The **Underwater Research Robot Company**

Technical Documentation

Marine Advance Technology Education

May 26, 2016

The UR^2 Team:

Elizabeth Thomson: (Tenth Grade)

- CEO and Safety Officer

Josh Beatty (Ninth Grade)

- Chief Technician
- **Savannah Thomson** (Ninth Grade)
- Lead Engineer

Sam Beatty (Tenth Grade)

- Pilot

Nathan Cosbitt (Tenth Grade)

- Pilot

Alyssa Gehrke (Eleventh Grade)

- Public Relations

Kady Gehrke (Tenth Grade)

- UR^2 Correspondent

Tara Myers (Tenth Grade)

- Lead Researcher

Katie Nicholson (Tenth Grade)

- Software Engineer

Ian Shriner (Ninth Grade)

- Fabrication Technician

Bob Thomson

- Mentor

Katie Thomson

- Mentor

Alpena High School Underwater Robotics Club

500 W River Street

Alpena, MI 49707 (USA)

(989) 471-2855

therobotfactory4h@gmail.com

www.facebook.com/therobotfactoryur2rovteam

Table of Contents

Abstract

With six years of experience, Underwater Research Robot Company (UR²) holds safety, innovation, environmental preservation, and planetary discovery as our highest priority. The team is comprised of ten determined and skilled team members, ranging from ninth to eleventh grade. All members participated in each design and construction phases of our Remotely Operated Vehicle (ROV). Our new temperature resistant High-Density Polyethylene (HDPE) frame allows for easy modifications and efficient performance in the cold waters of Europa. The electronic speed controller is connected to the robot by a new enclosure from Blue Robotics, enabling us to keep the robot compact. Our innovative sensors determines the depth of water and can measure the thickness of ice. We placed our cameras at exact positions to provide optimal visual aid, which will enable us to take pictures of underwater coral reefs and determine population growth or decay. The company programmed servos to control a Vex claw allowing us to collect oil samples, recover equipment, and secure a wellhead. Scientists and engineers frequently use ROVs for scientific research and to collect data where it would be unsafe to send a human to gather. Having a compact and light ROV provides for easier transportation on any job site. Underwater Research Robot Company is prepared to use our top of the line ROV to complete the product demonstration successfully.

Underwater Research Robot Company

Understanding the ROV

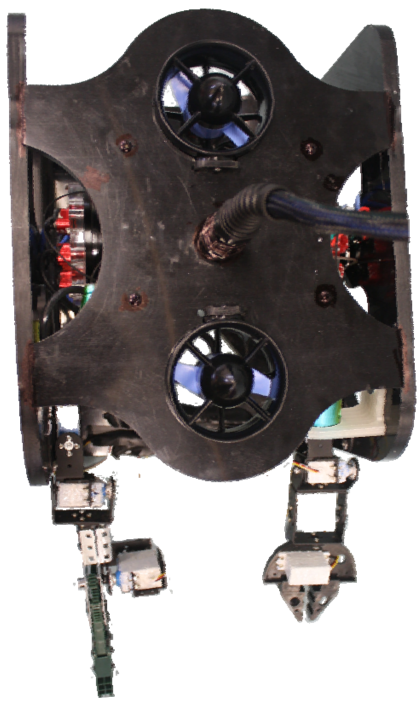
The Underwater Research Robot Company (UR^2), is committed to meeting our clients research needs. Completing research on Jupiter's Moon, Europa, has certainty been one of our greatest challenges, but the UR^2 team has embraced the challenge.

