Oostburg High School ROV

'24 **Aidan Bossler** Lead Electrical Engineer
'24 **Chloe Breunig** Camera Manager
'24 **Sebastian Schefsky** Lead Frame Engineer
'24 **Livie Stader** Project Manager
'23 **Ethan Brumirski** Lead Mechanical Engineer
'23 **Aiden Hendrikse** Lead Electrical Engineer
'23 **Gavin Konitzer** Software Engineer
'23 **Leigha Rauwerdink** Poster Team
'23 **Levi Rondeau** Camera Manager
'23 **Logan Schuessler** Electrical Engineer
'22 **Quinn Helmer** Poster Team
'22 **Timothy Leitzke** Lead Software Engineer
'22 **Alaina Rauwerdink** Presentation Manager
'22 **Ana Wilson** CEO

2022

Mentors
Terry Hendrikse
Robert Boenisch

Oostburg ROV
Oostburg High School
Oostburg, Wisconsin

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Abstract

The Oostburg ROV Company is a 23-student company from Oostburg, WI, and attending Oostburg High School. The company is composed of curious and creative members intending to draw attention to the issues occurring in the poles of the Earth. Specifically, Antarctica is getting increasingly warmer due to increased global warming and CO_2 levels. This brings harm to sea life and danger to explorers in the ocean because of the formation of polynyas. Oostburg ROV has designed, engineered, and produced a remotely operated vehicle (ROV) that is capable of completing the tasks necessary to help maintain the Southern Ocean.

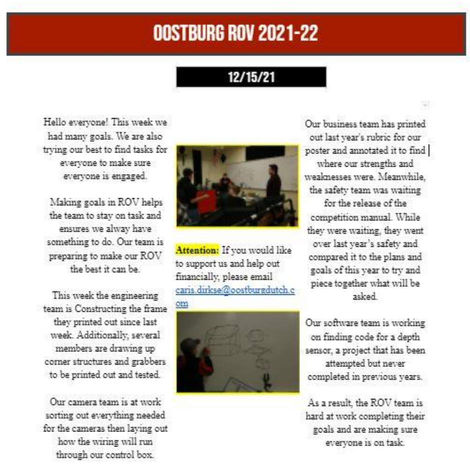
Corporate Profile

The Oostburg ROV Company is divided into two subgroups in order to maximize company productivity and efficiency. These two groups, business, and engineering are then divided into their own individual roles and sub-teams. The engineering department is organized into many groups including electrical engineers, mechanical engineers, software engineers, and tooling engineers. The business team is organized into marketing, technical writing, poster, presentation, and accounting. Each of these departments is managed by our project manager. Our project manager is responsible for creating a schedule for completing various tasks. Every member is responsible for getting their jobs done, and the project manager makes sure these jobs are done on time so no team is put behind. Our team also has two co-CEOs this year. One CEO is in charge of opening statements and managing the business team while the other is in charge of running the closing meetings at practices and managing the engineering aspects of our company. This set-up has allowed us to maximize efficiency and be diligent about completing our work.

Figure 1: Oostburg ROV Company

Corporate Responsibility (Community Outreach)

Our business department has organized several community-outreach events. Our main event this year was our kid's science camp. This year was our first camp back since covid disrupted the last two years and we were surprised and excited to have 73 kids sign up. Because of this large number of kids, we had to strategically organize groups and leaders to make sure kids were well taken care of, but were also having fun and learning about science. To our company, influencing and motivating younger kids to join innovative clubs or extracurricular activities, like ROV, is crucial. Without others leading the way before us, many of us would not have gotten the opportunity to explore this program and would therefore miss out on countless opportunities to learn about the world around us, and also ourselves. Further, our company has had a unique opportunity to be a part of the Endurance 22 mission. A documentary is being made about the mission and following the journey to search for the Endurance ship. A film crew came to a few of our team meetings and got a chance to record our practices and follow us around to see how the Endurance mission directly correlates to the competition this year. Lead members and our mentor were also able to have separate interviews with the crew talking about what ROV has taught us, and how this year's competition inspires us to go on missions like the Endurance. This was an amazing opportunity that offered an experience of professionalism for which our company is grateful.



OOSTBURG ROV 2021-22

12/15/21

Hello everyone! This week we had many goals. We are also trying our best to find tasks for everyone to make sure everyone is engaged.

