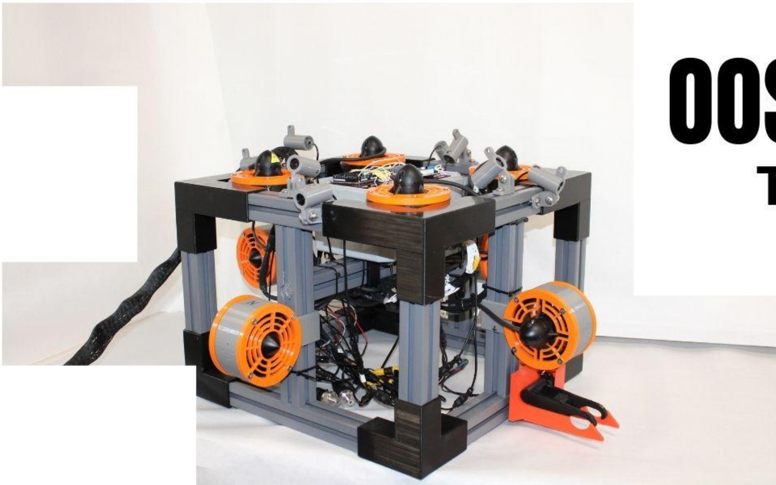
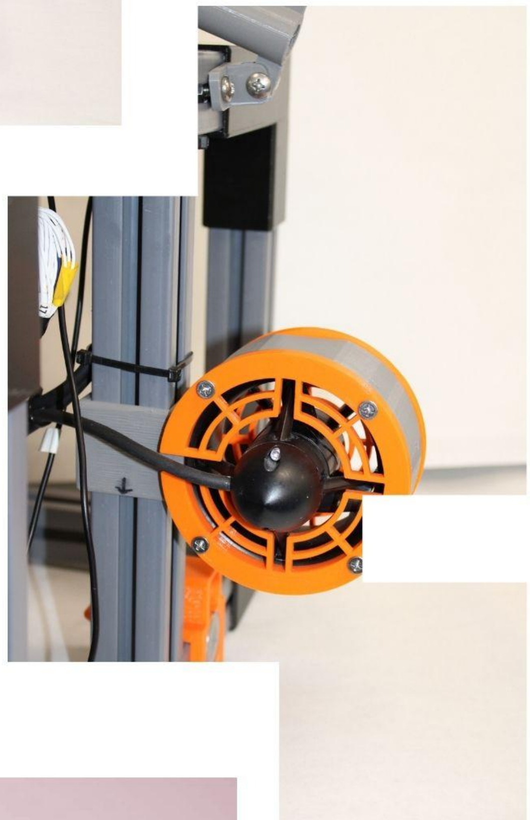
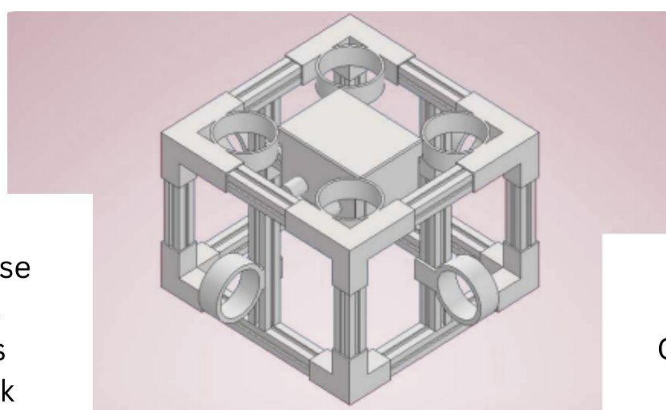


OOSTBURG ROV

Technical Report



‘23 Caris Dirkse: Company CEO, Lead Technical Report
‘23 Ethan Brumirski: Lead Mechanical Engineer
‘23 Gabrielle Mentink: Lead Poster Team
‘23 Aidan Hagg: Software Engineer
‘23 Aiden Hendrikse: Lead CAD Drawing
‘23 Gavin Konitzer: Lead Software Engineer
‘23 Gabe Mentink: Lead Props and Mechanical Engineer
‘23 Breleigh Navis: Lead Poster Team
‘23 Leigha Rauwerdink: Lead Presentation Team
‘23 Levi Rondeau: Mechanical Engineer
‘23 Karli Swart: Lead Finance
‘23 Natalie Walker: Finance
‘24 Aidan Bossler: Lead Electrical Engineer, ROV Pilot
‘24 Chloe Breunig: Lead Cameras and Safety
‘24 Livie Stader: Lead Project Manager and Community Outreach
‘25 Connor Marcantel: Mechanical Engineer
‘25 Colleen Wilke: Props



