OOSTBURG ROV COMPANY

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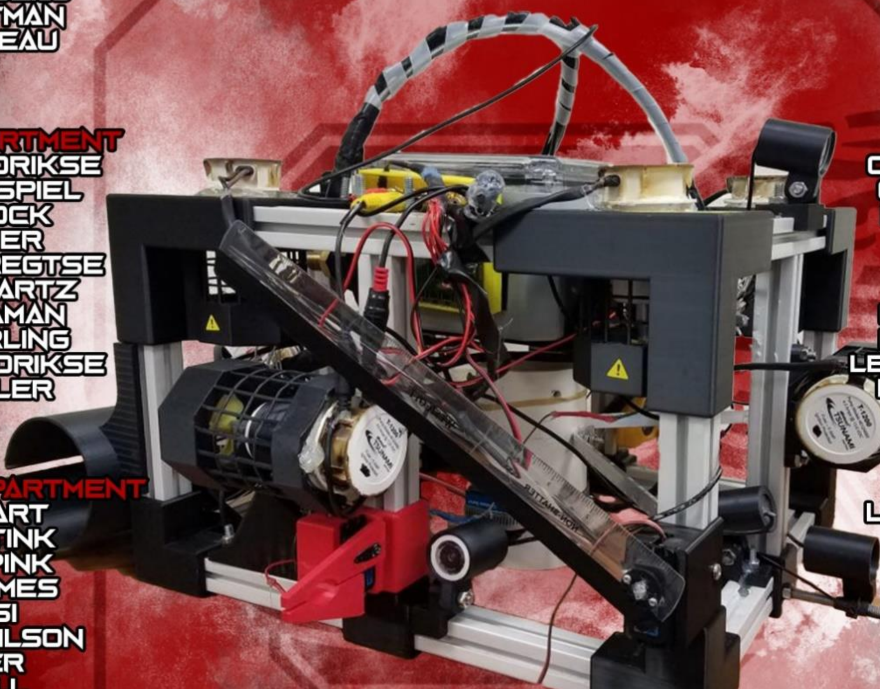
PILOT
NAVIGATOR
ROV HANDLER
TETHER
SAFETY
SETUP



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CAMERA ENGINEER
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ELECTRICAL ENGINEER
SOFTWARE ENGINEER
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OOSTBURG HIGH SCHOOL
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Abstract

Oostburg ROV is an ROV Company comprised of 31 students from Oostburg High School. Our company mission is to create a world-class ROV and a high-functioning business while forming external connections and internal relationships, with all of these tasks being completed by our high school student team members. At first, 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 code, building the frame, and designing tools. Throughout the year, our team members displayed a high level of professionalism and a readiness to step out of their comfort zones and do what needed to be done. This year, our team took on a new initiative to put more emphasis on team leaders. The 15 leaders had meetings either before or after full-team practice every week to discuss progress, timelines, and goals. This setup increased the flow of communication and made it easier for all groups to work with each other in an effective way.

Corporate Profile

The Oostburg ROV company is organized into four main personnel groupings in order to increase efficiency and communication. These groups- Business Team, Mechanical Engineers, Software Engineers, and Electrical Engineers- created a working environment that was cooperative and efficient. The Business Team members were working double-duty throughout the year: each member was part of either Marketing or Finance and also working on either the poster or presentation. The Marketing Team was primarily responsible for handling the “publicity” of the ROV company. This included community outreach and sponsorship opportunities. The Finance Team was in charge of placing orders, applying for grants, and making sure the project was on budget. The Mechanical Engineers spent much of their time constructing the actual ROV. They created a sub-team in charge of tooling for each task. The Software Engineers focused their efforts on cleaning up previous code to make it more user-friendly. Finally, the Electrical Team worked on designing and creating circuit boards, working closely with Software Engineers to create the brain of the ROV. This division of labor made it possible for many projects to be completed simultaneously at a high level of competency. Yet, even with many groups working separately to complete their respective tasks, specific systems were implemented to maintain a high level of communication between the four groups, such as the frequent Team Leader meetings. This company format encouraged each member to utilize their own talents individually for the benefit of the entire ROV company. One way the company remains organized is keeping up with a project notebook. Maintaining a project notebook is a good business practice that will help to capture ideas and document the company’s progress – including research, designs, trade studies, experiments, data, vehicle specifications, testing, expenditures, and donations. The notebook is also a place to keep track of the company members’ contributions (time, support, etc.).

Corporate Responsibility (Community Outreach)

Our business department has organized several events for community outreach including mentoring middle school ROV students and creating more social media sites. Our largest event for community outreach was our 2nd Annual Science Camp for kids. For this camp, members of our ROV company became the teachers and led 80 elementary kids ranging in ages from 5-10 in the hands-on science activities. Our members love working with the kids to bring the joy of science and engineering to the next generation. Some of our Marketing Leads were in control of sending out a weekly newsletter to our sponsors and supporters to update them on our progress throughout the year, as seen in Figure 3.

Oostburg Robotics Team

4/10/19

Click for the Website!
Click for Facebook Page!

CRUNCH TIME

Hey everyone! Deadlines are approaching--fast. The countdown till the competition is on everyone's minds. There is officially 2.5 weeks until the competition!

Important Information

All members are expected to be at the competition on Sunday, April 28th which takes place in Milwaukee. Our team will travel on a bus to the competition and all team members are expected to be at school by 6:45 am.

Member of the Week

Name: Logan Gartman

Role on the team: Math Equation/ Prop Leader

Favorite part about ROV:
His favorite part about ROV is learning how to think outside of the box to solve complex problems.

Business

This week, the business team was writing the poster, technical report, and the presentation. The deadlines for these are very soon so they have been working hard to complete this writing in advance.

Joke of the Week:
What was the name of the first electricity detective?
Sharlock OHMS!

We would like to extend our thanks to:
- Grande Cheese
- Kurtz Ersa Inc.

Sign up for our weekly newsletter through our website!
https://oostburgrov.weebly.com/

Engineering

Our engineers had a successful practice. Last week we mentioned how we put our robot in the water for the first time. During this, our robot only lost 2 propellers, 3 motors, a weight, and it had water in one of the cameras. While this is a pretty successful first run, our engineers have been focusing on fixing these problems along with making the robot faster. This week they designed new motor shrouds which made the ROV twice as fast.

Check out this link to see our ROV in action!
https://bit.ly/2D5IMwQ

Quote of the Week:
"The good thing about science is that it's true whether or not you believe in it."
- Neil degrasse Tyson