Making goals in ROV helps the team to stay on task and ensures we alway have something to do. Our team is preparing to make our ROV the best it can be.

This week the engineering team is Constructing the frame they printed out since last week. Additionally, several members are drawing up corner structures and grabbers to be printed out and tested.

Our camera team is at work sorting out everything needed for the cameras then laying out how the wiring will run through our control box.

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

Our business team has printed out last year's rubric for our poster and annotated it to find where our strengths and weaknesses were. Meanwhile, the safety team was waiting for the release of the competition manual. While they were waiting, they went over last year's safety and compared it to the plans and goals of this year to try and piece together what will be asked.

Our software team is working on finding code for a depth sensor, a project that has been attempted but never completed in previous years.

As a result, the ROV team is hard at work completing their goals and are making sure everyone is on task.

Figure 2: Oostburg ROV Newsletter

Communication

As our team continues to grow over the years, we have noticed how vital communication has been in order to work together effectively. To ensure that all departments of our company are communicating together, our company implemented three strategies to increase communication between company members. First, we utilized a large whiteboard on the wall of our workspace room to keep track of important information such as announcements and deadlines. Laying out our deadlines on this board significantly promoted production among our company. Second, our company departments consistently used email. Email was an efficient way to communicate messages with all members, especially those who cannot make it to our regular meetings due to sports conflicts. Third, our company uses a combined Google spreadsheet that's shared with every member. This spreadsheet has sub-tabs that include names, emails, deadlines, project notes, and other information that is useful to team members throughout the season. Keeping our community members aware of what our company has accomplished is just as important as communication among the team. Our project manager is dedicated to ensuring that all deadlines are met. If they are not, steps are put into place on how to complete the task ahead. A department of our company is in charge of writing and sending virtual Newsletters to community members, parents, and individuals who signed up to receive them. These newsletters are sent out weekly and talk about accomplishments.

Tasks	Status	Goal Date	Completion	Person Assigned	Notes
Software - (Tim and Gavin)					
Depth Sensor		www.youtube.com			Waiting on new depth sensor
clean up github			11/17/2021	Tim	
boxes in hud to read serialVal		Extra Goal	1/30/2022		It's called the consonle log, no, seriously.
see which way ROV going		Extra Goal			
Github new people		12/22	12/15	Tim	
teach new members how to use github		1/12		Tim	
Vision		1/29/2022	03/06/22		Delayed due to hard to read documentation for OpenCV
Autonomy		2/5/2022	2/6/2022		Delayed due to vison not working
Cardio			11/17/2021	All	
figure out how depth sensor works		12/22	12/24/2022	Gavin	Waiting on new depth sensor
program depth sensor			2/14/2022		Waiting on new depth sensor
Is santi coming back		12/15	12/15/2021	Gavin	Santi isn't comming back

Figure 3: ROV Project Managing Spreadsheet

Design Rationale

Our company spent considerable time focusing on improving many systems throughout the year. Everything from the ROV frame, to the camera system to tooling has been completely redesigned and rebuilt with the goal of making it more stable and user friendly.

Frame

This year, our company has made significant upgrades to our frame. A prototype of the frame was drawn in CAD and CNC laser cut out of cardboard to ensure proper sizing and allow for visual placement for tooling. The final frame was then built the same size as the prototype with 3D printed connectors and plastic 80-20. The frame was 3D printed in order to be accurate and minimize errors. The dimensions of the frame are 36 cm wide x 70 cm deep x 20.3 cm tall and take up a total area of 51,156 cubic cm. Our engineers made the frame from size 10 80/20 plastic because it is a very versatile material and allows the dry frame to have an economically friendly mass of 2.915 kg. The 12 cm by 12 cm T-type slot material is superior to other materials because it allows tools such as grippers and cameras to be attached anywhere along the frame within the T-slots. Our team has had lots of success with the material in the past and believes the material used is the most economical and cost-effective method.