Mentors:
Terry Hendrikse
Travis Obbink
Jacob Dulmes
Justin Mentink

Oostburg ROV
Oostburg High School
Oostburg, Wisconsin

Table of Contents

Abstract……..3
Corporate Profile……..3
Corporate Responsibility……4
Communication……5
Design Rationale:
Frame……5
Dry Housing…….. 6
Bulkhead Connectors……..6
Electronics and Internal Wiring……..7
SID……..8
Microcontroller and Software…… 9
Tether…… 9
Propulsion…… 9
Motor Shrouds…… 10
Cameras……..10
Tooling:
Gripper…… 11
Power Probe…....12
Control System and Coding Software…… 12
Software Flowchart…… 13
Safety…....14
Troubleshooting and Testing…… 14
Challenges and Lessons (Technical)...... 15
Challenges and Lessons (Non-technical)...... 15
Senior Reflections……..15
Mentor Reflections……16
Budget Cost…… 17
Acknowledgements……18
Photo Accreditation……18

Abstract

The Oostburg ROV Company is made up of 17 members from Oostburg, WI, and attending Oostburg High School. Our company desires to address the issues that have arisen from Colorado's waterway in order to align with the United Nations movement for a *Decade of Ocean Science for Sustainable Development.* We significantly impact the ocean from Colorado even though it is hundreds of miles from the nearest shore. The rivers and waterways are direct conduits to the ocean. Anytime you leave trash and plastic in the yard outside, or live a wasteful lifestyle, trash can make its way into waterways that eventually flow into the ocean. Oostburg ROV has designed, engineered, and produced a remotely operated vehicle (ROV) that is capable of completing tasks like installing a solar panel array, administering Rx to diseased corals, and monitoring the endangered giant frogs of Lake Titicaca. These things are necessary to help maintain and promote clean energy in the Colorado waterways.

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. We also have a company CEO that is in charge of all other team members and staying on track with our company schedule. The CEO was the main channel of communication between the engineering and business team. Each week at practice, meetings were held at the start and end of practices that helped facilitate communication between all departments. This set-up has allowed us to maximize efficiency and be diligent about completing our work.

Figure 1: Oostburg ROV Company Team Photo

Corporate Responsibility (community outreach)

Our business department has organized several community-outreach events. Our main event this year was our annual kid's science camp. We were excited to have 47 kids attend the camp. 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. All of the experiments the kids did were science related, yet connected to Disney movies. 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. We were able to raise $1175 through the outreach, and got the unforgettable experience of sharing science with young kids.

Figure 2: Kids Camp Photos

Communication
As our team strives to be effective in serving the Colorado community, we understand the importance of communication. 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 the beginning 10 and last 10 minutes of practice to meet all together as a team to work and brainstorm ideas cohesively as a team. Conducting these meetings and laying out our deadlines during them 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 can not make it to our regular meetings due to sports conflicts. Third, our company uses a combined Google spreadsheet that is shared with every member. This spreadsheet has 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. Most of the time steps include regular email reminders, accountability on new deadlines, and if needed, recruitment of more people to complete the task as quickly as possible. 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.

Design Rationale
Our company spent considerable time focusing on improving many systems throughout the year. Everything from the ROV frame to tooling has been completely redesigned and rebuilt with the goal of making it more stable and user friendly. The following sections will focus on the design rationale of the frame, dry housing, bulkhead connectors, electronics, software, cameras, and tooling.

Design Rationale: Frame
This year, our company has made significant upgrades to our frame. We obtained a sponsorship from Thermoprene. Thermoprene gifted our company with custom made 18 cm by 18 cm quad rail (the company's specific version of type T-slot material). Our frame engineer then made drawings on CAD in order to get the exact dimension needed of each frame piece

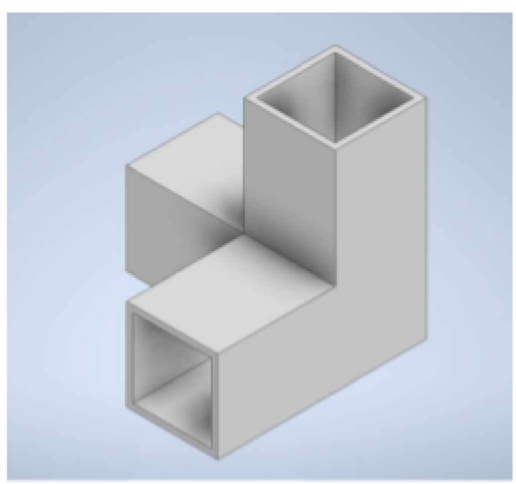


Figure 3: Corner Frame CAD Drawing

before cutting and building the frame. The frame had ends that were created and 3D printed in order to be accurate and minimize errors. The dimensions of the frame are 46.99 cm wide x 46.99 cm long x 34.29 cm tall and take up a total area of 75, 714 cubic cm. Our engineers chose Thermoprene's material because it is very versatile, allows for easy mounting of tools and allows the dry frame to have an economically friendly mass of 5 kilograms. The frame was specifically designed to do all tasks at a high caliber.