Figure 1: Oostburg ROV Newsletter

Figure 2: Oostburg ROV Company

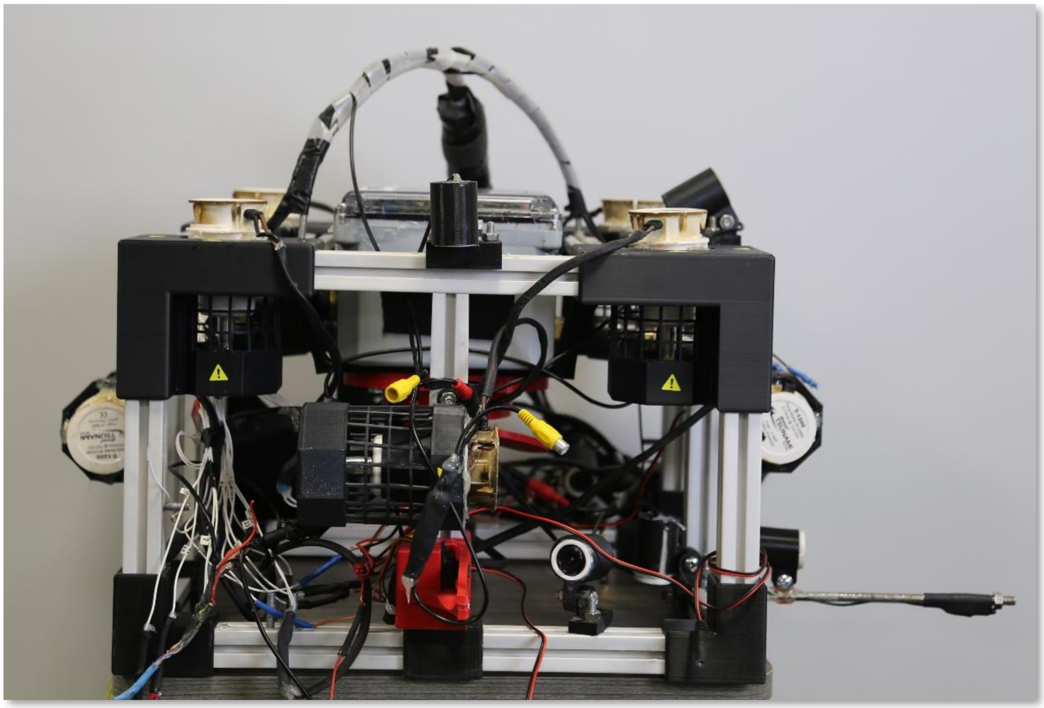


Figure 3: Complete Vehicle Otis-Rupert

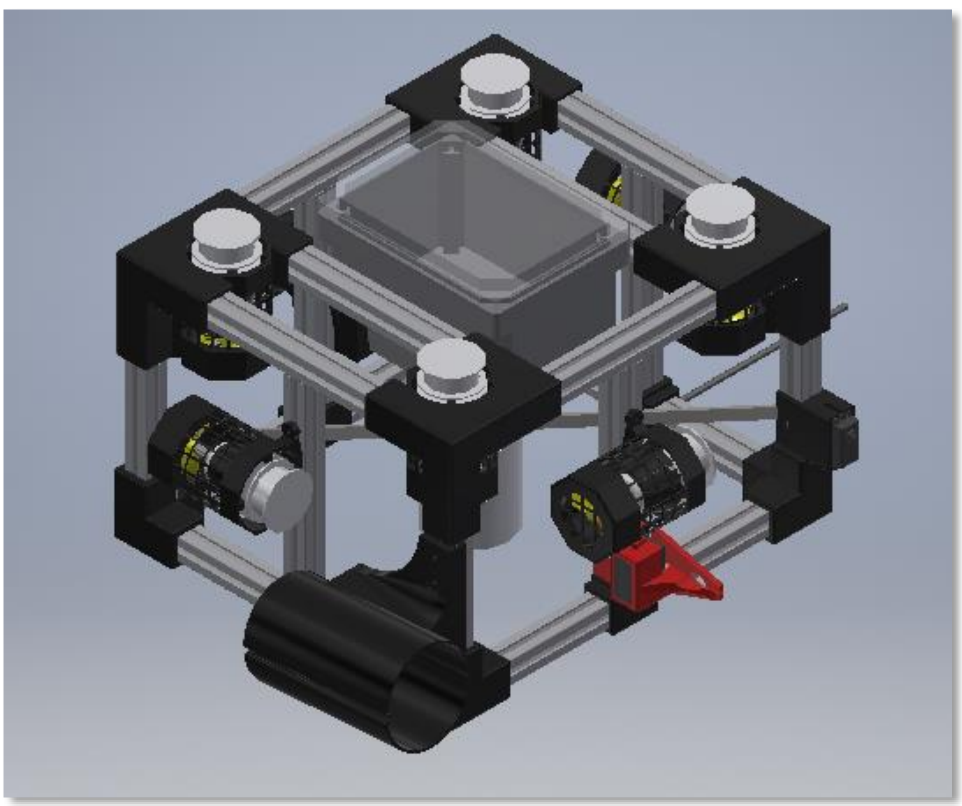


Figure 4: CAD Mechanical Drawing of Complete Vehicle

Design Rationale

Frame

This year, our frame engineers Eli and Riley decided to go a different route in terms of material. Ideally, the frame would have been constructed out of 80/20 aluminum, but aluminum is too heavy to meet MATE's strict size requirements. For this reason, they ultimately made the frame out of 2.5 cm x 2.5 cm PVC 80/20-type T-slot material. This material is ideal because it allows tooling and cameras to be attached anywhere within the T-slots while being able to change the tooling placement easily. Its density of .957 g/cm is also significantly lower than the 3.7 g/cm aluminum, making the entire ROV frame lighter while still being very functional. The frame design is entirely new this year with a similar shape as last year, but with several improvements. Last year, our engineers 3D printed corner connectors, but they were very weak, which resulted in them breaking very easily. This year, they designed them to be considerably stronger to avoid this issue. The corner connectors and motor shrouds that were engineered together were 3D printed to be dual purpose, so instead of screwing the shrouds onto the frame, the shrouds are a part of the frame. The final design also incorporates pieces to connect to the dry housing. The weight of the frame alone is 3.5 kilograms, and the final weight of the whole ROV is 9.2 kilograms. The dimensions of the frame are 38x43x29 for a total of 47386 cubic cm, as seen drawn to scale in Figure 5.

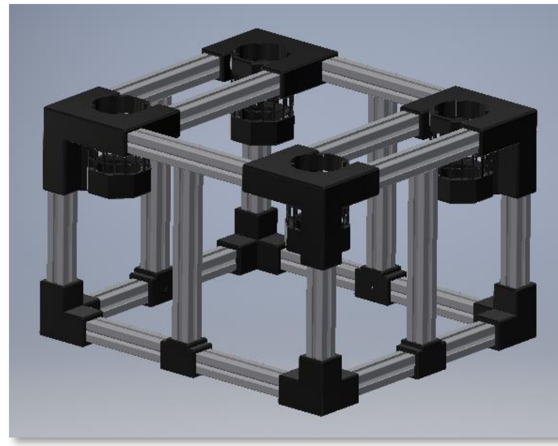


Figure 5: CAD Mechanical Drawing of Frame

Dry Housing

The dry housing is an essential component in the ROV, as it provides buoyancy and protection for the underwater electronics. We use a 3000 cubic cm IP68 electrical box, generously donated to us by Integra Enclosures last year. 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 and heavier parts like tooling and motors near the bottom. Based on a calculated value of 3000 cm^3 of displaced water providing 29.4 Newtons of buoyancy force, this dry housing was selected to provide the perfect buoyant force while still providing ample space for all required electronics. In the end, our mechanical engineers had to add 500 grams of ballast to the bottom corners of the ROV to achieve neutral buoyancy. In the past, the Electrical Engineers struggled to fit all electrical components into the dry housing in an efficient way, so electrical engineer Charlie designed a shelf for the dry housing this year to increase organization of electrical components.

