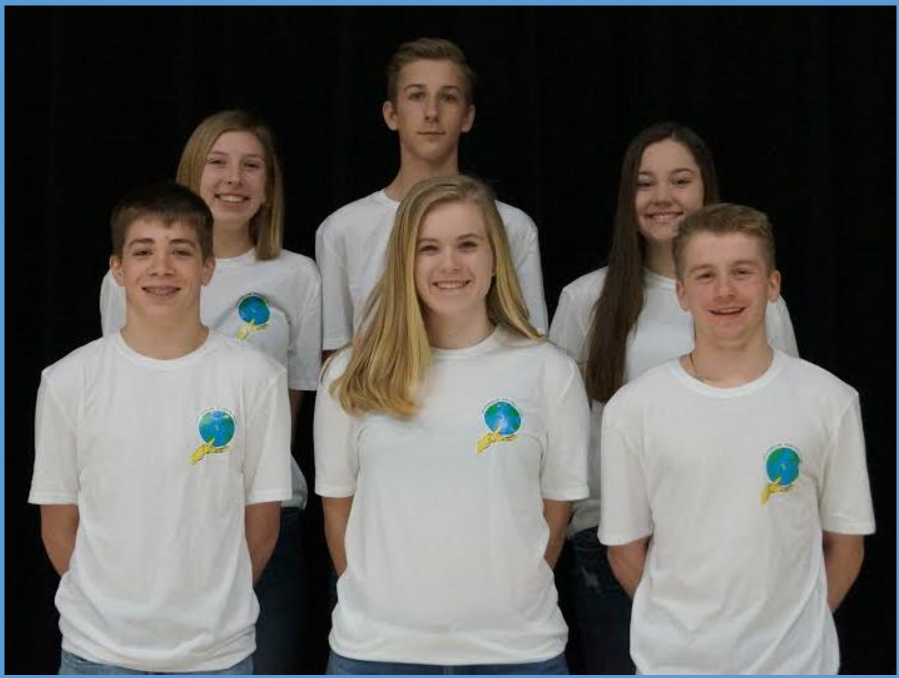
Stockbridge High School Gold Team

Stockbridge High School - Stockbridge, MI 49285

"Using robotics and 3D printing to Inspire, Engage, and Educate, while leaving a positive impact on the world."



Back: Faith Whitt, Colin Lilley, Madi Howard
Front: Kael Bunce, Michelle Zemke, Jake Chapman
*Photo by Kelly Cool

Kael Bunce- Engineering, Class of 2020

Jake Chapman- Marketing Lead, Class of 2017

Madi Howard- Design Engineer, Class of 2018

Colin Lilley- Pilot, Class of 2018

Faith Whitt- CEO, Class of 2018

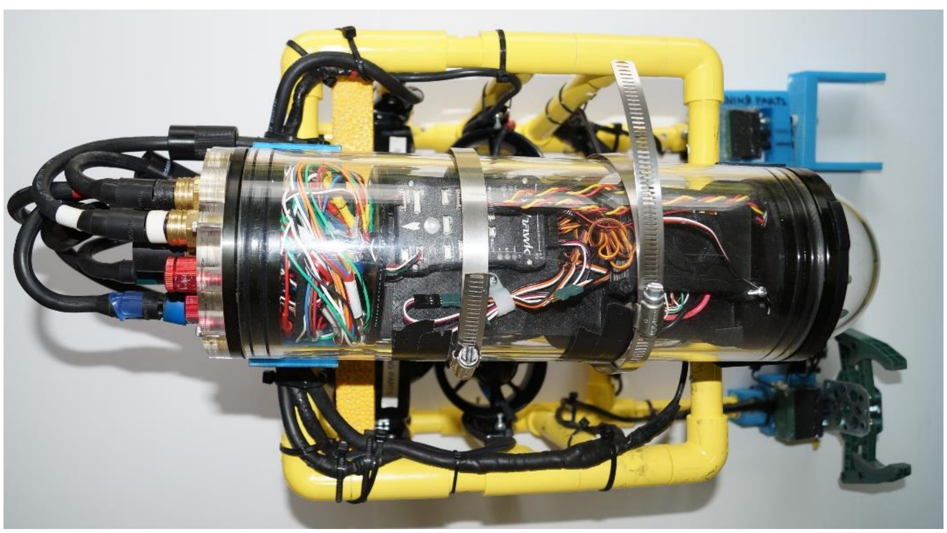
Michelle Zemke- CFO, Class of 2019

Robert Richards- Class Instructor

Abstract

As the Stockbridge Gold Team, we are devoted to designing, engineering, and marketing an Underwater Remote Operated Vehicle (UROV) that is capable of solving any task presented to us. At the 2017 MATE international competition, the missions deal with hyper loop construction, light and water maintenance, environmental cleanup, and risk mitigation.

Our ROV, The Flounder, is specifically designed to complete the challenges that accompany this competition. We have constructed an innovative frame that will easily glide through the water with little resistance. In addition, we have equipped our robot with five thrusters that will enhance our company's performance. We have positioned our Blue Robotics T-100 thrusters in three different locations, two that move our robot up and down, two that move our robot left to right, and our fifth thruster allows our robot to move laterally for precise movement to effectively and efficiently complete any task. The claw that's positioned on the front of the robot allows our company to safely perform high level missions, such as the hyper loop construction. Also, our newly developed electronics and software allows us to control all five of our motors, as well as our camera and claw all on one microcontroller. With all these advancements on our ROV, we are able to more efficiently solve the many assignments given to us. We believe that because of these advancements, our ROV can not only solve the mission tasks, but fix real world problems through hard work, cooperation, and determination.



Top view of ROV, including our clear acrylic electronics housing
*Photo by Michelle Zemke

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Teamwork

Company Effort:

Running our class like a company has many advantages to our effort and productivity. The real world projects that we work towards every year forces us to care about the quality of our robot and our teamwork. The aspect of teamwork plays a factor in our everyday class procedures, you cannot be successful in the pool or on the boat if you are not first successful in the classroom with your team. Our instructor, Robert Richards, understands this concept and applies it while we are learning and improving our robots. He gives us, the students, the materials to produce our robot but encourages our creativity, ideas, and problem solving in a hands on approach that optimizes our learning experience.

Company Assignments:

To achieve the level of efficiency that our program preforms each year, our company assigns tasks that allow each of our six team members to perform to their individual ability. Each team member was given each task based upon their strengths. Once the missions were released, the engineering team met together. They discuss how they are going to build and test the new payload tools. They tested each new concept to see which was the most effective. The marketing side decided how each team member was going to contribute to the technical document, poster and presentation. This system allows each member strengthen the teamwork of our company. Operating in this structure, we have the confidence that our robot and its attributes will perform to their best abilities.