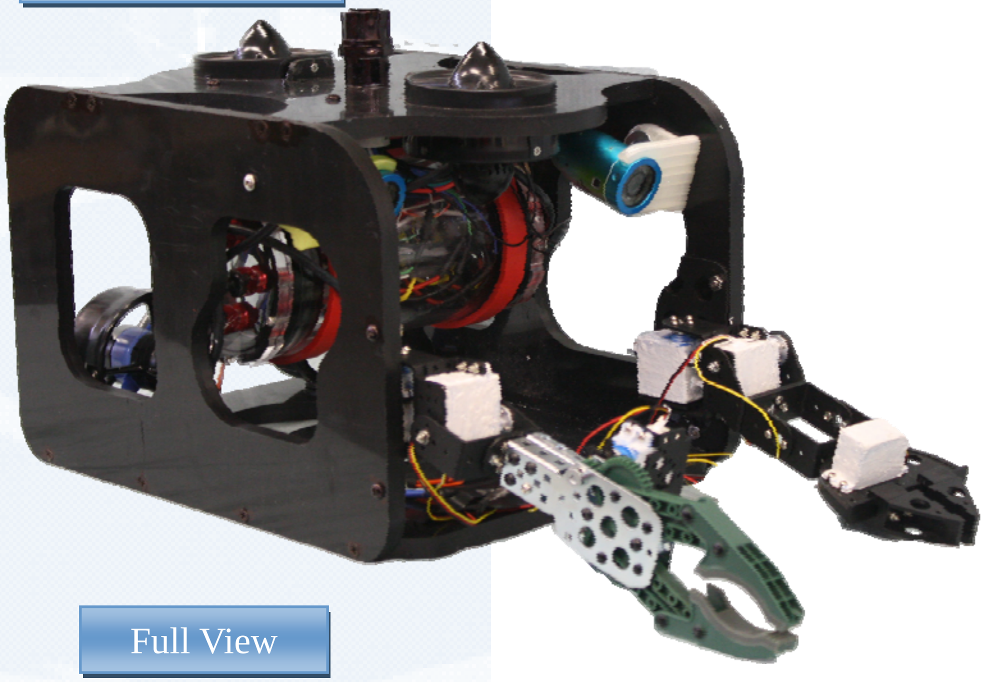
With six years of experience, Underwater Research Robot Company holds safety, innovation, environmental preservation, and planetary discovery as our highest priority. Our most recently develop ROV is not only capable of completing research here on Earth, but on the far reaches of the Solar System. Our frame is designed out of High-Density Polyethylene (HDPE). HDPE will not expand or contract under extreme temperature changes like normal plastics. Also, HDPE allows for easy modifications. With the addition of an on-board watertight enclosure, all electronics and electrical connections are enclosed on the ROV. This allows for the tether width to be reduced and total weight of the tether is significantly decreased. Our onboard sensors determine the depth of water and can measure the thickness of ice by providing accurate depth location of the ROV. We placed our cameras at exact positions to provide optimal visual aid, which will enable us to take pictures of underwater reefs and determine population growth or decay. Also, we added something special to this year's design. Our company programmed multiple servos to control a vex claw allowing us to collect oil samples, recover equipment, and secure a wellhead.

Our overall design focused on developing a ROV that is compact and light. This design provides for easier transportation in any work environment. UR^2 is committed to provide reliable and useful research platforms capable of providing our clients accurate and trustworthy data. Underwater Research Robotics Company is the answer to your research needs.