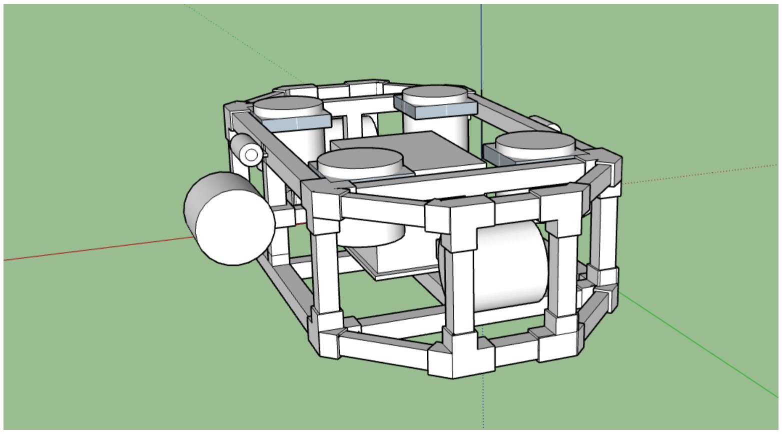


Figure 4: Complete CAD of ROV and Frame

Dry Housing

Dry housing provides both buoyancy and protection for underwater electronics, proving to be a key aspect of the ROV. Using the same dry housing box generously donated by Integra Enclosure last year, engineers designed the ROV to have maximum stability by placing more buoyant dry housing near the top and heavier components on the bottom. This allowed us to have 43 Newton of buoyant force based on the equation 4.4 kg x 9.8 m/s/s. A double shelf rack is being utilized in the dry housing to help avoid any issues with tangled wires, or bad organization of electrical components which can be hazardous to the ROV and team members.

Figure 5: Dry Housing

Bulkhead Connectors

The bulkhead connectors allow communication and energy into the dry housing while keeping the internal electronics dry. In short, without the bulkhead connectors, the electronics will fail. The leak could cause major issues in the functionality of the ROV as well as thousands of dollars of damage to the electronics. The past two years we have used SubConn bulkhead connectors that performed at a high caliber. Because of this, our engineers decided to use this 300-volt bulkhead connector series for power distribution and 21 pin connectors for communication and motor power distribution. These connectors allow us to operate from a depth of up to 2900 m showing how versatile our company ROV is due to the extensive functioning range. Our company was donated these connectors by SubConn a few years ago, and their professional composure has allowed us to reuse those same connectors.

Figure 6: Bulkhead Connectors

Electronics and Internal Wiring

Our dry housing is contained in a box placed in the middle of our frame. This box works well in combination with custom plexiglass levels that organize our wires and converters; this provides no chance for disconnections or tangles. Our system contains 8 thrusters; four for up and down, two for forward and back, and two additional thrusters for strafting. In total, all thrusters consume approximately 20 amps of current at 12 volts, when at full capacity. Also, within our dry housing, are eight Blue Robotics Electronic Speed Controls (ESCs) that power eight Blue Robotics, brushless T200 Thrusters. To provide our desired 5 volts to power the Savox SW-1210 digital, waterproof servers, we installed two DC-to-DC step-down converters. Our input wires for tooling and cameras lie on the top level to provide easy access.