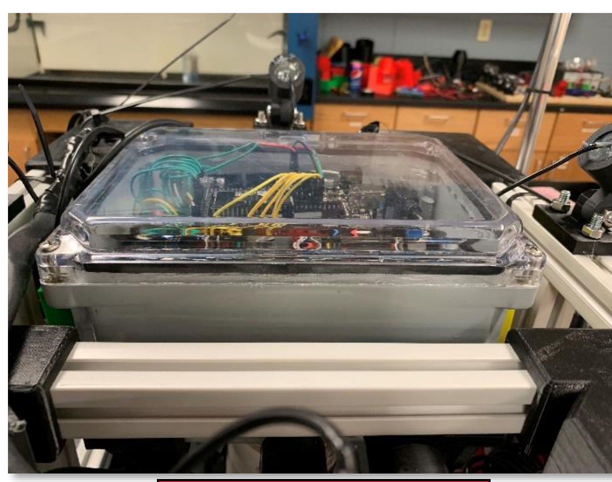


Figure 6: Dry Housing

Bulkhead Connectors

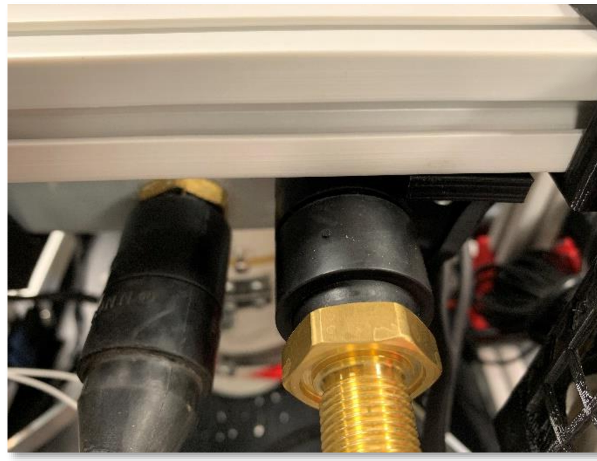


Figure 7: Bulkhead Connectors

The bulkhead connectors have the extremely important job as they serve as a buffer between the electrical components and the surrounding water, as seen in Figure 7. They allow power and communication to penetrate the dry housing while keeping the internal electronics dry. Initial research from previous Electrical Engineers have 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 of the internal electronics. For this reason, our engineers have partnered with SubConn for another year and use 3 of their commercial grade 300-volt bulkhead connector series for power distribution and microseries 21 pin connector for communication and motor power distribution. Our engineers feel confident with using these bulkhead connectors because the application is within the SubConn power ratings and the working depth rating for these bulkhead connectors will be used in less than the maximum 300 bar depth. These bulkhead connectors are professional-grade and are, subsequently, very expensive. Fortunately, SubConn has continued their partnership with us, allowing us to purchase high-quality bulkhead connectors at a reduced price.

Electronics and Internal Wiring

The navigational electrical systems are powered by 8 Polulu, 15 amps, H bridge motor drivers. We chose these motor drivers because they will be able to easily power 8 Tsunami T1200 thrusters wired in parallel circuitry, 4 thrusters for up and down and 4 for directional controls. In a successful effort to reduce electrical noise and guard against power strikes, capacitors with a value of 220 microfarads were added to each motor driver. One DC to DC step-down voltage converter is used to provide 5-volt power to the onboard electronics, as well as 7.5-volt power the Savox SW-1210 waterproof servos used to run tooling. A plastic shelf in the middle of the dry housing was installed to hold all of the motor drivers and the power cords. Now, the power wires travel directly from the bulkhead connectors to each individual motor driver, and a communication wire is run between each motor driver and the Arduino to allow for control of motors and tools.