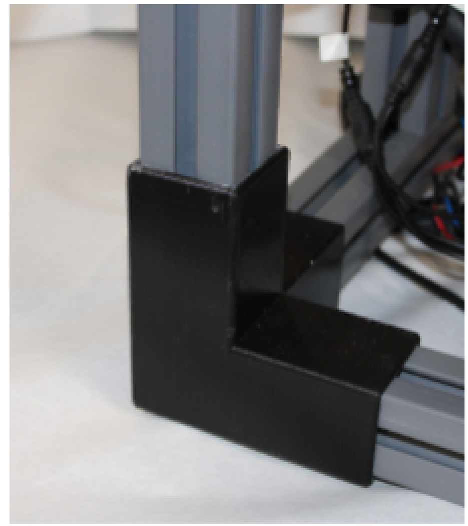


Figure 4: Actual Corner Frame

Design rationale: Dry Housing

The dry housing provides both buoyancy and protection for underwater electronics, both key aspects 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. A double shelf rack is being utilized in the dry housing to help keep electrical components and wires organized.

Design rationale: Bulkhead Connectors

The bulkhead connectors allow communication and energy into the dry housing while keeping the internal electronics dry. Without the bulkhead connectors, the electronics will fail. A leak could cause major issues in the functionality of the ROV as well as thousands of dollars of damage to the electronics. The past three 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. Our company was donated these connectors by SubConn a few years ago, and their quality construction has allowed us to reuse those same connectors.

Design rationale: Electronics and Internal Wiring

Our dryhousing is contained in 16.5cm by 21 cm by 13 cm 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. The wiring in our system supports 8 thrusters; four for up and down, two for forward and back, and two additional thrusters for strafing. In total, all thrusters consume approximately 20 amps of current at 12 volts, when at full capacity. Also within our dryhousing, are eight Blue Robotics Electronic Speed Controls (ESCs) that power eight Blue Robotics, brushless T200 Thrusters which are controlled by the Arduino. 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. Wiring for the ROV is neatly organized so that it does not get caught on the solar panel array prop.