Figure 7: Wiring and Electronics inside of Dry Housing

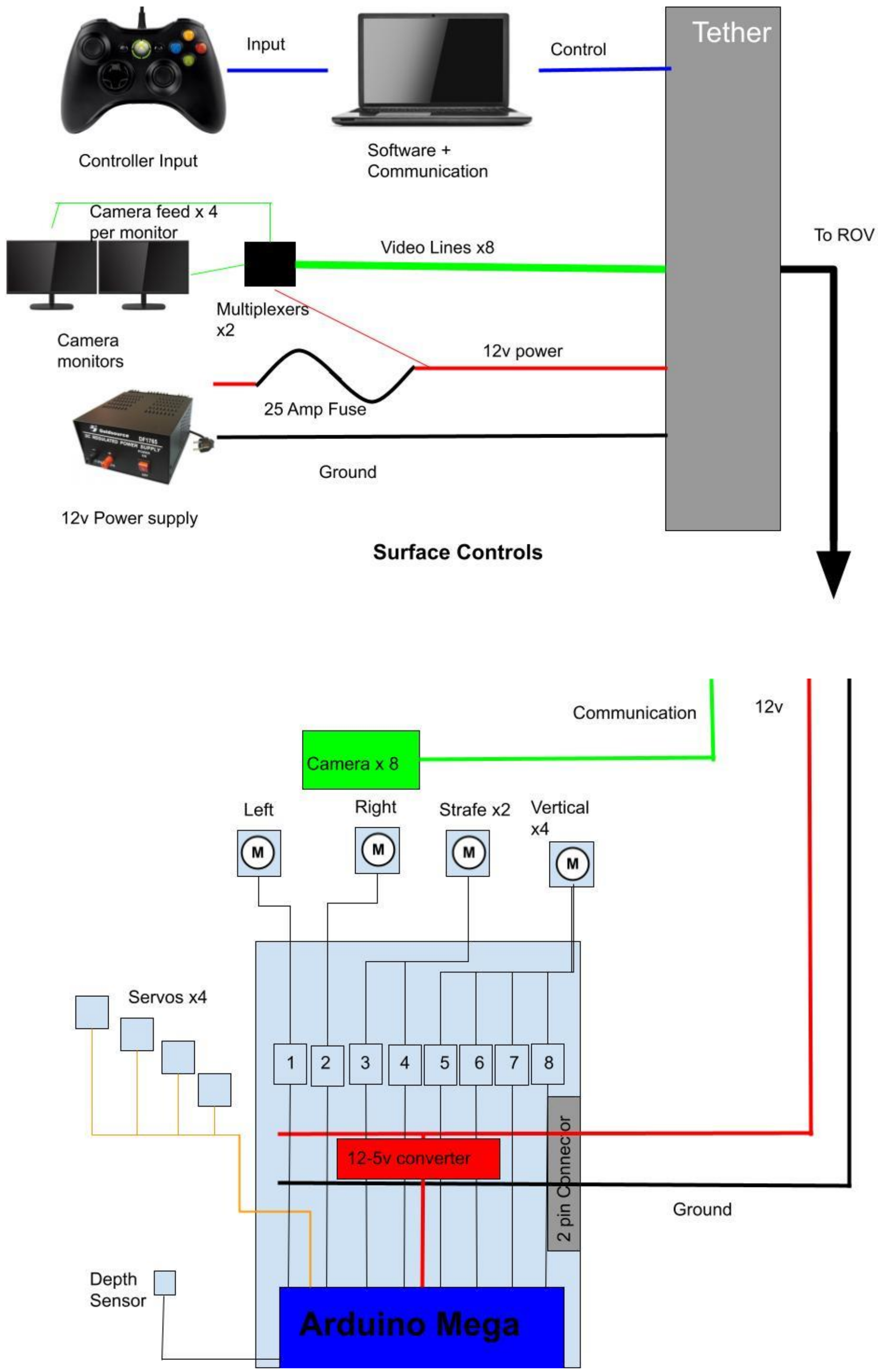


Figure 8: Electrical SID showing 25-amp fuse by Jason Becker

Microcontroller and Software

Our original written software code was altered and updated as our ROV and electrical connections changed. Our code was written in JavaScript through processing and C++ through Arduino. Our Arduino board is a mega 2560. Processing spits out the GUI and interprets the voltages from the Xbox 360 into serial values. Serial values from processing are injected into the serial monitor for processing.

Tether

The tether is encased by a cable management sleeve. This sleeve organizes and houses eight RCA video cables, a USB communication, and two marine-grade, 12-gauge, braided cables that provide 12 volts of topside power to the ROV. The tether is 16.25-meters long, and its main job is to transfer power, communication, and video between the ROV and the controls. We are using 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 intakes 15.28 amps. When handling our tether, our protocol is to inspect all parts of the cable management system to make sure there are no free wires and make sure that the tether is not twisted. These things allow for releasing and retracting the tether from the pool.

Propulsion

Just like years past, we have implemented Blue Robotics T200 motors into our ROV. We have experienced much success through the brushless technology and the efficiency of these motors, which is why we continue to use them. These 4.45 in. by 3.9 in. motors are placed strategically around our ROV to maximize stability and maneuverability. A total of 12 volts is fed into the motors, however, they are rarely run at full speed. Covered by custom motor shrouds, 8 motors sit on our ROV; 4 for up and down movement placed in the top corners, and 4 are used for horizontal movements, surrounding the dry housing.

Motor Shrouds

Our engineers completely redesigned and 3D printed new motor shrouds to include maximum efficiency and to meet the 12.5mm opening safety requirements. This helps protect our company members along with our equipment. Mechanical engineers chose to use the same motors, but the motor shrouds still needed to be updated because of our new frame. Our shrouds are 12 cm wide x 11cm deep x 12 cm tall and are mounted on both the x and y planes of the frame. This helps create easy movement up, down and left to right along with balance in the water. The placement of the motors is key to creating a natural buoyancy.