Colin Lilley: Pilot and Structural Mechanic
Faith Whitt: CFO and Media Display Designer
Jake Chapman: Chief Media Executive and Technical Report Writer/Editor
Kael Bunce: Engineer and Design Manager
Madi Howard: Head of Engineering and Technical Report Writer
Michelle Zemke: CEO and Technical Report Writer/Editor

Photo of Madi, Colin, and Jake working together to complete a mission at the MATE Regional Competition.
*Photo by Robert Richards

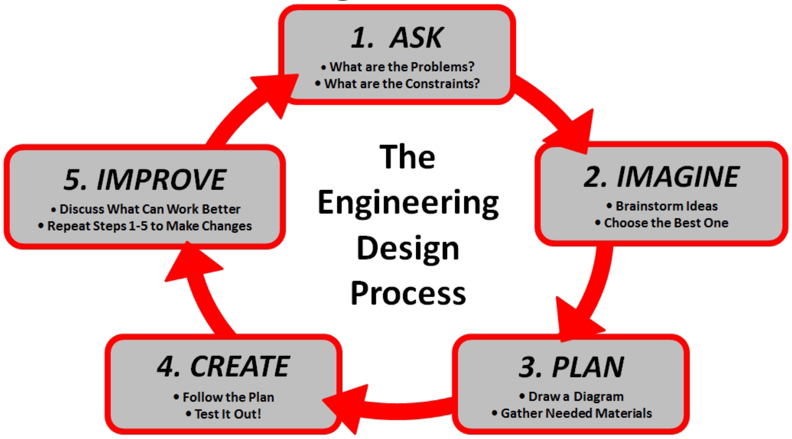
Project Management:

This is a photo of our Trello planning project, which we use to stay organized.
*Photo by Jake Chapman

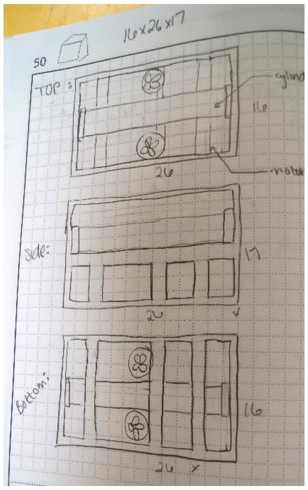
Our team is very concerned with sticking to a schedule because of how many projects we have going on. Every task that is given to us requires lots of work to go with it. This means that each individual has a certain job for everything that needs to get done on that specific day. Each and every day, our company had a briefing before and after class had ended. There, we would talk about what we needed to get done today, and what we would need to finish up the next day. We set clear and concise goals to ensure that all tasks were completed each day. We kept track of everything that we did by writing down what we had done in our engineering notebook, as well as a management site called Trello. Everyone is able to communicate easily through this site. This helped us when there was someone gone, so we could pick up on the task that they had been working on the previous day. Every part that our company needed was run through our CFO, Faith, before they were bought in order to stay within our budget. Our company also has regular checkpoints for every month because we needed to see if we were ahead or behind schedule. Based upon our progress at the end of each month, we would decide what we would need to do for the next month ahead. Since we run our class like a business, we keep an Implementation Plan to stick to throughout the year. It is posted below.

January- Students start new semester of the school year. Begin on building and engineering a new ROV for upcoming underwater robotics competitions.
February- Students continue to go through the design process in building their ROV.
March- Students compete in the Square One Education Network Underwater robotics competition. They write and submit their technical paper for the MATE Regional competition.
April- Students prepare for the MATE Regional competition by going to the pool weekly. **April 21, 2017** compete in the MATE Regional competition.
May- Prepare for the MATE International competition in Long Beach, CA. Fundraise $10,000 for travel and hotel in Long Beach, CA. Submit the technical document by May 26.
June- Submit the Outreach and Inspiration document. Participate in the MATE International competition.

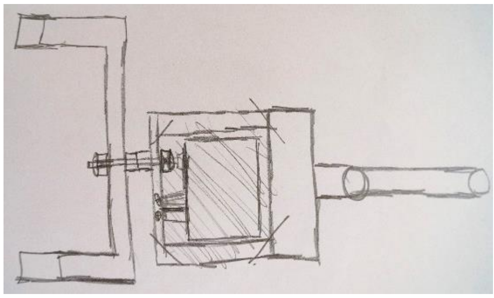
Design Process:



1. As a team, we first determined what the problem that we wanted to solve was. We decided that our goal was to effectively design an ROV to complete the tasks at the MATE ROV competition, as well as preform in real world missions.
2. To start the design process, we read the MATE competition manual and determined what we could build to preform to the best of our ability. We sketched and drafted out a design.



Left: A sketched design of our ROV.
Below: Rotating manipulator design
*Photos by Michelle Zemke



3. To test several designs, we made cardboard cutouts to get a large-scale view of what our potential ROV would look like.
4. We assembled our first ROV based on the blueprints we made in the previous steps.
5. We tested our ROV in the pool and in a smaller competition to see what we could improve on. Then, we adapted the design and repeated the process until we have our current ROV.

Design Rationale

Control and Electronics

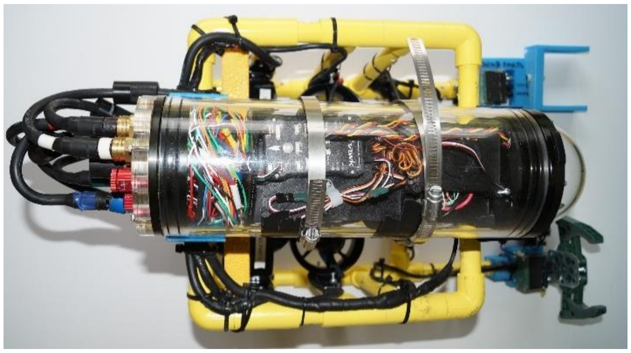
Using the knowledge we gained previously when working with aerial drones, our company has completely redesigned our control system to mimic the same system that our drones use; therefore, this allowed our pilot to easily maneuver and complete all of the mission tasks in a timely fashion. To do this, we have switched to a Pixhawk microcontroller to control our motors and servos.

Our ROVs electronics are completely underwater, except for one topside board, which receives signal from the ROV and converts the signal to a USB plug for convenient access on a laptop. The interface we are using includes QGroundControl, and it allows us to control the ROV using a wireless game controller. The wireless controller allows us to have better cable organization, and it gives us joystick functions instead of buttons or switches.