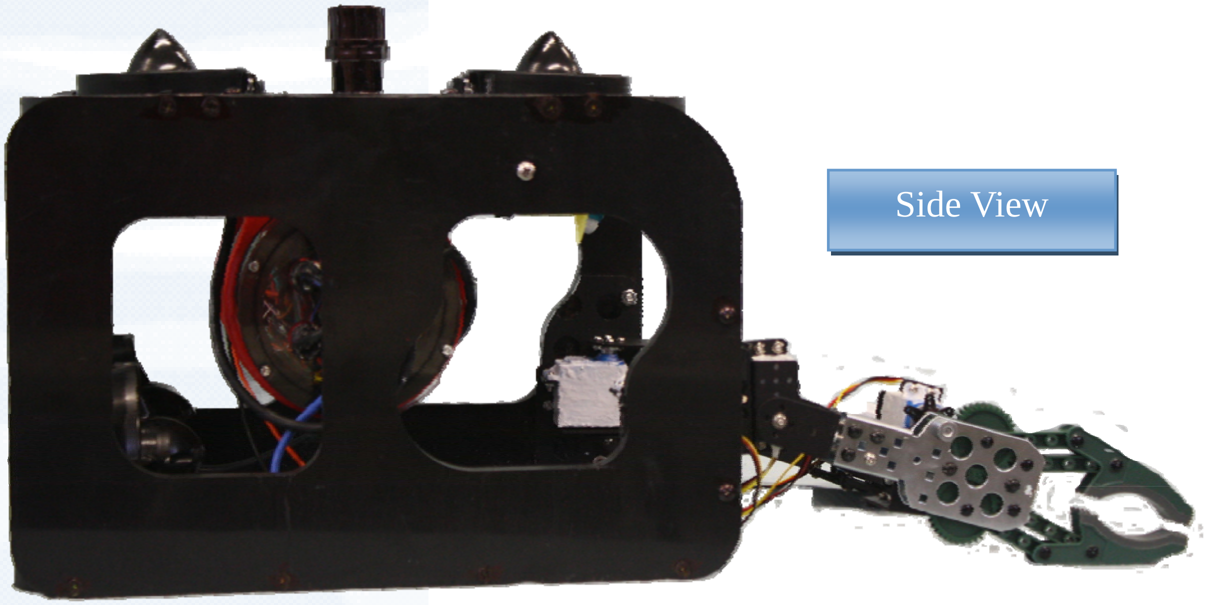
UR^2

Top View





Full View



Side View

Underwater Research Robotics is a non-profit educational research company. Our funding is developed through research and educational grants. Funding also comes from individual investors that have an interest in promoting the company projects. Nearly eighty percent of this years company's budget came from our Shipwreck Discovery Project. The remaining percent of the founding came from a Phase Two component of the Shipwreck Discovery Project where we designed and developed two community educational ROVs called EDU ROV1 and EDU ROV 2. Within this Phase Two component, we were able to supplement our own research ROV to help cover cost for upgrades for this year's competition. For information about the Shipwreck Discovery Project visit: https://www.facebook.com/shipwreckdiscovery/?skip_nax_wizard=true.

The development of two additional ROVs this year did not leave a lot of flexibility in the budget to purchase all new parts for this year's competitive ROV. We spent time working out the budget to decide first what parts were needed. Then we had to determine which parts could be rebuilt, what parts to make, and/or which to purchase off the shelf. The time needed to develop new parts was weighed against purchasing off-the-shelf components. In the development of the two robotic arms used on the ROV, we started the process by building and programing our own processor to control the arms with four joysticks. This was a more cost effective way, but the pressure of time and the need to get the ROV built, required us to rethink controlling the robotic arms through individual RC Controllers. To purchase the RC controllers we had to take funding from pool rental funds. The decision was based on the fact that if the ROV could not collect samples, the need for the pool would not be necessary.

UR^2 Company CEO, Elizabeth Thomson, inspecting the bottom panel for one of the EDU ROVs the company developed for the Shipwreck Discovery Project.

T

Source	Amount
Michigan STEM Grant	$1,000.00
NE Michigan Community Foundation	$2,000.00
Besser Foundation	$3,000.00
Private Donations	$3,000.00
2015-2016 Financial Total	**$9,000.00**

Underwater Research Robot Company

Competition ROV Financial Summary

Company Income	Amount
Personal Donations	$3,000.00
Grants	$1,000.00
Ossineke Building Supplies (Parts valued donation)	$300.00
NOAA In-kind Support (Not totaled as Available Funds)	($2,500.00)
Total Incoming Founds	$3,300.00
Expenditures	**Cost**
Scheduled 40 PVC Pipe	$45.00
HDPE (frame material)	$80.00
Tether Conductors	$150.00
RC Controller System (all parts including practice control model)	$250.00
Robotic Arm Servos and Hardware	$630.00
Consumables (Tape, solider, etc…)	$110.00
Pool Time	$900.00
Total Expenditures	$2,165.00
Re-used Parts	**Value**
4 Cameras	$260.00
4 –Way Monitor	$150.00
Actuator and Grabber Mechanism	$400.00
Thrusters and Control System	$1,200.00
Total Amount Re-used	$2,850.00
Total Value of ROV	**Amount**
Purchased Items	$2,165.00
Re-used Items	$2,850.00
Total	$5,015.00
Final Accounting Summary	
Available Funds	$3,300.00
Expenditures	$2,165.00
Net Balance	**$1,135.00**

Underwater Research Robot Company

Competition Travel Summary

Estimated Cost	Funding Support
Plane Tickets (Ten Team Tickets)	$6,300.00
Room Costs (Three Rooms for four nights	$4,800.00
ROV Shipping and supplies	$400.00
Food and misc expenditures	$1,0000
Total	$12,500.00
Estimated Fund Raising Activities	**Cost**
Spaghetti Dinner and Auction	$1,750.00
Bottle Drive	$800.00
www.gofundit.com	$6,000.00
Personal Donations	$2,000.00
Total Estimated Funds Raised by June 20, 2015	$10,550.00