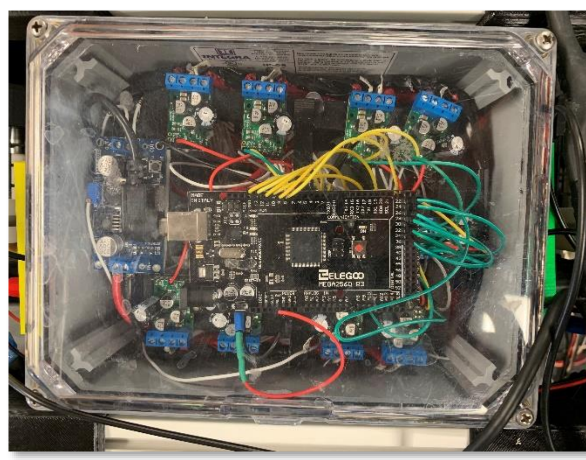


Figure 8: Wiring and Electronics inside Dry Housing

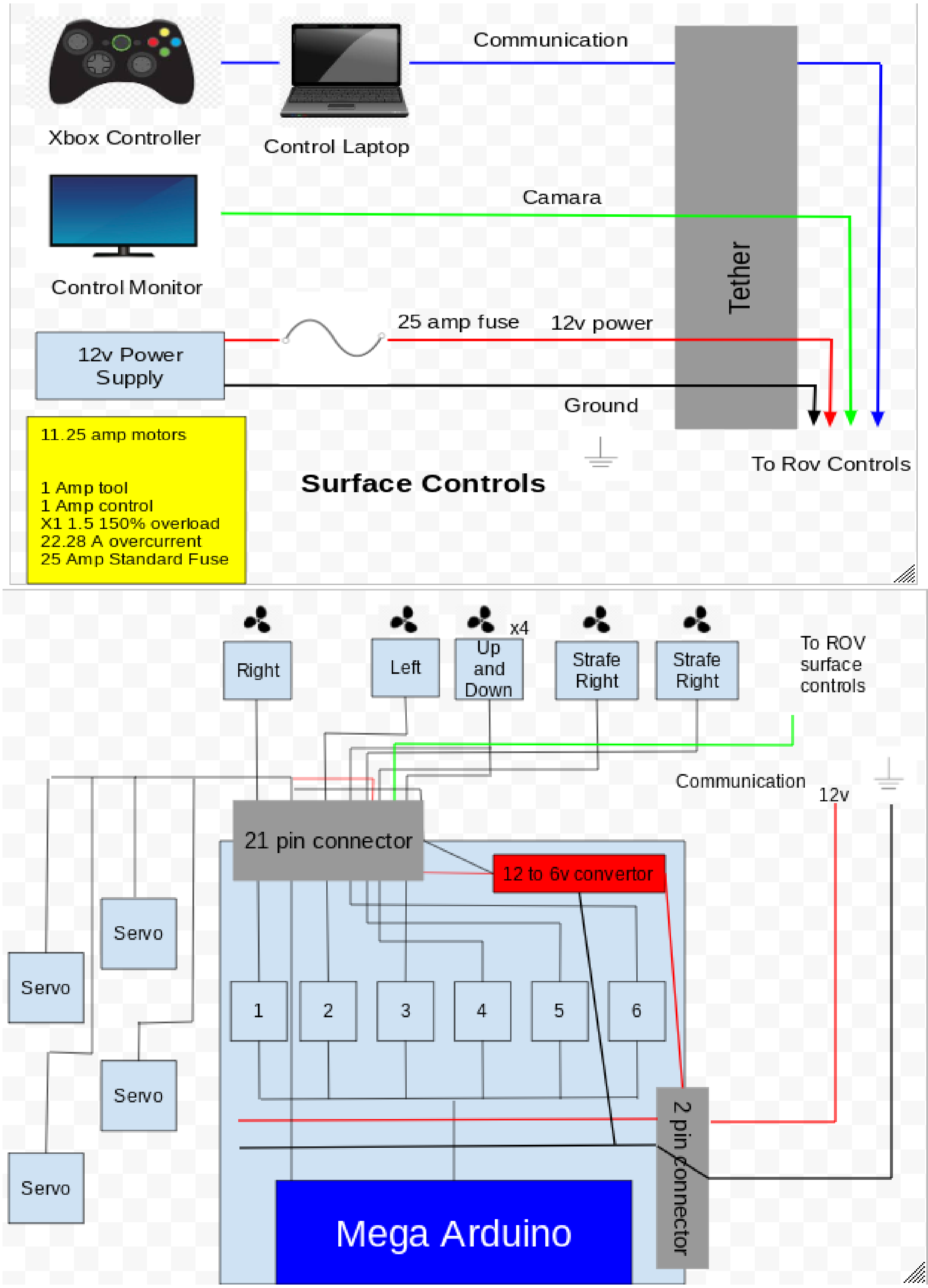


Figure 9: Electrical SID showing 25-amp fuse

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 due to the 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 18 meter tether to a topside laptop, which runs Processing, a program used to communicate with the ROV Arduino. The software our driver utilizes is a new and improved version of what had been used in previous years. The software allows the pilot to access tank steering and switch the “front” side of the ROV with the push of a button. The design of our ROV to have four front facing sides has made accomplishing tasks extremely quick and efficient. Another aspect our ROV possesses is the “Hover mode,” which is an extension that can uses the information gathered from the depth sensor to automatically turn on different motors to keep the ROV floating at the same depth. Despite being crude in years past, our software engineers have spent considerable time upgrading the graphical user interface (GUI). The GUI is Java-based, and it modifies calculations that appear on the screen of the laptop to be more user-friendly. The GUI has many useful features. For instance, it is able to lock in the locations and depths of different objects and calculate the distance between the ROV and that object. Overall, the GUI- paired with the updated software coding- makes driving the ROV easier and more efficient.

Tether

The tether connecting the ROV to the surface is 18 meters in length and provides power, communication, and video from the ROV to the topside command station. There is a 25-amp fuse installed on the positive power within 10 cm of the power supply. The company chose to use a 25-amp fuse based on our calculations. The ROV uses eight 1.41 amp motors (11.25 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. Total, the ROV consumes 15.25 amps and when multiplied by 150% overload, a 22.88 overcurrent draw is calculated. Based on these calculations, our company is using a 25-amp standard fuse. Our engineers made major renovations to the tether this year. Last season, there were nearly 16 cords on the tether because every camera needed its own cord in the tether. However, the engineers are now using two waterproof multiplexers that are located on the ROV. Another wire is responsible for communication, and it has two signal amplifiers located on it, as shown in Figure 10. This allows for a much stronger signal and less messy wires. Two more marine grade, 12 gauge, braided cables provide 12-volt topside power to the ROV. The fuse attached has the ability to monitor the power going through, and if the power exceeds 25-amps root-mean-square (rms), it will blow the fuse and stop the power, so the ROV is not damaged by a surge.

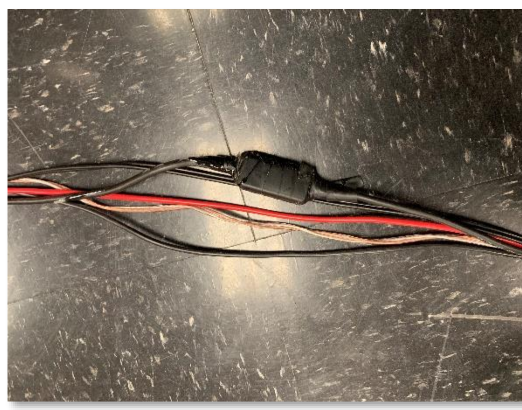


Figure 10: Tether with Signal Amplifier

Propulsion

Propulsion is achieved by 8 Tsunami T1200 thrusters that were donated to us by Attwood Marine. These thrusters are able to move water at a rate of about 4542 liters per hour when used in a bilge pump application. We had previously removed the plastic casing with a CNC laser, and we had constructed very much-improved shrouds for the motors that make them adaptable to the frame. There is one motor in each corner with the propellers facing up to allow the ROV to move up and down. 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 forwards and backwards. 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 turning to be done while at a standstill by running two motors in opposite directions (also known as "tank" controls- the ability to rotate the body while remaining still along the x-axis) This creates efficient movement for the ROV, as we can propel and steer the robot in in whichever way the task at hand requires. For example, in Task 3, we are able to carefully maneuver the ROV in order to precisely measure the radius of the canon. Without this placement of motors, precise movements would be very difficult.

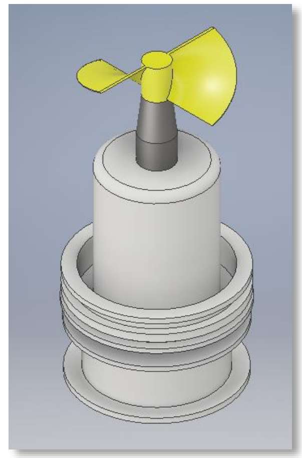


Figure 11: Motor

Motor Shrouds

The motor shrouds are an essential part of the ROV for increasing motor safety and efficiency. The engineers of our team used our new 3D printer to create a cage-like mechanism to protect wildlife from the propellers and the propellers from any potential hazards. Our motor shrouds we used last year provided us with much success, therefore we decided to reuse the same design. With the motor shrouds being a product of 28 drafts, we only needed to make small adjustments in order to better the ROV performance. Not only do we aim for the goal of efficiency, but we also expect reliability and consistency. The original design did not initially include the enclosure around the motor, but was re-engineered after further inspection of safety codes, specifically MATE MECH-006 IP. The caging around the shrouds includes <12 mm spacing, and was built in a way that only the motors are trapped inside, and nothing besides water can enter or exit. The shrouds also feature rounded or filleted edges that allow for maximum hydrodynamics. Motor efficiency is increased by the angled Korz nozzle bottoms of our motor shrouds that allow for a higher output force by directing a large current through an increasingly smaller space. The corner shrouds are combined and printed with the corner connectors of the frame, and the side shrouds are externally connected to the frame.

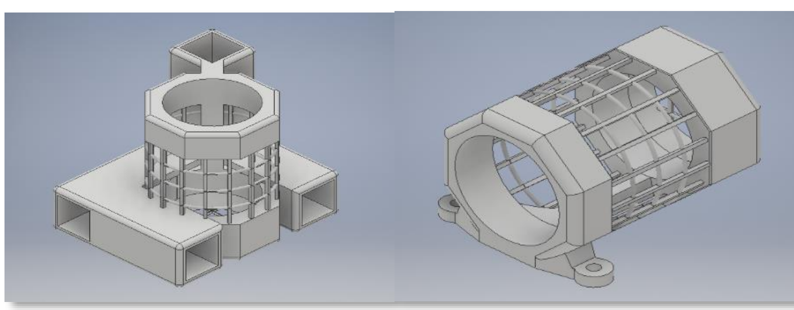


Figure 12: CAD Mechanical Drawings of Corner Shroud (left) and Side Shroud (right)

Cameras

Nothing could be accomplished in competition without the ROV's eyes: the cameras. Last year the ROV was equipped with 8 Aqua-Vu Micro II cameras. However, they quickly began to fail, so this year we ordered Raayoo cameras. These cameras were cheap, waterproof, and had RCA inputs. Upon first hooking them up, our engineers realized that the cameras projected a mirror image on the TV screen and the picture featured backup lines as found on backup cameras in cars. They soon overcame this problem by cutting a wire- the green wire, of course- and they were good to go. Then, they potted the cameras, which is the process of putting each camera in a film canister, covering the front in acrylic, and filling the back with epoxy to fully waterproof the cameras. The cameras are color and have a field view of 150 degrees. Whereas the old controls had so many wires they were exploding out of the container, our new boards have significantly less wires. This new compact design is achieved by soldering the wires we do have to the circuit board- the main control center for the cameras. The previous system used a control center that was located on the pool deck, but this was unfavorable because it required many cords running through the tether, and the communication was not great. Now, they used a multiplexer that they waterproofed with epoxy that can attach directly onto the ROV. This also allows for less wires to be running through the tether, so it benefits more than one system. They also have a remote that allows the pool team to switch screens through the multiplexer. The final pieces of the camera system are the 82 cm screens, a setup that allows for the driver to have a 360-degree view of the pool and the tasks.