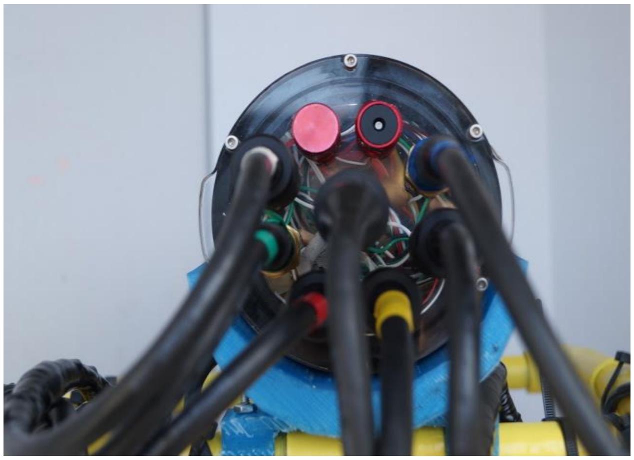
On the ROV itself, our five motors are controlled by basic electronic speed controllers (ESCs). We chose to use a Pixhawk microcontroller to control all five PWM signals from the ESCs because it is easily programmable with our computer cockpit interface. Signal is sent to the topside board by another Fathom-S interface boards that connects to the Pixhawk. This system is user-friendly and gives us capabilities to run up to 10 motors and/or servos.

Having the capabilities to control up to 10 servos or motors is helpful to us in the competition. This allows us to incorporate more payload tools, such as rotating devices to help spin the valve in mission #2.

Clear acrylic housing containing our electronics
*Photo by Kelly Cool

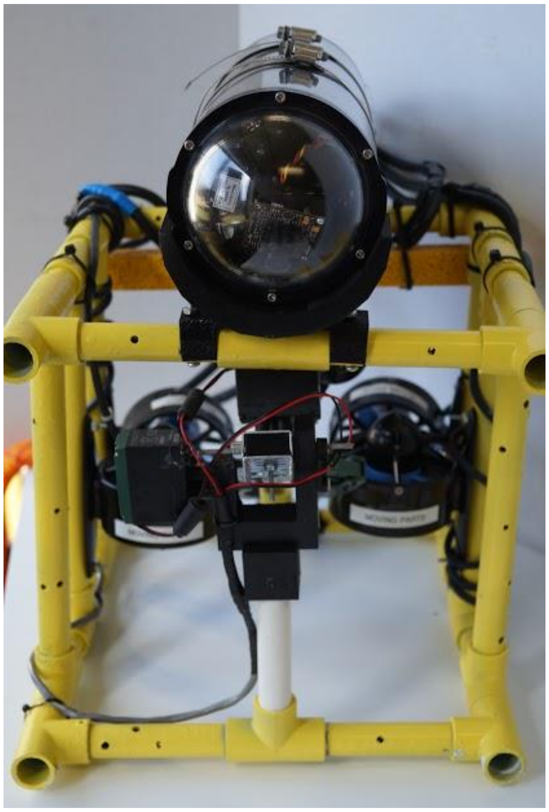


Rear view of the ROV with the SEACON connectors going from the housing to the tether
*Photo by Kelly Cool



Structure

To design our ROV, we first started by sketching designs we thought would be best suited for the challenges ahead of us. Our company met and we presented our ideas and combined them into our first design. We constructed two completely different prototypes and tested the positives and negatives to each design. We soon learned that we needed to cut down our design because a smaller, more compact frame made the ROV move more efficiently in the water. We chose to use ½" PVC for our frame. To make transportation efficient, we have created a vehicle with a height of 42 cm and width of 33 cm and a length of 30 cm for easy shipping. By utilizing minimal material, one person can carry our whole ROV. When using this material it makes it easier to maneuver through the MATE competition, which helps us practice for real-world situations. With all of these considerations, we believe that our current design is both practical and innovative.



Front View of our ROV
*Photo by Kelly Cool

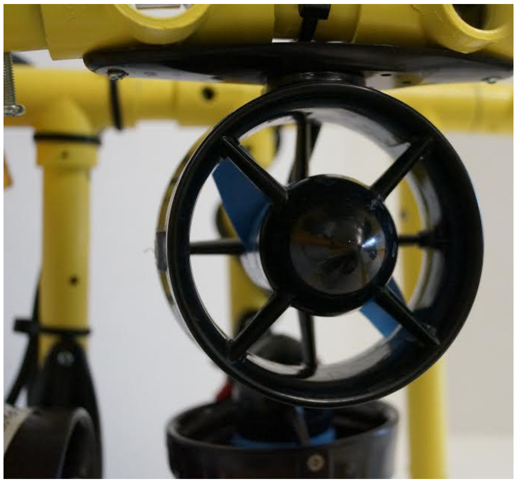
Front view of the ROV, showcasing the dome endcap.
*Photo by Kelly Cool

Buoyancy

We believe that buoyancy and floatation is a very important aspect in any ROV. Our clear acrylic electronic housing serves as a double purpose. The first is to encase our electronics in a protective water tight housing. It also serves the function of our ROVs buoyancy pod. The housing is located in the middle of our ROV to keep consistent buoyancy because of its central location. The housing is depth tested down to 300ft. Our company specifically tested it this past summer in the Great Lakes, down to 200ft.

Tether

Our tether is very manageable. It consists of 1 piece of Cat-5 wire, as well as positive and negative wires, which makes our tether much smaller than other systems. Having a smaller tether is very valuable to the robot because there is not as much drag behind the ROV. It is easier for our members to supervise the tether at the surface. Our tether is in a sleeve of nylon, braided, protective casing, called TechFlex. We have also constructed a U-Bolt strain relief to ensure that our tether cannot pull off our end cap; consequently, the tether also remains directly behind the ROV at all times. This allows us to complete mission tasks quickly and not waste time on being caught on the props.



View of our Lateral Thruster
*Photo by Kelly Cool

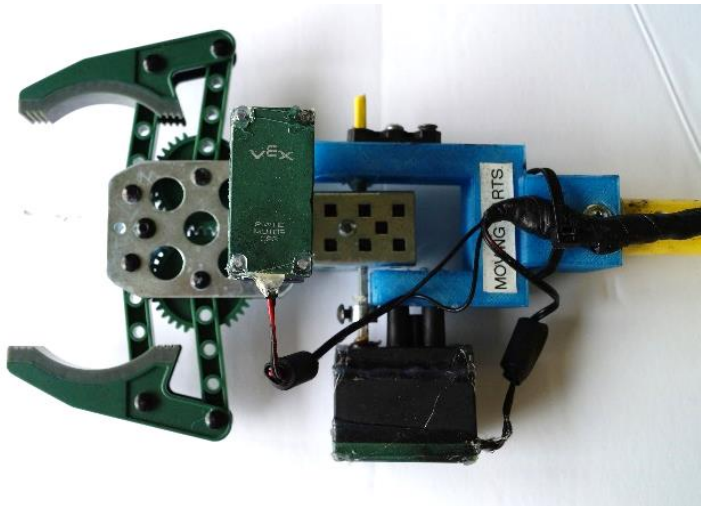
Motors

We are using T100 thrusters from Blue Robotics because they are efficient and durable. Our company decided on using five thrusters to maximize performance of the ROV. Having a five-thruster system compared to a four-thruster system works better because it allows the ROV to have a lateral thruster. This will help during mission #2 when we have to unlock the locking mechanism at the base of the fountain. The five- motor system is the perfect median between both weight and thrust.