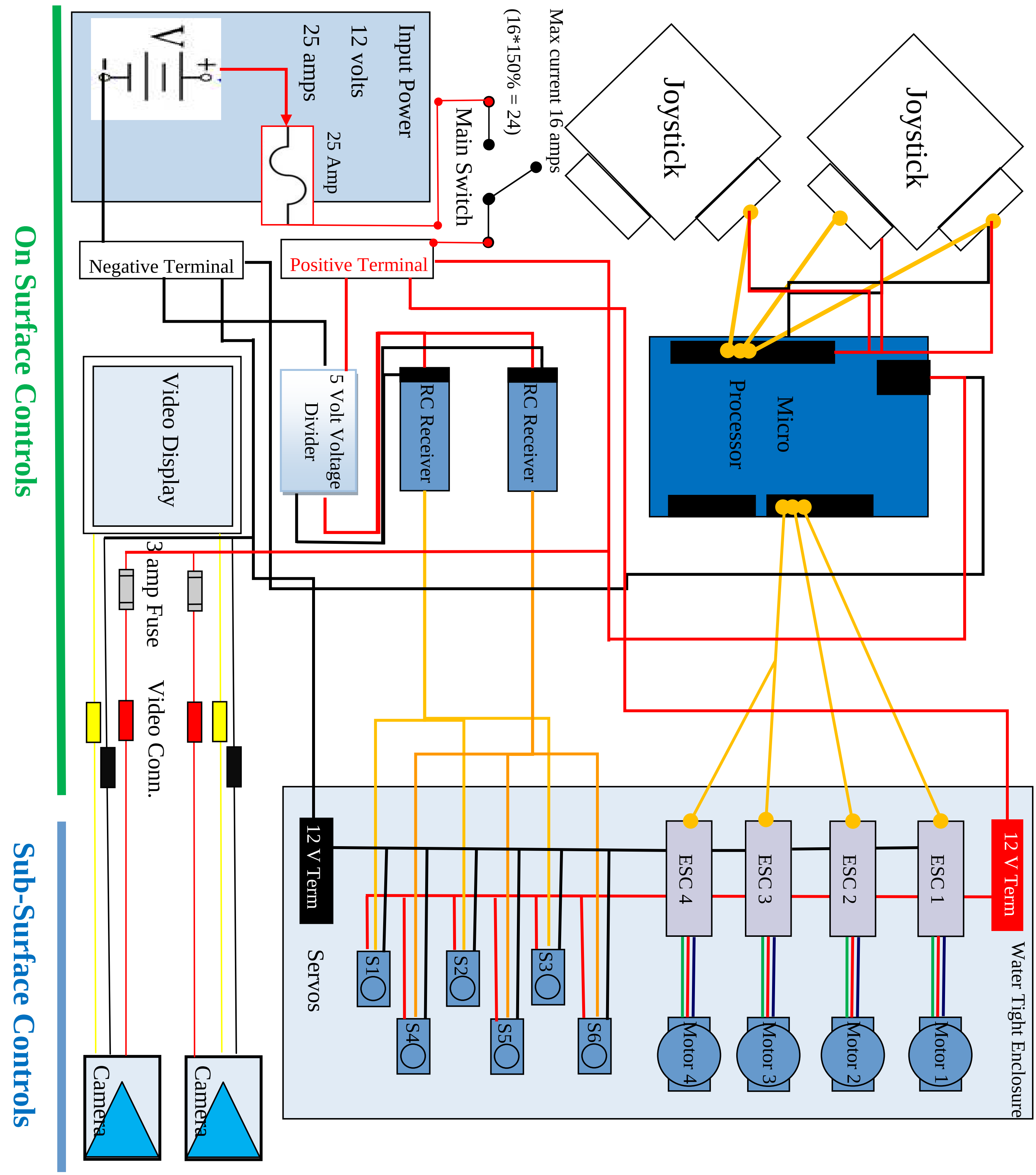
A Budget that Leads to Success

In the image to the left, Katie is strolling down the sidewalk headed to the *R/V Strom* to test the ROV in open water. Our goal was to make a complete ROV package in the most economic way that could be easily transported and fit into one complete package. We were able to stay with in our original budget, but we had to get creative in the way we used our resources.