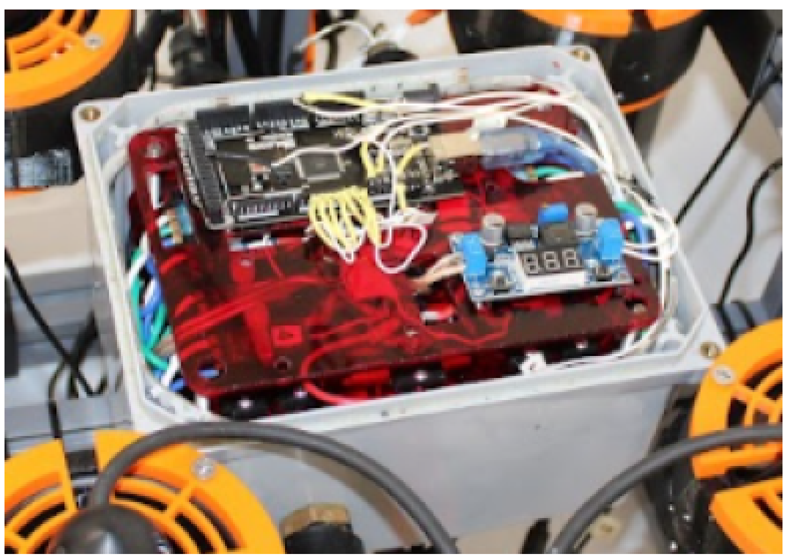
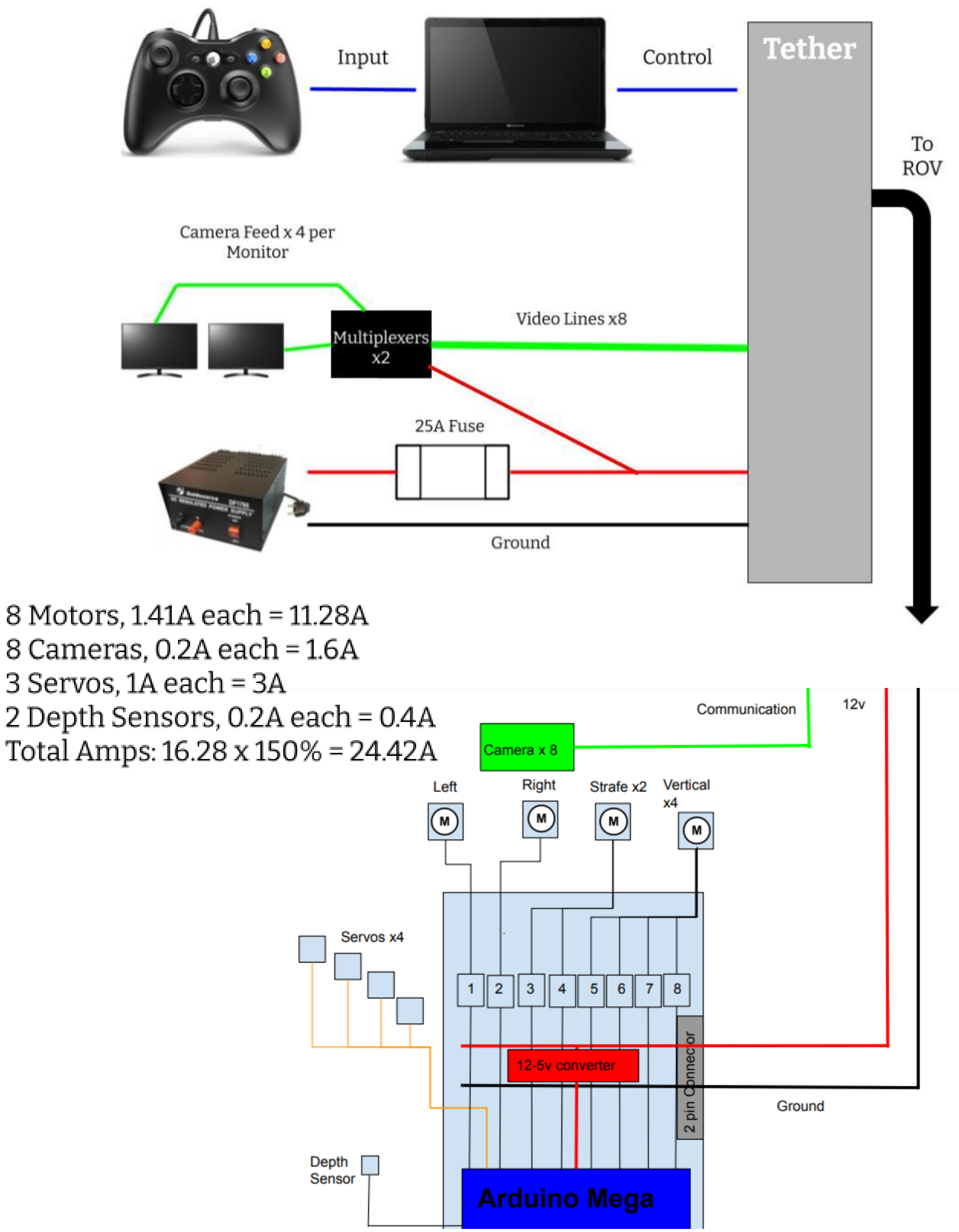


Figure 5: Dry Housing without Lid



Input
Control
Tether
To ROV
Camera Feed x 4 per Monitor
Multiplexers x2
Video Lines x8
25A Fuse
Ground
8 Motors, 1.41A each = 11.28A
8 Cameras, 0.2A each = 1.6A
3 Servos, 1A each = 3A
2 Depth Sensors, 0.2A each = 0.4A
Total Amps: 16.28 x 150% = 24.42A
Communication
12v
Camera x 8
Left
Right
Strafe x2
Vertical x4
Servos x4
1
2
3
4
5
6
7
8
12-5v converter
2 pin Connector
Ground
Depth Sensor
Arduino Mega

Figure 6: SID

Design rationale: Microcontroller and Software

The original written software code was modified and updated as our ROV and electrical connections changed. Our code was written in javascript through processing and C++ through Arduino. Our ROV utilizes an Aurdino mega 2560. Processing spits out the GUI and interprets the voltages from the Xbox 360 controller into serial values. Serial values from processing are injected into the serial monitor for processing. This system allows us to easily pilot the ROV to remove biofouling from the foundation and mooring lines of floating wind turbines.

Design rationale: 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 requires 15.28 amps at 12 volts which is supplied through tether. 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. The theater also has positive buoyancy so that it does not get caught on the side motors or any surrounding props.