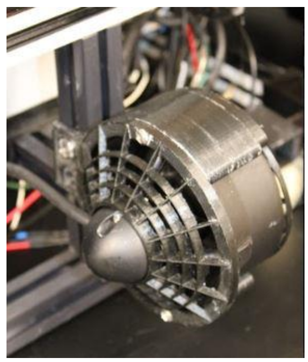


Figure 9: Right Motor Shroud

Cameras

High-functioning cameras allow our pilot the ability to see and complete tasks quickly and clearly. Although we have struggled for numerous consecutive years, we have continued to problem-solve to obtain (resolution) camera quality. Our camera team selected CCTV ⅓ Sony HD Mini cameras. These cameras were waterproofed by nicking the wire coating so that epoxy would fill in this gap. This ensures that even if water is able to travel down the tether, the cameras will not be affected. The focus was tested and adjusted before any further steps were taken. Next, the first layer of epoxy was affixed to the power and video wires to cover exposed wires. These specific wires were separated before this with a non-conductive material to ensure no malfunctions or faults. They were then put into custom 3D-printed cases with another layer of epoxy around the outside. The cameras undergo pressure testing at 10 PSI, to replicate pressure at 25 ft underwater. Focus tests are run to weed out the best-performing cameras, which are then placed on the ROV. There are 8 cameras on the ROV; 4 on the x plane and 4 on the y plane. These are placed all around the ROV for maximum vision as we carry out the mission.

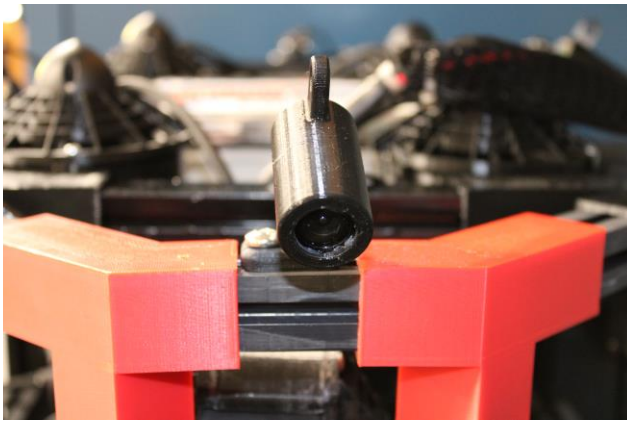
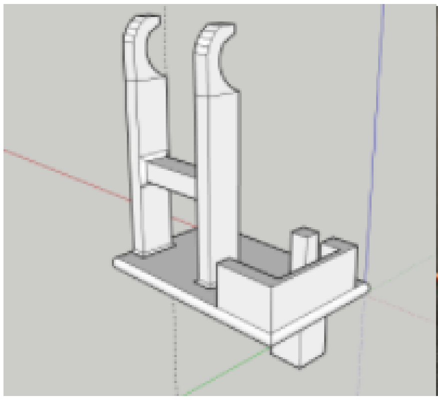


Figure 10: Front Side Navigation Camera (one of eight cameras)

Tooling

Gripper

This year, our tooling engineers designed and created three different grippers. All the grippers attach and detach from our universal mounting system magnetic hook located on the frame. Our universal gripper uses three prongs. The three-prong gripper is crucial for stronger grip on objects because the prongs overlap and lock in place. This gripper is used to pick up things that are moderate in weight and size. Our second gripper is the pin puller. This gripper will be utilized to deploy the hydrophone and ghost net in task 2 in order to help produce affordable and clean energy. The four-prong gripper is useful for heavier and bigger pieces that will be used in task 1 for releasing a clamp and rotating it 180 degrees before removal. Along with these grippers, we have also incorporated a tape measure for measuring fish size in task 2.3. This will be held by our grippers and is a part of a meter stick. All grippers were 3D drawn and printed by our lead tooling engineer.