Camera

Our company chose to apply a Blue Robotics analog camera. We have found this camera to be more reliable compared to other Ethernet versions. This camera is at much higher standards compared to our competitors' camera systems because we are able to view the feed on a laptop display. This helps with our organization during the competition. In addition, the camera helps us to complete missions such as helping our pilot maneuver the ROV through the environmental cleanup in task 3.We have also developed a 3D printed camera tilt to further our capabilities in the missions.

View of the dome end cap on our electronics housing.
*Photo by Kelly Cool



Claw

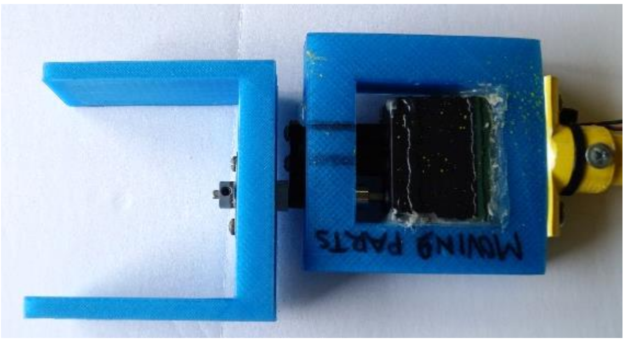
We chose to use a Vex claw as our first payload tool because of the many functions that accompany it. The Vex claw has a wrist that moves vertically up and down. This function will specifically help turn the valve to stop the flow of water in task 2. In addition to this functions, the claw can also open and close to obtain objects. By having a Vex claw, our company has enhanced its efficiency and can complete the missions easier.

This is our VEX claw
*Photo by Michelle Zemke

Other Payload Tools

To more effectively complete the mission tasks, our team developed three aditional manipulators and payload tools. The first is a rotation device that helps spin the water flow valve in mission #2. It is controlled by the wireless controller and consists of plastic and vex motors. We also made a measuring device to effecively determine the distance and direction from the high-risk container so that we can make the correct diagram for mission #4. It is simpily a small measuring tape with a hook attached. Finally, we made a sediment sample device to collect 150 mL of Agar in mission #3. Finally, we have a red led light that is secured to the bottom of our claw so that we can highlight the sediment samples in mission #3.

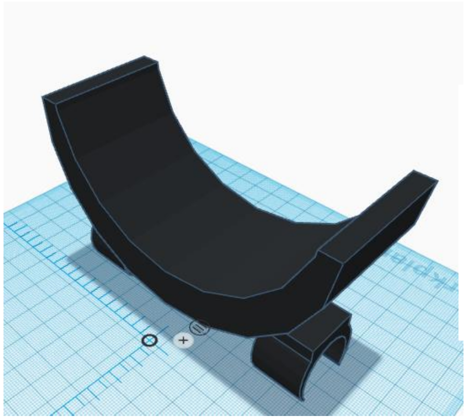
Above is our measuring device for task 4 that allows us to identify the distance between contaminated containers.
*Photo by Michelle Zemke



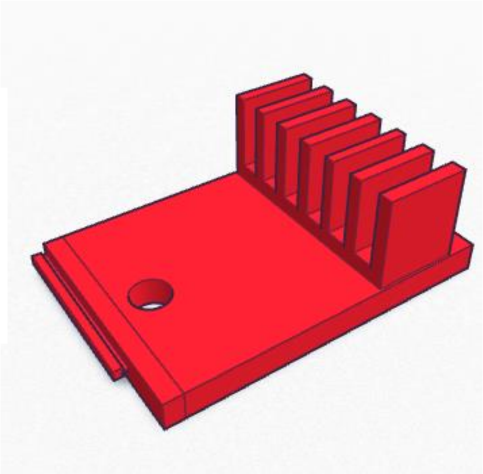
Above is a picture of a payload tool we attatched to our ROV. This payload tool will help us with the Light and Water Show Maintence Task. To build this tool, we used a vex motor, PVC, and ABS plastic frrom a 3D printer.
*Photo by Michelle Zemke

3D Printing

Our classroom setting is very unique due to the fact that we have a lab of 13 3D printers. This allows us to print multiple objects at a time in order to make the most robust ROV. Our company used 3D printing to make various parts for our ROV. The base of the claw was designed and printed, as well as the tube holders that secure our electronics housing. We also used 3D printing to construct an electronics plate. Most other companies have bought the Blue Robotics electronics plate that costs around $80, while we are able to print the same thing for less than $10. 3D printing has helped our company make a low-cost and effective ROV for the MATE International Competition.

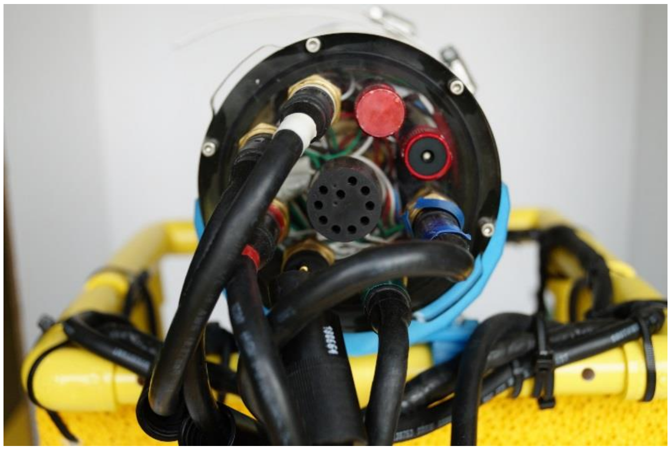


3D Printed Baseplate and Tube Holder
*Designed by Faith Whitt and Madi Howard



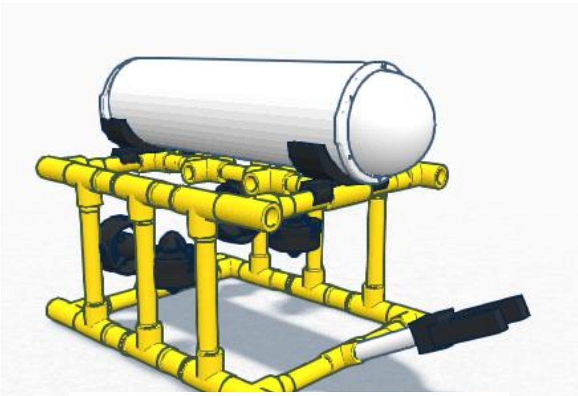
Waterproofing

From previous experiences, our team has learned that waterproofing can become a serious issue. Because of this, we invested in commercial grade SEACON connectors. Our watertight housing is depth rated to 300 ft, and it includes a double O-ring seal. We have tested this in Lake Michigan 180ft deep, surveying the Christmas Tree Shipwreck. To waterproof our servos and vex motors, we pack them with lithium grease and coat them with epoxy.