Design rationale: Propulsion

Just like years past, we have implemented eight total Blue Robotics T200 motors into our ROV for navigation. We have experienced much success through the brushless technology and the efficiency of these motors, which is why we continue to use them. These 11.3 cm by 9.06 cm motors are placed strategically around our ROV to maximize stability and maneuverability. A total of 12 volts is supplied to the motors, however, they are rarely run at full speed. Covered by custom, 3D printed 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. Our pilot has found that the placement of these motors work well for small

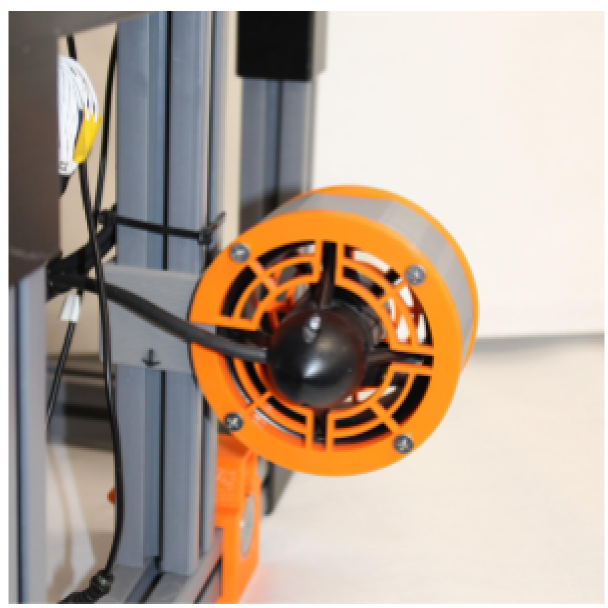


Figure 7: Side Motor of ROV

and precise movements which will help us complete tasks like inserting a syringe filled with “probiotic” fluid into the port.

Design rationale: Motor Shrouds

Our engineers completely redesigned and 3D printed new motor shrouds to include maximum efficiency while still meeting the 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 11 cm in diameter and 1 cm deep and 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 stability and efficient maneuverability.

Design rationale: 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 68,950 Pascal, to replicate pressure at 7.62 meters 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. The placement of our cameras allow for excellent viewing and is essential in completing all tasks in an efficient and timely manner.

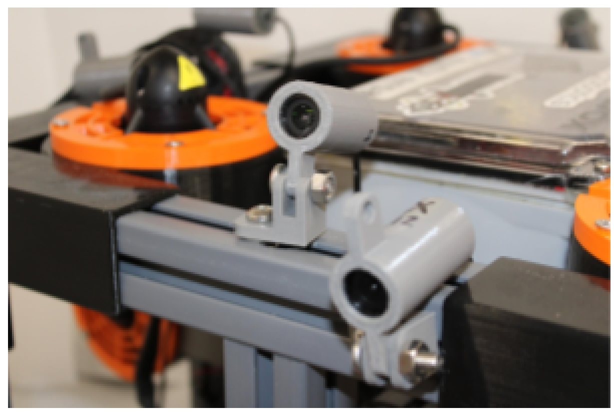


Figure 8: Top Camera

Design rationale: Tooling

Design rationale: Gripper

This year, our tooling engineer designed a unique gripper. The grippers attach and detach from our universal mounting system magnetic hook located on the frame. Our universal gripper uses four prongs. The four prong gripper is crucial for stronger grip on objects because the allprongs overlap and lock in place. This gripper is used to pick up things that are moderate in weight and size. Our gripper will be used to remove biofouling from the foundation and mooring lines of floating wind pipes along with many other tasks. The gripper is fully functional and ready to serve the Colorado waterways in order to maintain healthy environments and marine renewable energy.