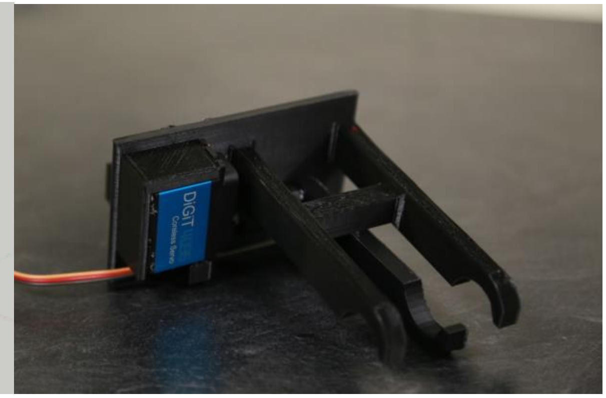


Figure 11: CAD of Three-prong Gripper **Figure 12: Three-prong gripper**

Power Probe

One of our company mottos has always been to “KIS”, or keep it simple. One way we continue to do this is by the use of the power probe. The power probe is a threaded, stainless-steel rod attached to the frame that is 20 cm long. The power probe is reliable and ensures simplicity in a complex functioning ROV. It is a “safety net” on some tasks in case a gripper was to fail.

Sub Bouy

Our buoy, unlike the typical form, has the ability to sink and return back to the surface. We designed this for task 3.1 and hope to achieve 40 points through this float. This was designed using a plexiglass box with a syringe within the middle, which can be moved with a servo with a gear attachment. This allows water to enter into the box and change the buoyancy; therefore, allowing the buoy to sink. The syringe moves when a battery is turned on and relies on a timer to know when to add or lose water. Our engineers made sure to make this time-frame large enough so that they can complete the task within the timetable, but also quick enough that it would not hold them back from moving forward in the pool run.

Control System and Software Coding

Just as in past years, our ROV navigation is achieved through input from an Xbox 360 controller. The software engineers 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 replacing a section of an inter-array cable. The left stick controls forward and backward movement of the left side motors, while the right side controls the right-side motors. We added an overdrive feature to the ROV last year. Using that same feature, the ROV can move at double the speed and can travel longer distances in a timelier manner. 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 our team of software engineers.

Challenges and Lessons (Technical)

A technical challenge our team had this year was with our software coding. Our Arduino could only receive 5 volts of analog input, and the depth sensor output was giving out voltage up to 10 volts. Typically, a converter would need to be purchased for the ROV, but this wasn't possible because the voltage needed to vary. Our company is extremely innovative, and one of our engineers decided to make one instead of purchasing one. The handmade DC to DC converter features two 220 ohms resistors in series with another parallel 220-ohm resistor. This innovative project has proved to be fully functional and helps the depth sensor operate properly.

