 | -$3,836.22 |
| Tooling | Purchased | Savox waterproof servos, 6 spools of PLA | -$697.23 | -$4,533.45 |
| | Reused | Threaded rod for Power probe, 2 spools of PLA | -$40.00 | -$4,573.45 |
| Frame | Purchased | spools PLA, 80/20 tooling mounts | -$84.54 | -$4,657.99 |
| | Reused | HDPE 80/20 Frame Material | -$100.00 | -$4,757.99 |
| General | Purchased | Registration, Team shirts, tools, toolboxes New pool | -$3,370.00 | -$8,127.99 |
| | Reused | Team buttons, PVC parts for props | -$325.00 | -$8,452.99 |
| Travel | Purchased | No travel expenses to Regional | $0.00 | -$8,452.99 |

**Income**

| Expense | Source | Amount | Running Balance |
|---|---|---|---|
| **Funds** | District Budget | $500.00 | $500.00 |
| | Personal Donation | $506.55 | $1,006.55 |
| | Personal Donation | $300.00 | $1,306.55 |
| | Acuity | $2,500.00 | $3,806.55 |
| | State Grant | $3,000.00 | $6,806.55 |

| | |
|---|---|
| Total Reused and Donated Parts | $3,231.89 |
| Total Raised | $6,806.55 |
| Total Spent | $5,221.10 |
| Final Balance | $1,585.45 |

Figure 19: Finance Sheet

## Travel Expenses

Because of our aforementioned success in budgeting, the trip to Tennessee will cost each member between $50-$100 depending on whether members are traveling with the team or family members. This is a very reasonable amount considering the long 4-day trip filled with many exciting activities. Lodging expenses and meals for all team members are estimated to cost about $4500. Some dinners family and team members will provide for themselves; however, most meals will be prepared by our international culinary team (of about 5 members).

## Acknowledgements

There are many thanks and acknowledgments that have to be made to those who made this year's ROV company possible. First of all, we would like to thank Liz Sutton, Jill Zande and others at MATE as well as other volunteers for organizing this competition and allowing us to participate. We are very appreciative to MATE for the support and opportunity to provide our services to the global community in the midst of these uncertain times. Next, we would like to thank our corporate sponsors Acuity and the State Robotics Grant. Personal thanks must be extended to our mentors Mr. Hendrikse and Mr. Boenisch, as their dedication, patience, expertise, and time helped us grow as a company and as future career professionals. Further, we express gratitude to our school faculty English experts for reading over the technical report and poster to avoid any grammatical errors. Finally, we would like to thank our parents for being supportive and encouraging during challenging times and supporting us in investing in our futures.

## Photo Accreditation

**Ana Wilson -** Front Cover Design and Creation

**Jason Becker** - Software Flowchart and SID of ROV

**Austin Lammers -** CAD Drawing of Gripper and Frame

**Andrea Pedroza -** Financial Sheets and Build Schedule

**Alaina Rauwerdink and Sydney Steuerwald -** Team and Practice Pictures

**Karli Swart and Hailey Bley –** Pictures of Dry Housing and Bulkhead Connector

**Levi Rondeau –** CAD of Floating Plastic Debris Extractor