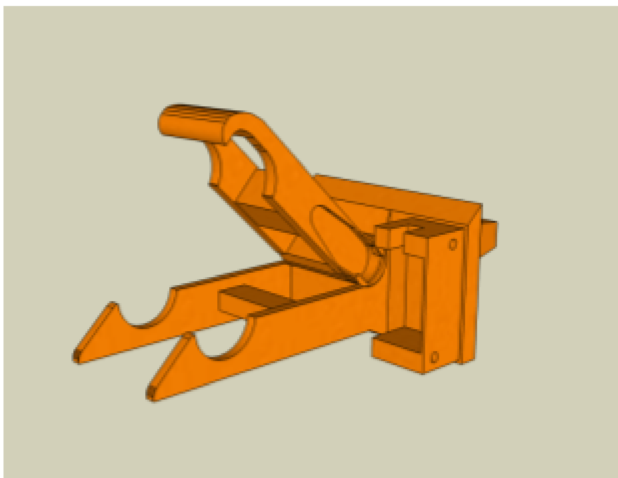


Figure 9: CAD Drawing of Four Prong Gripper

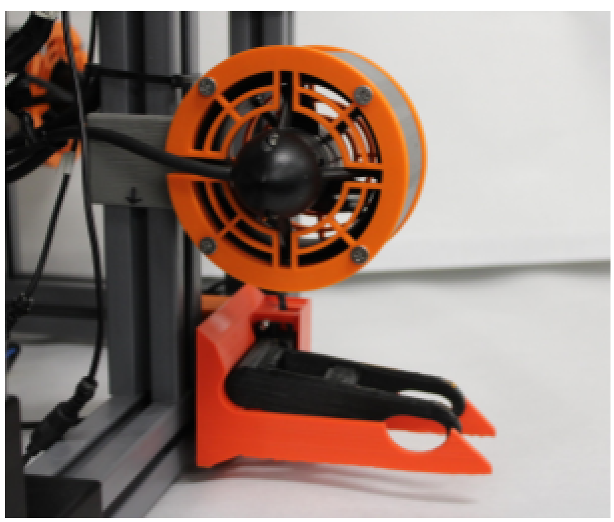


Figure 10: Gripper on ROV

Design rationale: Power Probe
One of our company mottos that we learned from ROV Godfather, Patrick Rowe 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 were to fail.

Design rationale: Control System and Coding Software
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 or electronic speed controller 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. This feature is critical for positioning solar array panels to promote marine renewable energy in task one. 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 more timely 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. Something new our engineers programmed this year is automated vertical input which allows the ROV to hover at the current depth it is at when the pilot releases the vertical input. This will allow for more steady completion of tasks.