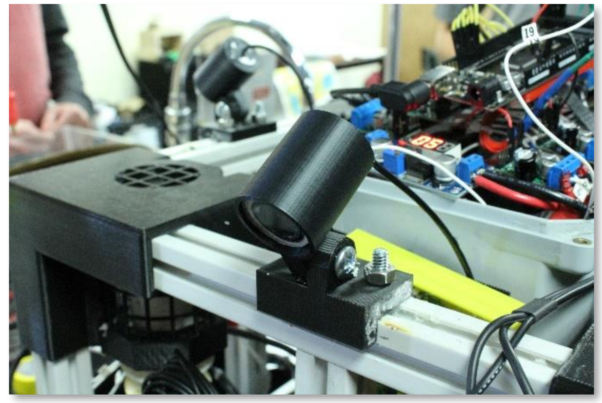


Figure 13: Camera Mounted to the Frame

Tooling

Gripper

Because the gripper made last year took the whole season to complete and failed at competition, two Mechanical Engineers, Nino and Chase, created a team dedicated to gripper design. Last year, they attempted to make both arms of the claw move, but they altered the design to have one moving arm and one stationary arm. One moving piece uses less power than two, which was our largest problem with the gripper last year. The servo was also upgraded to a more powerful Savox SW-1210. The gripper is comprised 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. The claw attaches directly to the ROV on one of the frame pieces. The gripper helps in procedures like Task 1, in which the ROV must remove the damaged screen of the trash rack and install a new screen.

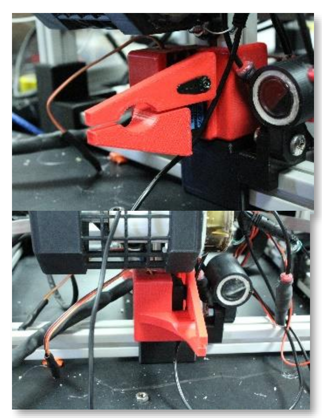


Figure 14: Gripper

Power Probe

The power probe is a tool that our engineers have utilized for several years that has continued on to this year. It is a 20 cm long threaded stainless steel rod that is attached to the frame. The probe is capable of completing tasks like removing the large and heavy degraded rubber tire in Task 2.

Mexican Beach Pebble Dispenser

One of the tasks that the ROV has to complete at the competition is filling a Red Solo cup with Mexican beach pebbles. The tooling engineers designed a mechanism that consists of a 7.62 cm PVC pipe 15.5 cm long that carries the beach pebbles from the deck to the cup. The bottom has a slit cut into it where a flat 3D-printed piece, a stopper, can move in and out of the tube. A servo is mounted to the side of the pipe with a modified hose clamp that moves the stopper. The stopper's default position is "closed," but it will open with the press of a button on the controller. The pool deck crew is responsible for filling the tube with approximately 160 cubic cm of the Mexican beach pebbles. The ROV will position the tube directly over the cup and move the stopper to "open" to release the pebbles into the cup. Our pilot performs this task first, as the rocks add significant mass to the ROV, rendering it extremely negatively buoyant.

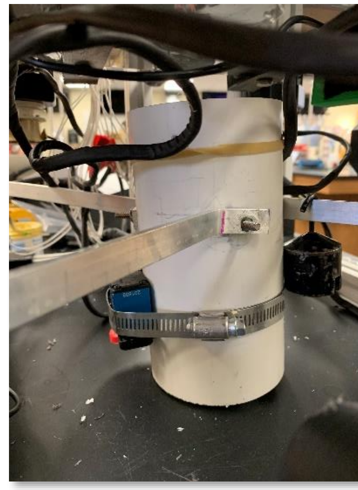


Figure 15: Mexican Beach Pebble Dispenser

Thermometer

The thermometer is a self-contained system implemented to measure the water temperature within 2 degrees Celsius, as required in Task 2. Our tooling engineers chose to utilize a Risepro waterproof exterior thermometer. One mechanical engineer, Anna, increased the wire length to 18 m and ran it through the length of our tether. Since MATE rules explicitly state the thermometer cannot be battery-operated, the thermometer draws power from the main power system with a 12-volt to 1.5-volt DC to DC power converter. The sensor of the thermometer is located on the end of the power probe, so the pilot can maneuver the sensor to a specific area and measure the temperature. Testing has proven that the thermometer is accurate to within 0.1 degrees Celsius.

Figure 16: Thermometer (top) and Power Converter (bottom)

Measuring Devices

One of the measuring devices our ROV has is the Oscillating Measuring Device (OMD). The OMD was created to measure the radius of the canon and the crack in the wall from any angle. It is comprised of a ruler attached to a servo motor, so it can oscillate to any location or in any direction. With this design, our ROV is able to move the ruler to whatever angle will be most conducive to measuring any specific object. The second measuring device is the Extendable Measuring Device (EMD). This device is used for measuring the length of the canon, as the EMD can be extended to a much longer length than the OMD. Our video engineers have carefully positioned cameras near these devices to accurately read the associated values.

Canon Volume Calculations

A new challenge our company encountered this year was solving mathematical based physics problems to calculate the volume of the cannon that our ROV has to attempt to lift at competition. Several of our ROV members who are currently in AP Physics and AP Calculus worked hard on developing a formula that can be easily used by any member of the team. Our Props and Safety leader Logan eventually cracked the code and created a formula that involved a 4,600 part Riemann sum. Initially, they tried to use an integral, but they had difficulties inputting the integral into a spreadsheet. Instead they chose to create a 4,600 Riemann sum that they were able to configure into the spreadsheet for easy access. The members on the pool deck will be able to plug in the numbers provided at competition to calculate the underwater weight on the cannon in seconds. All calculations can be seen in Figure 17.