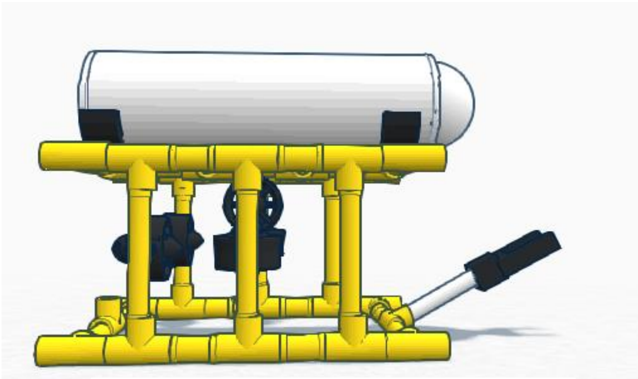


Rear view of the ROV, showing the SEACON connectors.
*Photo by Kelly Cool

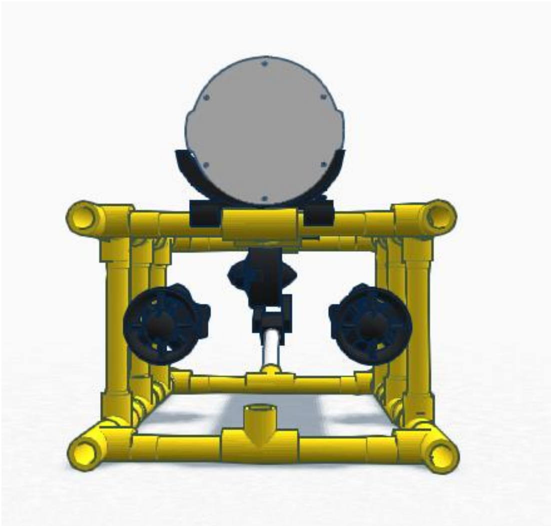
CAD Drawings



Diagonal view of our ROV
*Designed by Jake Chapman



Side view of our ROV
*Designed by Jake Chapman



Rear view of our ROV
*Designed by Jake Chapman

Build vs. Buy

Our company developed our ROV by combining off the shelf parts and self-designed pieces. We had precise decisions on why we bought or built certain aspects of the ROV.

Built

Our company decided to build some of our own components to not only save money, but also to make devices specifically suited to the competition mission. We built the rotating manipulator and measuring device ourselves to get a custom design to complete the mission tasks. The rotating manipulator is specifically designed to rotate the water flow valve in mission #2, light and water show maintenance. The measuring device is constructed to measure the distance and direction from the high-risk containers in mission #4.

Also, we constructed and designed our ROV ourselves to get a unique design that maneuvers better than competitor’s ROVs. We used PVC to construct it because it is easily adaptable. In addition, we 3D printed and self-designed components of our ROV. This includes an electronics tray and tube holders to ensure that all the electronics are secured. Other companies have bought a Blue Robotics electronics tray for $80.00, while we can produce the same high quality product for $10 using 3D printers

Buy

We have gained knowledge from previous experiences and learned that one of the most common problems that occurs on the ROV is having everything watertight. We decided to buy commercial grade SEACON connectors because they are the most effective when waterproofing. These connecters are screwed into a self-tapped clear acrylic end cap from Blue Robotics. We purchased a 4” Blue Robotics Acrylic housing. The end caps of the housing have a double O-ring seal to insure that there won’t be any water leaking into the tube. Also, the O-ring flange and the clear acrylic end cap have another waterproof seal. This will insure that our housing is able to go down to 100 meters. We are looking to invest in an aluminum housing that is depth rated down to 400 meters. This would allow our ROV to explore new frontiers, and give us a larger spectrum of new projects.

Front view of the ROV, displaying our dome end cap
*Photo by Kelly Cool

Product Demonstration

We carefully evaluated and selected design ideas to better improve the technique needed for the tasks.

Task #1: Commerce: Hyperloop Construction

An underwater Hyperloop system that is simulated in Mission #1.

Photo credit to: Zoubida IDRISSI

The first task is Hyperloop construction. A Hyperloop is a series of reduced pressure tubing that can propel cargo underwater. The Port of Long Beach wants to construct this to expand their limited size and increase efficiently within the port. ROVs help construct these underwater systems. Our ROV was designed to complete this task due to our effective manipulator. The claw is specifically important when installing the rebar reinforcement rods into the steel baseplate. Our camera is also specifically designed with a wide angle; consequently, it is able to be the eyes for the teammate who is lowering down the frame for the concrete.

Task #2: Entertainment: Light and Water Show Maintance

The Port of Long Beach uses ROVs to maintain their entertainment structures. Not only does this increase the revenue coming from the Port, but it also preserves the fun spirit of Long Beach. The key design that makes our ROV superior when maintaining the entertainment structures is the rotating device. This device can both open and close the valve to the platform efficiently. Unlike other ROVs, this is a unique device that truly sets us apart from the competition. Once again, our claw plays an important role in completing this task. Its vertical tilt allows our pilot to easily lock and unlock the mechanism inside of the fountain.

Task #3: Health: Environmental Cleanup

The third task simulates collecting a infected sediment sample to insure the safety of those in and around the port. ROVs are more beneficial at this task due to the fact that ROVs decrease the amount of exposure that scuba divers encounter to bad sediment.

Our well-planned design to collect sediment samples in this mission is truly one of the most innovative features on our robot. The Agar Sampler is a device that can safely shoot a spring loaded pipe into the sediment. The device can collect almost 120 mL of sediment in a matter of seconds; as a result, we are able to complete the task more efficiently than other companies.