Software Flowchart

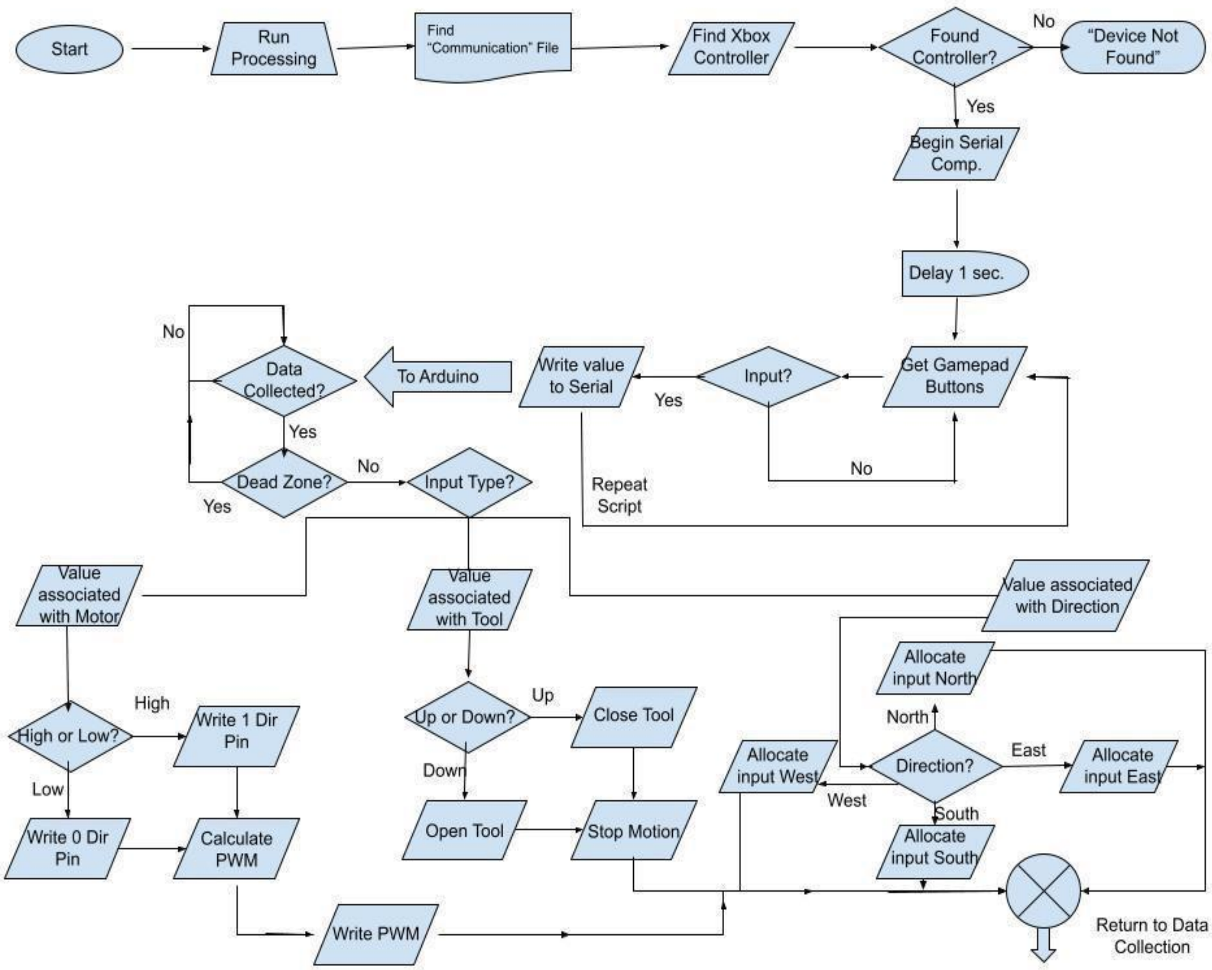


Figure 11: Software Flowchart

Safety

For the Oostburg ROV Company, safety is our top priority. Thus, many safety precautions have been utilized to ensure all members are completing their jobs safely. With the ongoing pandemic, our company has made it a priority to adhere to school policies by being responsible for evaluating our own health to protect ourselves and other company members. Safety glasses were 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 12)

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 12: Safety Checklist and Protocol

Troubleshooting and Testing

Our ROV Company has placed a large focus on persevering 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 for each department (see figures 13 and 14 below) that would allow for 20 or more practice pool runs. Completing these 20 practice 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 (Technical)
A technical challenge our team had this year was with our depth sensors. Keller technologies had generously donated depth sensors last year that did not function properly. We reached out once again, and they donated new depth sensors; however, the same issues were still arising. So, our engineers shifted to Amazon and ordered new depth sensors. While they are functioning at the time of this writing, the code does not fully function to include all the aspects required to complete the 3D model of a diseased coral head autonomously.

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 this size, there are also a couple of challenges that our company has faced. One challenge we faced was availability due to school sports. We are all working towards the same goal: communication and delegation of tasks were extremely important. Early on, miscommunications were common and because we all rely on each other, when one person was behind schedule, everyone ended up behind schedule. The company CEO was responsible for keeping track of the work that everyone was doing, and sending out emails each week to people who missed delegating tasks to ensure our company met our deadlines.

Senior Reflections
“I have been a part of ROV since I was in sixth grade. I had zero interest whatsoever, I just went to the first practice to “check it out” since my older brother participated in middle school. I came back every 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 future goals in nursing for my future. I am confident ROV will give me an advantage in the tough coursework I am about to experience. While ROV can be a long, rigorous season, the consistent success with our team in the past has motivated me to keep the high standard set for our company in previous years.”

- Caris Dirkse, Company CEO, Lead Technical Report

“Even though I only joined ROV last year, it has had a major impact on my life. It has invigorated my love for computer science, and has led me on the career path I am on today. I have learned so much about how a company works in terms of the departments and interpersonal relationships you have to maintain in order to have a successful and productive work environment. This has undoubtedly affected my life in only positive ways, as it lets me do something I love while also developing skills within both team and company style structures.”

- Gavin Konitzer, Lead Software Engineer

Mentor Reflection

“It has been an unbelievable experience to be part of this year’s ROV team as both the engineering and business teams have been focused and efficient in developing and implementing their ideas. I am not only excited to see their hard work play out in the competition, but also to follow them as they move forward in the next steps of their education and careers.”

- Terry Hendrikse, Team Mentor

Build a Schedule

Tasks	Status	Goal Date	Completion	Person Assigned	Notes
Software - (Gavin and Haag)					
Test and ensure keller depth sensors are functional	-	by February-March	-	Gavin, Haag, work with Bender	[illegible]
Test and ensure new depth sensors are functional		by February-March		Gavin, Haag	Code ready to test, waiting on parts
get depth sensor for buoy working		11/9/22	11/9/2022	Gavin, Haag	It works!
get code for buoy working		TBD		Gavin, Haag, work with Gabe	Code is started, but we need a buoy.
get reciever for buoy working		End of February		Gavin, Haag, work with Ethan	We have code made, need RTC
Test depth sensor code on ROV		TBD		Gavin, Haag	Code done, waiting for parts to test/troubleshoot
Autonomous hover mode (F/B)		February-March	12/26	Gavin, Haag	[illegible]
Code pitch into the ROV (F/B)		01/04/23	12/26/22	Gavin	Completed on code end, just awaiting testing on ROV itself
Code roll into the ROV (L/R)		01/04/23	12/19/22	Gavin	Completed on code end, just awaiting testing on ROV itself
Neutral roll/pitch state with gyroscope		by February/March		Haag	Waiting to test/fix any issues that come when we test
See if it is possible to use more of the buttons on the controller		01/04/23	12/19/22	Gavin	Definitely is, made new config file for processing, was able to get use out of 6 more buttons that are now programmable for increased use of the ROV