	A	B	C	D	E	F	G	H	I	J
1	length of Cannon	Radius 1	Radius 2	Radius 3	T		Cannon VOLUME Calculated		actual Volume (cm^3)	Voltage Used
2	46	5.3	2.8	7.7	0.05217391304		5042.557808		5042.557808	13.1
3	46	5.3	2.8	7.7	0.05217391304					
4	weight*Archimedes' principle= force needed to lift cannon									
5	Force that is lifted up:		5027.430135							
6		Weight(g)	Underwater Weight of Cannon(g)	Underwater Weight (NEWTONS)	Force the Lift bags provide:			Force the ROV can lift:	18.32061069	
7	AF:	40491.7392	35464.30907	347.9048719	329.5842612					
8	BF:	39684.92995	39684.92995	389.3091628	370.9885521					
9	FPF:	39684.92995	39684.92995	389.3091628	370.9885521					
10	TF:	39684.92995	39684.92995	389.3091628	370.9885521					
11										
12										
13	Density Options	Density(g/cm)								
14	Bronze:	8.03								
15	Iron:	7.87								

+ NICE LAYOUT TECHY STUFF Sheet3

Figure 17: Cannon Volume Calculation Spreadsheet

Lift Bag

One of the tasks that the ROV has to complete is lifting a cannon from the bottom of the pool. The weight of the cannon is unknown- which is why we have the spreadsheet to calculate the weight- but it is a guarantee that it will be too heavy for the ROV to lift. Our ROV can lift about 20 Newtons. For this reason, our engineers have designed the ROV will have to attach a lift bag to it in order to lift the camera. We purchased a lift bag capable of lifting 90 Newtons and a bike tire pump, and the tooling engineers rigged the bike pump to inflate the bag.

Mini ROV

This year, our engineers were faced with the unique challenge of creating not one but two ROVs for competition. Our tooling leader Abram took the lead on the design, and he created a sleeker version of a motor shroud with guides on the side. With the guides, the Mini ROV is able to be controlled using only forward and backward controls and move along the tube with the guides that hit the edges of the tube. The Mini ROV is also equipped with a camera and an LED light on the front for maximum visibility. The design also has elongated laminar flow to better propel the ROV. He wanted this design to be as simple as possible as to minimize failures while still being effective. The objective of the Mini ROV is to drive through a tube to simulate searching for cracks in a dam and preserve the dam without damaging it more.

Figure 18: Mini 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 motor control, 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 transporting and releasing trout fry. 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. 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 engineers.

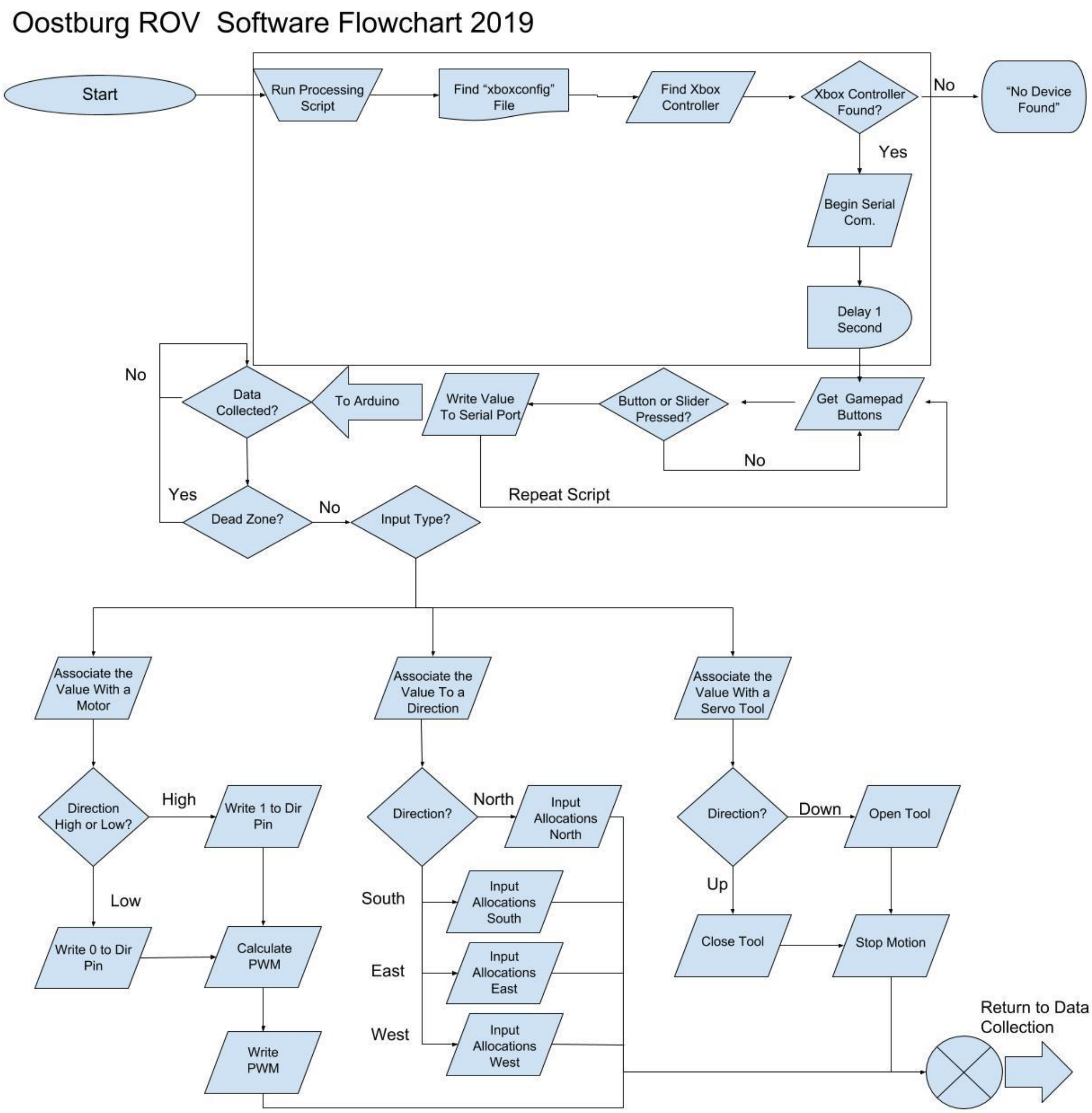


Figure 19: Software Flowchart

Safety

For the Oostburg ROV company, safety is top priority. Thus, many new and continued safety precautions have been utilized over the course of the year to ensure that all members are completing their jobs as safely as possible. 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.

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

Troubleshooting and Testing

Oostburg ROV relies greatly on the power of perseverance and determination to solve problems. We know that we are not, nor will we ever be, perfect. We expect mistakes and problems to arise. Thus, we allotted time for testing, problem solving, and troubleshooting before the competition so that we can find and correct as many of these mistakes as possible. In the beginning of the year, we created a build schedule that allotted enough time for the engineers to test and troubleshoot everything long before the competition. Unfortunately, the build time for the frame was longer than anticipated, so we lost out on some pool time for the ROV.

When testing the entire vehicle, our pool deck crew focused a lot on basic functions at first: double-checking electronics, making sure the TV monitors are set up effectively, and getting power to the ROV. After the ROV has power and the driver is in control, he tests the motor and thruster capabilities. Once satisfied that the ROV could move as intended, he employed the tools. If all pieces of the ROV are functioning efficiently, the pool deck crew begins the run. Eli, the ROV handler, watches closely for any issues that may arise while in the pool. Throughout this process, a member of the team writes down every problem that the pool team runs into. If the problem is not dire enough to stop the process, the driver will continue, and the problem list is addressed at the end of the run.