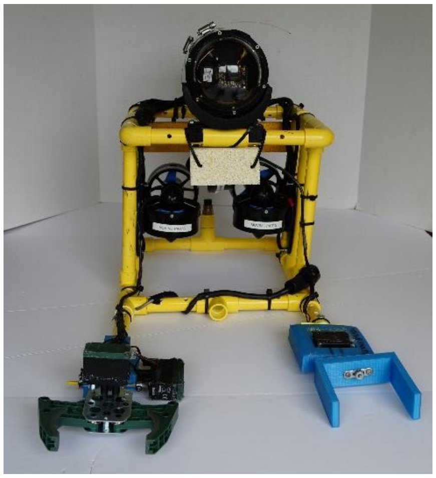


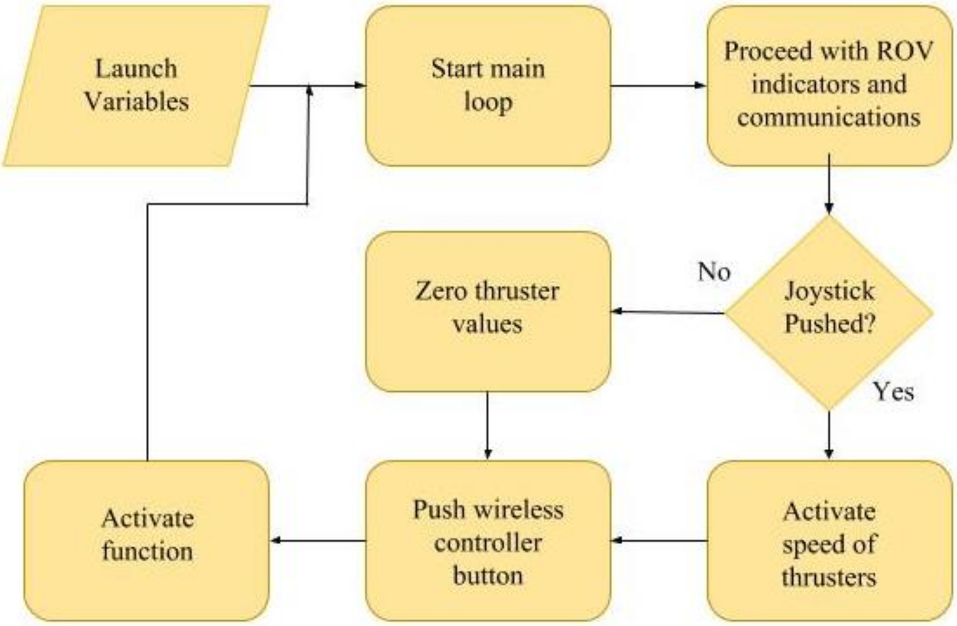
Photo of our ROV that is capable of completing any task.
Photo by Michelle Zemke

Task #4: Safety: Risk Mitigation

ROVs help detect and remove risky cargo containers that are navigational hazards or contain toxic materials. This once again ensure the safety of those in or around the port.

In Task #4, our company was challenged by the measuring aspect of the task. However, we were able to create a device that can measure effectively, with no hassle and little time consumption. Our ROV was designed to complete this task. It does it through our simplistic measuring device that is easy to read.

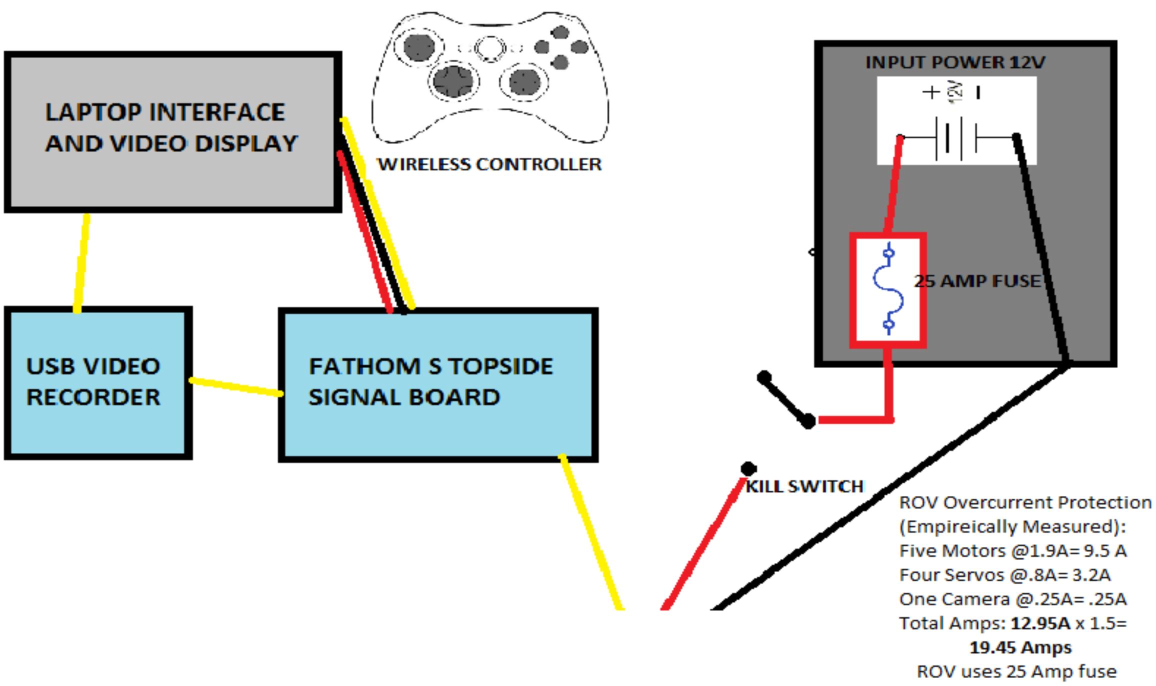
Software Flowchart



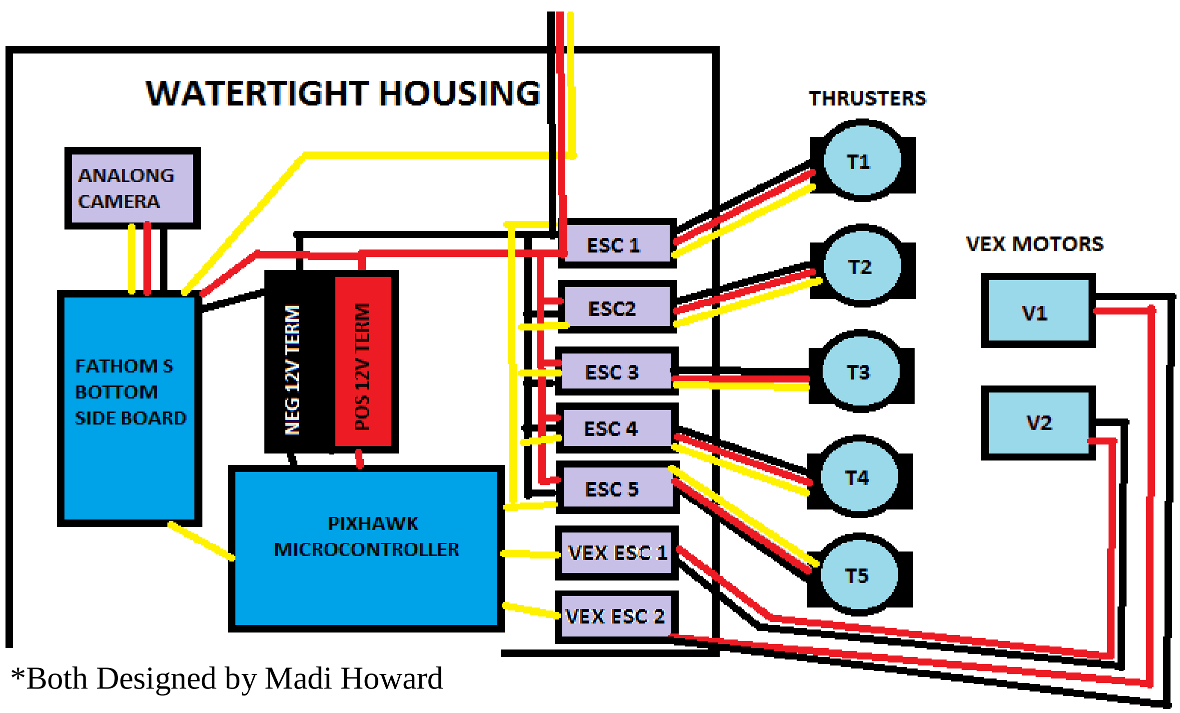
*Designed by Faith Whitt

System Integration Diagram

TOPSIDE



ROV SIDE



*Both Designed by Madi Howard

Safety

At Stockbridge High School, we make safety the top priority for our company, operators, and our ROV. To ensure our clients, and operators safety, we take many precautions to reduce any chance of any disaster.