Figure 13:Schedule for Software Department

Tasks	Status	Goal Date	Completion	Person Assigned	Notes
Technical Report/Safety - (Caris)					
Review last year's rubric and scoring		11/09	11/07	Caris	notes taken on computer, improvements and suggestions taken into account for this year
Write sections we can		Every week		Caris	team setup, abstract, corporate profile, gripper, sevos, etc.
Interview people when tasks completed to stay up to date with information		Weekly		Livie	
Find formatting that works nice		1/11	1/5	Caris	Made it universal so can access on all computers
Prep formatting and rough draft		3/15	3/25	Caris	
Rough draft due		3/25	3/27	Caris	
Make corrections/revision		04/05	4/2	Caris	
Insert photos and figures		4/15	4/16	Caris	
Final proffing					

Figure 14: Schedule for Technical Report

Budget Cost

This year our budget consisted of funds from $250 in personal donations, $2500 from the Oostburg School District, and up to $4500 in matching funds from the State of Wisconsin Robotics Grant. We opened two POs from separate accounts to order all of the supplies we needed this year, and made most of our purchases from Amazon and Blue Robotics. The majority of our budget this year went to building new tools and props. We kept track of all our spending by creating a spreadsheet organized by purchase number and account it came from. In order to have good communication with other team members we created a google form where anyone could submit supply requests for what they needed to ensure that it was documented properly. Before the regional competition, we had spent approximately $1535 on our ROV and had earmarked $8,870.14 of funding to financially offset any travel expenses if we were to move onto the international competition. Since moving on to the international competition, we have reserved hotels to host team members totaling $3,848.20. We also received a $200 donation from a community member after announcing our team would be attending the competition. That leaves us with $5,221.94 to pay for gas and food in Colorado.

Expenses			
Expense	**Examples**	**Amount**	**Running Balance**
Cameras	12 cameras	$350.68	$350.68
Electrical	Power connection plugs	$13.48	$364.16
Software	Gyroscope, Antennae, LCD Display	$38.37	$402.53
	Pressure Transducer Sensor	$28.87	$431.40
	Thread Pressure Transducer	$50.00	$481.40
Tooling	2 Servos & 3 Servo horns	$207.36	$688.76
	3D Printer Filament	$389.50	$1,078.26
	Tapping screws	$16.87	$1,095.13
General	Food for Early Release Practices	$268.68	$1,363.81
	Registration	$165.00	$1,528.81
	LED Lights	$6.99	$1,535.80
	Stipends	$2,696.28	$4,232.08
	T-shirts	$330.00	$4,562.08
Travel	No travel expenses to Regional	$0.00	$4,562.08
Income			
Expense	**Source**	**Amount**	**Running Balance**
Funds	District Budget HS	$2,500.00	$2,500.00
	State Grant	$3,679.00	$6,179.00
	HS Donations	$250.00	$6,429.00
	Salaries/Benefits	$2,696.28	$9,125.28
	Activity account	$4,306.94	$13,432.22
	Total Raised		$13,432.22
	Total Spent		$4,562.08
	Final Balance		$8,870.14

Figure 15: Final Expenses and Income Statement

Acknowledgments
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 our regional competition successful. We appreciate the continued support and organization of this competition and the international competition. Next, we would like to thank our sponsors Thermoprene and Keller Sensors. A personal thanks is extended to our parents and mentors who have been supportive and encouraging throughout the whole entire season. Our mentors, Mr. Hendrikse, Mr. Obbink, Mr. Mentink, and Mr. Dulmes that have invested into our futures and expertise in the field of robotics, we are determined to not let it go unnoticed. Lastly, we would like to thank the staff at our school for reading over the technical report and giving feedback and supporting our mission. All of these people have made our team hopeful of great success at the competition, and more confident in our skills to be used in our future professional fields.

Photo Accreditation

Team Photo - Breleigh Navis

Kids Camp Photos - Aiden Hendrikse

Corner Frame CAD Drawing - Aiden Hendrikse

Frame Photo - Caris Dirkse

Dry Housing Photo - Caris Dirkse

SID - Chloe Breuing

Side Motor - Caris Dirkse

Top Camera Photos - Caris Dirkse

CAD Drawing of Four Pronged Gripper - Ethan Brumirski

Gripper Photo - Caris Dirkse

Software Flowchart - Gavin Konitzer

Safety Checklist and Protocol - Caris Dirkse

Schedule for Software Department - Gavin Konitzer

Schedule for Technical Report - Caris Dirkse

Final Expenses and Income Statement - Karli Swart