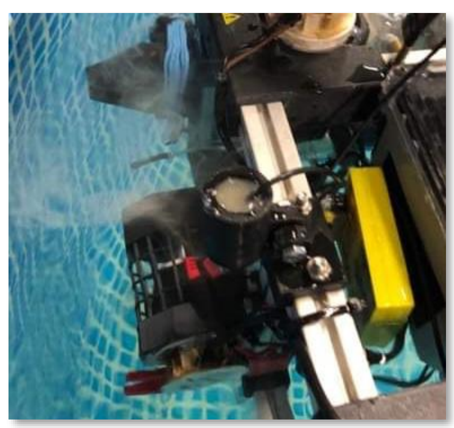


Figure 20: Fried Camera Cord

As our company began preparing for the international competition, troubleshooting was done after each upgrade was made. We had some issues with camera functions at the competition, so cameras were improved and tested. In this test, Eli found out the hard way that one camera cord was not quite waterproof, as seen in Figure 20. Thanks to our safety precautions, no one was hurt, but Eli's hands did "smell like burned plastic" for a few hours afterwards.

Challenges and Lessons (Technical)

One significant challenge that our team faced this year was the task of waterproofing the multiplexers for the cameras. The camera team had the idea of potting the multiplexers by enclosing the multiplexer surface in epoxy. In past years, the tether was bogged down by 8 different camera wires, so a waterproof multiplexer that can connect directly to the frame was exactly what we needed. Unfortunately, as many other processes in ROV, it failed the first time. The epoxy did not dry fully, so AJ, Taylor, and Josh decided to dump it out and start again. Again, this failed. They attribute this failure to epoxy getting into the electronic plug-ins when they dumped it out. They tried a third time, and it finally worked. Perseverance led to perfection, and now the ROV is fully equipped with two waterproof multiplexers, although it did cost our team about $120 in multiplexers.

Another problem we ran into during our first pool run was the failure of the motor shroud design. The shrouds do not leave enough room on one end for water to efficiently flow through it. This caused the ROV to be almost three times faster in the forward direction than reverse direction. Similarly, the ROV could descend quickly but had trouble ascending. Abe came in on a Sunday afternoon about three weeks before competition and redesigned the shrouds to be capable of drawing in and dispelling water from both ends of the shroud, which increased our speed and nearly tripled our lifting capabilities.

Challenges and Lessons (Non-Technical)

One significant non-technical challenge that seems to reappear every year is timing. We started off the season with a concrete timeline for the subsystems and the entire ROV. Despite constant reminders, deadlines were being constantly missed and continuously pushed back. The ROV did not get finished before spring break, so the engineers were left with just one month of troubleshooting and pool runs. They had to put aside their own social lives to spend as much time working on the ROV as possible. Although it was not ideal, the team members were committed to making the best ROV possible, and they made ROV their #1 priority. It was because of this commitment that the ROV is working for competition.

Because this timing issue is not a new problem that the team faced, there is talk of making a stricter accountability system to stay on track next year. This way, team members can encourage and help each other in completing tasks instead of missing deadlines and falling behind schedule. One example of this is the friendly competition between the engineers in March. Each team member voted for which subsystem team they believed would complete their respective tasks first, and the team that did finish first got a prize. This competition was quite effective and even led to a few engineers coming to school to put in significant hours over spring break.

Future Improvements

One major improvement that our team will make next year is adhering to the schedule a little more strictly. Putting in a little more time after practice in the beginning of the year would have helped a lot with time management, and some would not have been coming in over spring break just to get the ROV in the pool. One large technical improvement that will be made next year is cracking the code to a perfect motor shroud design. Adding the shrouds to the corner connectors was a step in the right direction, but there were still a lot of issues regarding efficient water flow. In the future, the motor shroud designers will try to design a shroud with less material than they have now so water is able to flow without obstruction.

Prototyping

Our engineers are very invested in testing and prototyping, especially our frame engineers. Eli and Riley had big plans for the frame this year, but they ran into a lot of obstacles regarding materials. They originally drew up a design with aluminum in mind, as seen in Figure 21. They created a frame initially out of wood in order to have a frame they could hold and modify. Thanks to these designs, they realized they would have to use a PVC 80/20-type T-slot material, as seen in Figure 22, which has worked nearly perfectly for us to achieve our mission.

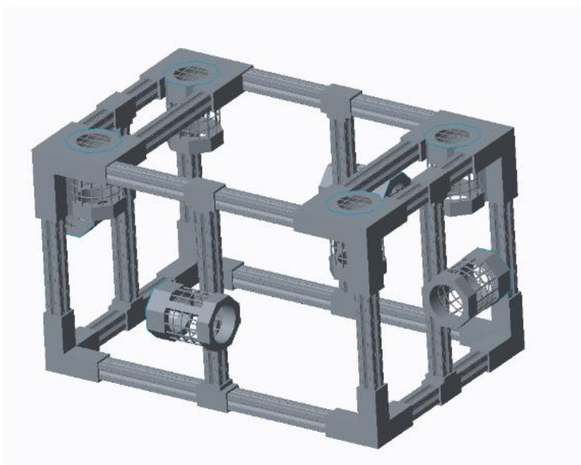


Figure 21: Frame Prototype CAD Drawing

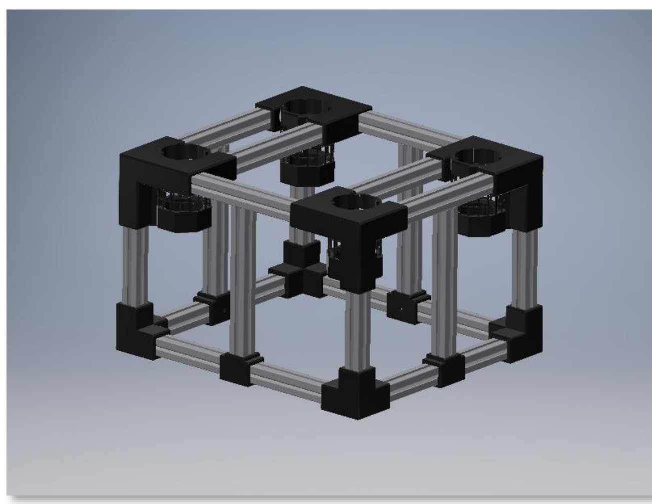


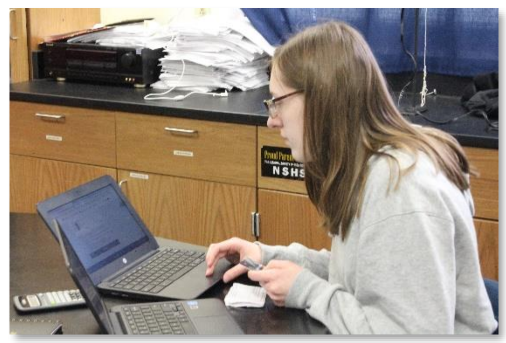
Figure 22: Final Frame CAD Drawing

Senior Reflections

Madelyn Hendrikse, CEO, 6th Year

My time in ROV has taught me how to manage my time and lead others in different ways. I have also learned that everyone works a different way and responds to failure differently and that in order for a team to be successful we all have to work together and push each other. I would say ROV has improved my patience and helped me to understand that everyone works differently than me. It is good to work with people who work differently because they bring better ideas to the table than just me.

Emily Federspiel, CFO, 1st Year



ROV actually helped me to decide that I wanted to major in accounting, so it changed what I was going to study. I was originally planning to major in business administration. ROV helped me decide and feel confident in what I'm going to do in college.