The most important step we take is requiring warning labels on all moving aspects of our vehicle. This includes our thrusters, claw, and other payload tools. These have made the injury rate decline dramatically. Next, all 5 of our T-100 Blue Robotics are encased in a shrouds. Another is that we make sure that the power is disconnected from any sort of power source before handling or working on the ROV. The company didn't just set safety guidelines for the operators, but the ROV had several safety features as well. We filed down any jagged edges of cut PVC to make sure there weren't any hazardous sharp edges. This would prevent any unwanted cuts and snags, which could be problematic. Also, we have put a sleeve of Techflex over our tether. This helps to avoid any entanglement to the environment we are in. We have a 25ampsingle inline fuse located within 30cm of our power source. This prevents a power surge from going to our ROV. If a power surge occurred, there would be little damage to our electronics housing, due to the 25amp inline fuse. Additionally, we have a dress code that all company members must abide by. This code makes all workers wear safety glasses at all time when around the robot. At the same time, all hair and loose clothing must be tied back. We follow both the safety and startup checklist, which are below, before the ROV is deployed into the water.

Kael Bunce (9) attaches our electronics housing for a practice run at the pool.
*Photo by Jake Chapman

Safety Checklist:

- Ensure that all operators with hair shoulder length or longer is tied back
- Make sure that all team members have proper safety gear on when appropriate
- All team members have closed toed shoes
- Before handling the ROV, make sure all power supply is disconnected
- Locate all electronics away from the water
- All team members must have good and appropriate communication
- Before applying power to the ROV, confirm all team members are aware
- Check that no wires are exposed
- Double-check that the battery is correctly hooked up
- Make sure all controls are correctly set up in the program
- Ensure a team member is manning the tether

Start Up Checklist:

1. Follow safety checklist.
2. Remove electronics housing from the carrying case and then place it into the 3D printed holders on the ROV.
3. Secure the hose clamps around the housing. Ensure it is completely secure and will not slide off.
4. Plug in the SEACON connectors from the motors, claw, and tether into the electronics housing.
5. Check strain reliefs.
6. Double check that the end caps are completely on and then vacuum test the housing.
7. Insert vent cap.
8. Follow safety checklist once more.
9. Attach topside box to power. Make sure the kill switch is off.
10. Attach USB cable to topside box. Attach RCA cable from topside box to USB video recorder. Plug USB recorder into computer.
11. Open QGroundControl and plug in the wireless remote dongle. Turn on remote.
12. Open Debut video recording software.
13. Power on ROV.
14. Arm the control system and ensure that all aspects of the ROV are functioning properly.
15. Visually inspect ROV once more, then carefully lower into the pool.
16. Hold ROV and check for any possible leaks. If no leaks occur, then you are ready to operate.

Critical Analysis

Testing and Troubleshooting:

To test our assembled prototypes, we first start by verifying the water tight seal with a vacuum pump. This is an essential precaution to ensure that we have zero leaks on the ROV. Before we place the ROV in the water, we test all of our thrusters and payload tools. We then move and test buoyancy and double check that everything is watertight. If we have a positive or negative buoyancy, we add or take off the syntactic foam. Once we have neutral buoyancy, we move onto checking our thrusters and payload tools. Finally, the ROV is tested in a pool so we can practice mission tasks and prepare for the competition. Since our school doesn't have a pool, we must drive 20 miles to the neatest school to use their pool for 1 ½ hours a day. In between all of these steps, we follow our safety and startup checklist before the ROV is powered on.

Our company has a troubleshooting checklist for any occurring problems. The first thing that we check if there is a sufficient power supply going to the ROV. Once we know there is, then we check for signal issues from the ROV to the top side. We do this using a multimeter to check from the connector pin on the ROV to the surface of the Fathom S board, making sure that there is signal through the tether. If there is signal, then the problem would be a broken ECS or a code or setup issue from the laptop interface, QGroundControl. If we are still unable to resolve the problem, we can resort to our engineering notebook. This has more in depth troubleshooting ideas for specific problems. Recording in this notebook daily, it has allowed us to troubleshoot almost any problem.

Challenges:

Technical Challenges

We faced an entirely new challenge this year. When designing our electronics board we integrated a Pixhawk microcontroller, originally used for drones. This challenge is not as easy as it sounds. In a previous competition we had camera feel issues which is made is extremely hard to complete the missions. We overcame this by having great communication at pool side, which resulted in us placing second for task demonstration. When we were back in the classroom we switched the fathom x board to the fathom s because it is an analog connection, and is much more reliable. Our company also ran into a problem with positioning the manipulators so that it didn't interfere with other aspects of the ROV. In order to conquer this problem we positioned the claw and rotator on opposite corners, so they wouldn't interfere with each-other while also having the weight being balanced equally.

Organizational Challenges

Just like every real world projects, not all challenges are technical. While creating this technical document, we ran into formatting issues that caused a delay in the completion of our document. To overcome this problem we moved everything over from Google Docs into Microsoft Word and found its capabilities much more suitable for a document of this size. Another challenged we faced was time management. While most teams competing have an afterschool program, we build ROVs as one of our classes in school. This means that we only get 90 minutes a day to work. So we must work diligently every single school day in order to complete our goals. We overcame this by making a monthly schedule for everyone to follow and complete. This helped us stay on track to be able to complete everything in a timely manner.

Lessons Learned:

The process of completely waterproofing an electronics housing is no easy task. Not only have we learned the technical skills to actually build and create our robot, but we also learned a lot about teamwork. For example dividing up work for an efficient and productive class period. The ability to communicate with all members of your team is an underrated skill that will make or break your success when performing a mission

Our company prides itself on versatility while engaging problems with the robot, while also communicating our problems to our fellow teammates and instructor. Communication moves beyond problem solving, our company needs an elite level of public speaking experience and skill to raise the money that we do. This will come in handy while we give our sales presentation.

Future Improvements:

Our company always looks to the future as an opportunity. Searching for missing Tuskegee Airmen airplanes in Lake Huron is no small order. So, after we complete our missions at the international MATE competition, we will be equipping our robot with upgraded attachments and a stronger power source. Our targets range from 25 ft. to 100 ft. underwater, to account for this depth, our company will be adding an additional 150 ft. to our tether. Furthermore, changes to our frame and buoyancy will need to be adapted for our ROV to properly perform at this depth. We will also be exchanging our T-100 thrusters to T-200 for more powerful movements. The timeline for the Tuskegee Airmen project will begin around August 1st and end around August 27th. We will be searching for 5 missing planes flown by the Tuskegee airmen that crashed during training missions. We also hope to find the body of William Hill who crashed on November 25, 1943. We hope to bring closure to the families of the missing airmen that risked their lives for us. While other students are taking time off, the Stockbridge Robotics Program will be in the classroom, making changes to our robot and preparing for a real world project.