Software Flowchart

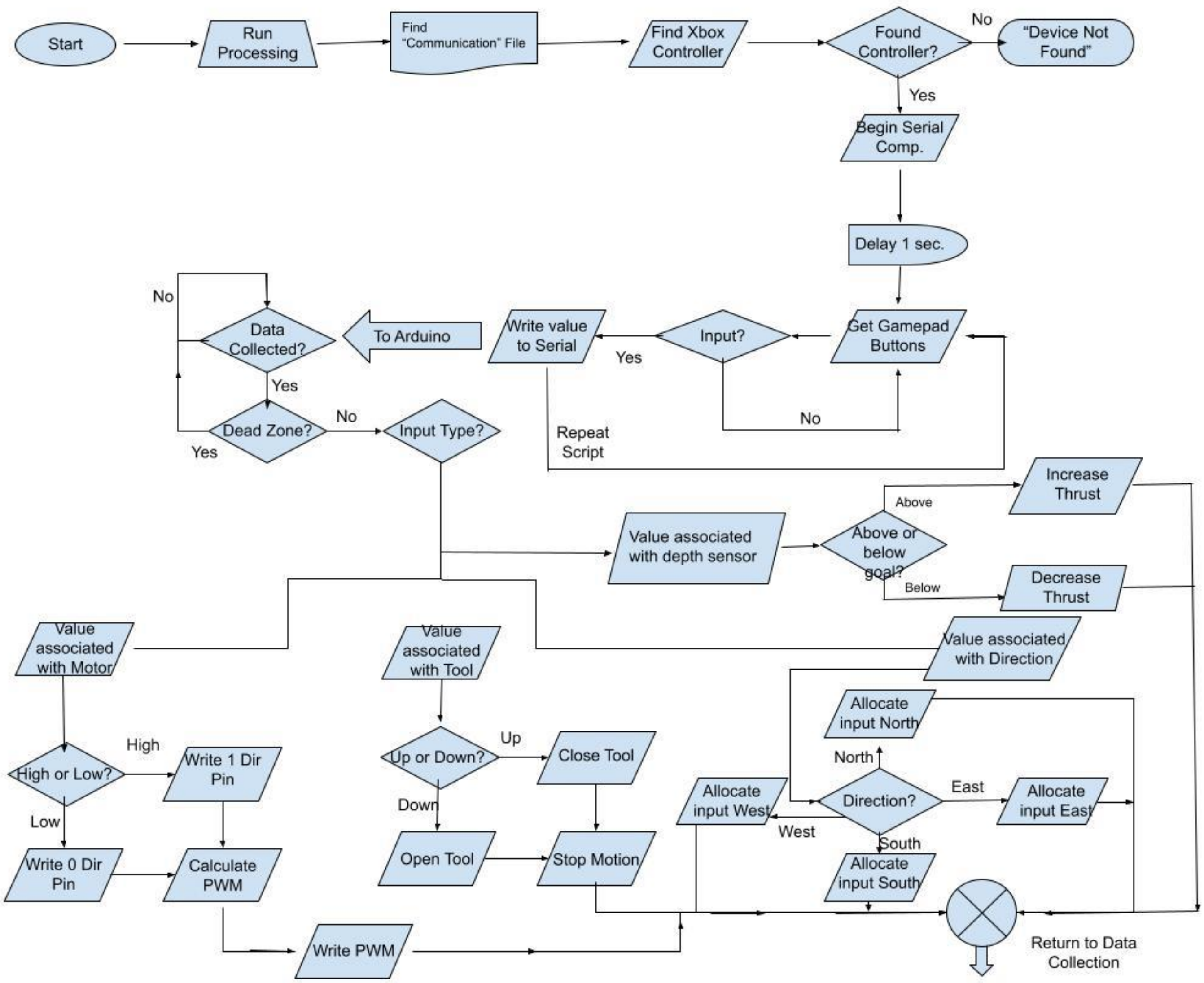


Figure 13: Software Flowchart by Jason Becker

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. 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 14)

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 • The on-deck team is wearing proper safety attire (eye protection, closed-toed shoes, etc.) • All fuses are installed and functional	• Uncoil tether and organize the area • Ensure safety checklist is observed and complete • Turn power on • Check camera feed and position • Test all systems for full and safe functionality

Figure 14: Safety Checklist and Protocol

Testing and Troubleshooting

Our ROV Company has placed a large focus on perseverance through tough problems. Time is an essential factor to the season, and more time practicing pool runs or touching up a paper has a direct impact on success. Knowing this, our company created a schedule that would allow for 20 or more practice pool runs. Completing these 20 practices runs allows engineers to troubleshoot any issues in mechanical or electrical disconnects in the ROV, and allows the pilot to create strategies on the quickest way to effectively complete all tasks. Our team perfected our services to Antarctica and marine life prior to the competition by meeting for 2.5 hours every Wednesday after school.

Challenges and Lessons (Non-technical)

As said before, we have a uniquely large company. And while there are a lot of advantages that come along with a team of this size, there are also a couple of challenges that our company has faced. We are all working towards the same goal, but miscommunications are common and because we all rely on each other, when one person is behind schedule, everyone ends up behind schedule. We faced this problem early on in the build when it came to the frame. Again, as we completely redesigned the frame this year, we faced prototyping and modifications, which put us drastically behind schedule. The project manager was set to the task to make sure our mechanical engineers were focused on completing the frame and preparing it for the electrical team. Although the frame was finished after the deadline, we problem-solved and incorporated many teams into this solution, learning that deadlines are crucial to stay on top of.

Prototyping

The main area where we used prototyping this year was the frame. As seen in the Figure 15, our mechanical engineers analyzed many different design prototypes of the frame. The prototype was cut out of cardboard on a CNC laser. They decided on a frame that was visually appealing but also functional. A key aspect of our frame this year is agility and the ability to move into smaller spaces. This allows for our team to move onto other tasks without having to come to the surface, and being able to move closer to the tasks, despite the larger size. The frame also has a defined front and back, different from the other prototypes, and our frame design in the past. Although we have switched the model from many past years, we believe the chosen design will bring the most success to the ROV.