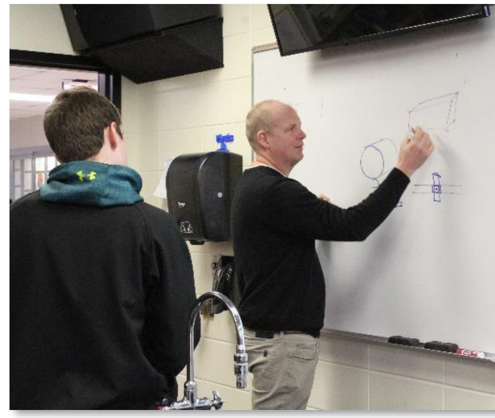
Logan Gartman, Props Leader, 2nd Year

There are a lot of challenges in ROV, and I like challenging myself, growing, and learning new things. The spreadsheet was the hardest thing I had to do this year. I had to figure out how to input my ideas into a program that would be able to do the calculations quickly. Fortunately, I could apply my AP Calculus knowledge to this problem to solve it.

Mentor Reflections

Mr. Hendrikse

There are countless real-world skills that play themselves out during the ROV seasons. My most rewarding part of being an ROV mentor is when teams start to take ownership over their specific tasks and become passionate about developing a high quality product. ROV is life. I have watched team members get introduced to their future careers through ROV. I have gone on ROV trips to Texas, Florida, Michigan, Washington, and Hawaii. I have watched teenage romances blossom through the smoke of a soldering iron and charge of a capacitor. Job, vacations, and love = Life.



Mr. Lammers

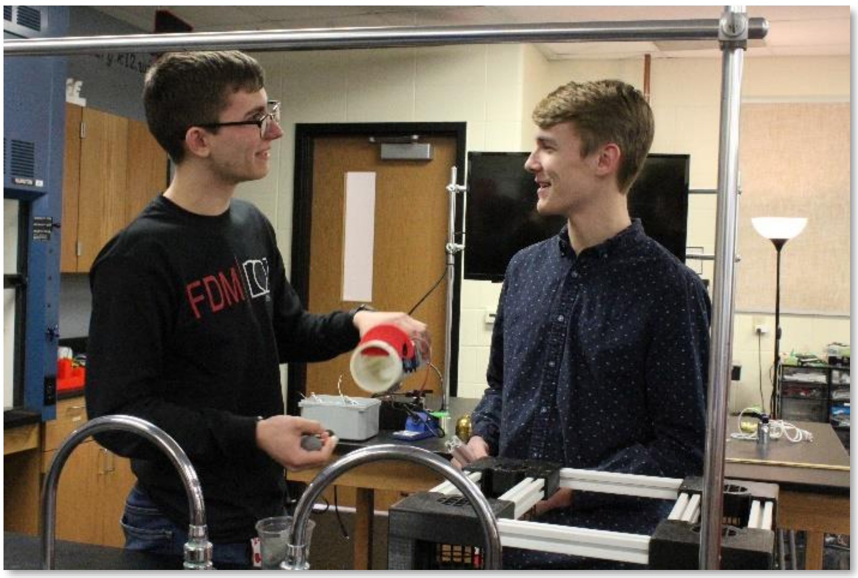
It is awesome to be able to share my skills and knowledge with students and help them learn and grow in their skills and knowledge to help them out in their futures. I think ROV is just one more place that can help me do that. There are so many areas and skills that can be acquired through the program, 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.

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 Schedule

Date	Build Schedule
12/05/18	ROV Kid's Science Camp
12/12/18	Create camera mounts and test cameras, 3D print prototype mini ROV
12/19/18	Complete gripper
1/02/19	Complete frame and begin mounting, test mini ROV prototype
2/06/19	All tooling mounted
2/13/19	Practice pool deck pullovers
2/20/19	Finalize TV system
2/27/19	Completed mini ROV
3/06/19	Finished presentation outline and poster design
3/13/19	Pool deck pullovers done, begin poster proofreading
3/20/19	Finished technical report rough draft
4/03/19	Practice, practice, practice!
4/28/19	Get 1st place at competition. Tennessee bound!



Budget/Cost Analysis

Our company strived to be thrifty and efficient in our spending. We looked for good deals and discounts on materials and supplies whenever possible. Because we were able to reuse and repurpose many items from last year, the only purchases we made were absolutely essential. Many items listed below were purchased by the money raised from the science camp we held in December.

Budget				
			Reporting Period	
School Name:		Oostburg High School	From:	10/31/2018
Instructor/Sponsor		Terry Hendrikse, Robert Boenisch, and Bryan Lammers	To:	4/28/2019
Income				
Source				**Amount**
Oostburg High School Grant				$1,000.00
Team Fundraising				$1,317.00
Grande Cheese Donation				$250.00
Kurtz Ersa Donation				$500.00
Expenses				
Category	**Type***	**Description/ Examples**	**Projected Cost**	**Budget Value**
Mechanical	Purchased	Used for building frame	$83.99	$83.99
Mechanical	Purchased	Used to make 3D parts	$267.29	$267.29
Mechanical	Purchased	Used to measure	$9.74	$9.74
Electrical	Purchased	Used to view around ROV	$365.01	$365.01
Electrical	Purchased	Allow vision underwater	$312.18	$312.18
Electrical	Purchased	Used to convert volts	$51.11	$51.11
Electrical	Purchased	All audio system gear	$288.88	$288.88
Electrical	Purchased	Bulb head connectors and plug adapters	$295.15	$295.15
Electrical	Purchased	Marine board HDPE half inch 12 x 24 in black	$17.97	$17.97
Electrical	Re-used	Used to move underwater	$130.00	-
Electrical	Re-used	Keeps circuits dry	$40.00	-
Electrical	Re-used	Brings power to the ROV	$40.00	-
Electrical	Purchased	Used to aid in ROV navigation	$101.65	$101.65
Props	Purchased	Used for ROV testing purposes	$243.28	$243.28
Business	Purchased	Team T-Shirts	$300.00	$300.00
Business	Purchased	Registration Cost	$140.00	$140.00
			Total Income:	$3,067.00
			Total Expenses:	$2,476.25
			Total Expenses- Re-use/Donations:	$210.00
			Remaining Balance:	$590.75

Figure 23: Budget Sheet

Travel Expenses

Because of our aforementioned success in budgeting, the trip to Tennessee will cost each team member about $50 out of pocket. We consider this to be a reasonable amount for a 4-day trip to Tennessee including meals, lodging, and activities. Lodging expenses will cost about $4000 in total for the team. Meals are calculated to come to about $1000 for the trip without including dinners that each member will pay for themselves.

Acknowledgements

There are many thanks and acknowledgements that have to be made to those who made this year's ROV company possible. First of all, we would like to thank Jill Sutton and others at MATE and Liz Sutton and other volunteers at UW-Milwaukee for organizing this competition and allowing us to participate. Next, we would like to thank our corporate sponsors: Grande Cheese, Kurtz Ersa, Polulu, and Aqua-Vu for their support and donations. Personal thanks must be extended to our mentors Mr. Hendrikse, Mr. Boenisch, and Mr. Lammers, as their dedication, patience, expertise, and time helped us grow as a company and as future career professionals. Finally, we would like to thank our parents for their love, support, and encouragement throughout this process.

Photo Accreditation

Nino Miosi- Cover Design and Creation

Charlie Scherpereel- Electrical SID

Ben Wiebe- Software Flowchart

Abram Swart- CAD Drawings

Logan Gartman- Canon Volume Calculation Spreadsheet

Emily Federspiel- Budget Sheet

Amy Antes and Taylor Miller- Team Photos

Maddie Block- Dry Housing, Bulkhead Connectors, Internal Wiring, Tether, Camera, Gripper, Mexican Beach Pebble Dispenser, Thermometer, Mini ROV