This is a P-39 Airacobra. We will be searching for this type of airplane flown by the Tuskegee Airmen in Lake Huron.

*Photo by National Archives

Team Reflection:

In our third year as a team, we have learned a lot from the Stockbridge Robotics Program. From public speaking, to the idea of chasing your dreams and anything is possible. Our program promotes education and inspires students to learn, all centered around one subject, robotics. The versatility of our class allows for a never ending stream of ideas, projects and creation. No idea is too crazy and no project is too big, if it is one thing we have learned from our experience here is that you can always achieve your goals if you are willing

to work hard enough.

Left to right: Kael Bunce (9), Colin Lilley (11), Madi Howard (11), Michelle Zemke (10), Jake Chapman (12), and Faith Whitt (11)

We competed in the MATE Regional ROV competition in Alpena, MI. We received 1st place in presentation and overall competition. Our company received the Ford's Innovation Award for our unique work with a drone microcontroller in our housing.

*Photo by Robert Richards

Budget

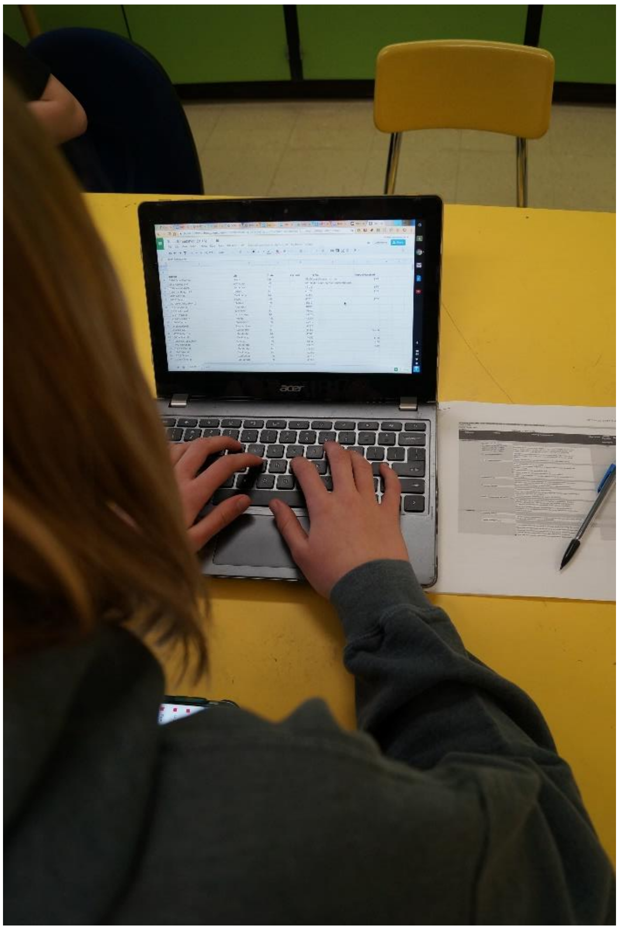
In the beginning of the year, the Stockbridge Gold Team came together to design our robot. We wanted it to be cost efficient, yet more advanced than most ROVs. We researched products that were within our budget as well as effective at solving the mission tasks. We are proud to demonstrate that we have raised all of the money by ourselves through no help of our school. We marketed our company on social media, collected donations on our crowd funding site, and have sought out corporate sponsors necessary to design and build our ROV. We applied for grants, accepted donations, and contributed a heavy amount of time to raise these funds. Over the summer we applied for the Michigan STEM grant, and won $7,000, which we used to build a new ROV. This immensely helped us stay within our projected costing because we had to log every purchase from this grant. We also had a weekly goal of raising at least $1,500.

Our company expects the travel costs for regionals to be $300, which includes gas money and hotel costs. When we travel to the international competition, we expect it to cost $5,300 for plane tickets and $600 for hotel. Through our crowd funding site and letters we have raised our goal of $10,000 in order to travel to the international competition.

Project Costing:

Item:	**Quantity:**	**Price:**	**Total:**	**New/Donated/Reused:**
10 pin SEACON connector	1	$106	$106	New
3D Printer Plastic	1 roll	$30	$30	New
3pin SEACON connectors	5	$50	$250	Reused
Blue Robotics Acrylic Housing	1	$54	$54	Reused
Blue Robotics Analog Camera	1	$32	$32	New
Blue robotics basic esc	5	$25	$125	New
Blue Robotics Depth Sensor	1	$68	$68	New
Blue Robotics Dome End Cap	1	$59	$59	New
Blue Robotics Flat End Cap	1	$25	$25	Reused
Blue Robotics Leak Sensor	1	$29	$29	New
Blue Robotics T-100 thrusters	5	$119	$595	New
Blue Robotics Vent Plug	1	$8	$8	Reused
Fathom-S topside board	1	$85	$85	New
Micro Servo	1	$6	$6	New

Pixhawk Microcontroller	1	$260	$260	New
Pool Time at Chelsea Schools	10 hrs	$75	$750	Donated
Power Terminal-power bus	1	$24	$24	New
PVC	1 (10ft piece)	$4.50	$4.50	Reused
Strain Relief	1	$5	$5	New
Vex Claw Kit	1	$20	$20	Reused
Vex ESC	2	$10	$20	Reused
Vex Motor	1	$15	$15	Reused
			TOTAL:	$2,570.50



Faith working on the budget sheet and fundraising letters.
*Photo by Kelly Cool

References

Aside from the real world projects we work on throughout the year, we gain knowledge from a number of references. These books and websites give us a clearer understanding of why we are interested in robotics in the first place.

Websites

MATE Website: https://www.marinetech.org/
BlueRobotics: http://www.bluerobotics.com/

Books

"Make: Sensors" Tero Karvinen, Kimmo Karvinen, Ville Valtokari
"Underwater Robotics" Steven W. Moore, Harry Bohm, Vickie Jensen. MATE Textbook
"Living and Working in the Sea" James W. Miller, Ian G. Koblick

Acknowledgements

**The team would like to thank anyone who supported us through the construction of our robot and the course of the class throughout the year.*

- The MATE Center, for giving us the opportunity to compete in this competition and responding to any questions we had
- Mr. Richards, for always believing in us, and being a great mentor
- Chelsea Pools, for donating their pool time for practice we greatly needed
- Peak Manufacturing, Gold sponsorship
- Karl Klimek, Square One. Mentor
- Wayne Lusardi, State Maritime archaeologist
- David Cummings, Mentor
- Governor Rick Snyder (MI), Media recognition