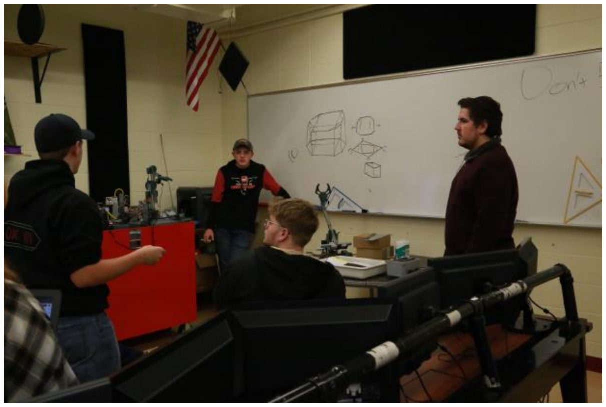


Figure 15: Mechanical engineers sketching frame ideas

Reflections

"As a freshman, I never thought I would join the Oostburg ROV team. In my mind, ROV was for the needy kids who were smart and knew things about engineering. The first time I heard of it was in middle school when they shared about trying out. I had zero interest whatsoever. Then, the summer going into sophomore year, I was walking through the activity fair held in the gym and came across the ROV table. Makenna Hendrikse, now an alumnus of Oostburg ROV, was so excited to see me walking through and called me over to the table. I still had no interest, but went to go hear her out anyway. After our conversation, I decided to take a chance and sign-up sophomore year, not knowing what to expect. One thing that helped was having friends join for the first time too! I came back both junior and senior year because ROV has taught me organization, hard work ethic, leadership, and good communication skills. The lessons and skills I've learned in ROV will be with me as I enter a new stage in my life to pursue my goals for my future. I am pursuing a nursing degree and believe that the communication skills and innovative ways of solving problems will give me an advantage in the tough coursework I am about to experience."

-Alaina Rauwerdink, Presentation Team

"I came into the ROV season with no expectations and had no clue what it was. I was approached by Mr. Hendrikse and asked if I could help with the program. Coming into the season, I was eager to get to know more students as it is my first-year teaching. Further, I was excited to learn about how ROV works and functions. This year I have learned a lot not only about ROV, but a lot about my new students' strengths and weaknesses. I quickly learned that our team motto was "ROV is life", and these kids proved that by working hard and coming in extra hours to help out. I am looking forward to the competition and continuing to mentor these kids in years to come."

-Travis Obbink, First-year Mentor

Company Effort

Our company is extremely dedicated to the success of our ROV. Even though our team was split into smaller sub-committees, beginning meetings helped us work. The open flow of communication between engineering and business members was key to our overall success. Team members are very industrious and focused on creating an ROV cohesive to our theme.

Cost Analysis

Our company strives to be thrifty and efficient in our spending and reusing of supplies. Fortunately, our company has the support of our school and several community members. In addition to a district budget of $500 and the State robotics grant of $3,000, our team received several anonymous donations amounting to $806.55. Our team has also partnered with Acuity Insurance the past few years, and they have graciously provided once again $2,500 to our program. Company members would fill out a shared Google Form with links to what needed to be ordered and the quantity so the financial advisors could make the purchase and record the information accurately.

Travel Expenses

Because of our previously discussed success in budgeting, our company will have no problem traveling to the international competition. Our company has budgeted enough money to be able to provide for all members hotel and food accommodations while at the competition. Team members purchase their plane ticket.

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 16: Finance Sheet

Acknowledgements

We would like to take this opportunity to thank a few key people who have helped with our company's success. First off, we would like to thank Liz Sutton and others at MATE who have helped make this competition successful and possible through continuing times of COVID-19. We are appreciative of the continued support and organization of this competition and the international competition. Next, we would like to thank our sponsors Keller America and Acuity Insurance. A personal thanks is extended to our parents and mentors who have been supportive and encouraging throughout the whole entire season. Our mentors have invested into our futures and expertise in the field of robotics and company set-up, and we are determined to not let it go unnoticed. Lastly, we would like to thank our school English experts for reading over the technical report and giving feedback and recommendations on grammar and rewording of phrases. All of these people have made our team hopeful of great success and the competition, and more confident in our skills we can use in our future professional fields.

Photo Accreditation

Ana Wilson – Front cover design and creation

Jason Becker- Electrical SID and Software Flowchart

Dylan VanEss- CAD Drawing of ROV

Ethan Burmurski- CAD Drawing of Grippers

Karli Swart- Finance Sheet

Alaina Rauwerdink- Team Photo and engineers brainstorming frame ideas

Caris Dirkse- Photos of dry housing, bulkhead connectors, motor shrouds, electronics and internal wiring, three-prong gripper, camera, and safety checklist.