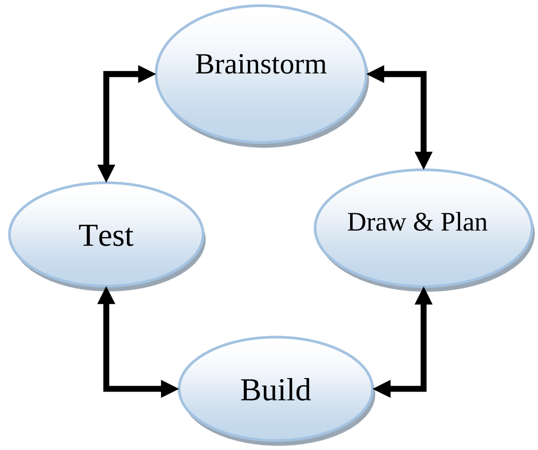
One budget item we did not cut corners on was the control case. We modified a Pelican Case to house the ROV controls. The case is very sturdy and allows for the ROV and tether to be attached to the case. It provides a complete package. One area that we plan on improving next year is a detachable tether. This is one future improvement that we will need to find room for in next year's budget.

Underwater Research Robot Company

System Integrated Diagram (SID)



Engineering Design Process



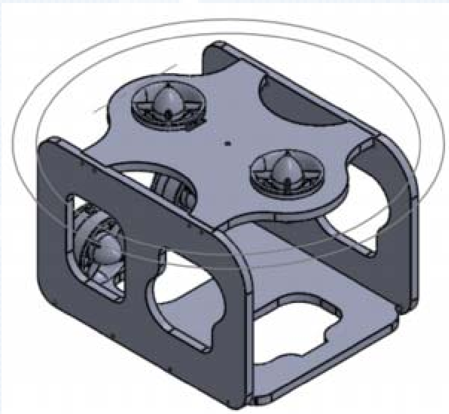
Each year we employed the engineering design process to improve and develop a more advanced and reliable ROV. We used this process to guide us through every step of the project:

1. What is the problem or idea we want to solve or improve?
2. Research the problem and past solutions.
3. Brainstorm ideas for possible solutions.
4. Evaluate potential solutions.
5. Choose a solution: design & refine.
6. Build a testable version for a proposed solution.
7. Evaluate if the solution is what we want and will it work.

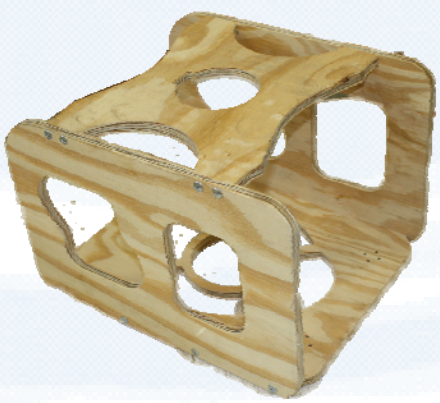
The Underwater Research Robot Company has experienced many successful research projects and competitive achievements, but in order to be more successful we challenge ourselves with new ideas and technologies. The company began meeting this year and it was clear that our goal was to create a more professional looking unit. We not only wanted to design our ROV to meet the size criteria, but wanted to go one step further. We created a single unit comprised of the ROV and surface controls that met the design criteria. In addition, we wanted to challenge ourselves more this year by developing two servos to control mechanical arms that work simultaneously with each other.

To reduce the weight of the tether, we brainstormed different ways to control the ROV. This required a lot of background reading and work to change from a primarily analog system with many conductors to more digital input system with less conductors in the tether. When we planned this change, several problems arose including: funding challenges, needing more thrust to handle the open water currents, rebuilding the entire robot from the ground up, fulfilling our commitment to the Shipwreck Discovery Project hosted by the NOAA and the Thunder Bay National Marine Sanctuary and hope to clinch first place at the Great Lakes Regional ROV competition. As a solution to these problems we reduced the size of the wires as well as the numbers of wires.

Structure



Original 3D Frame Design



Plywood Prototype

Completed frame design

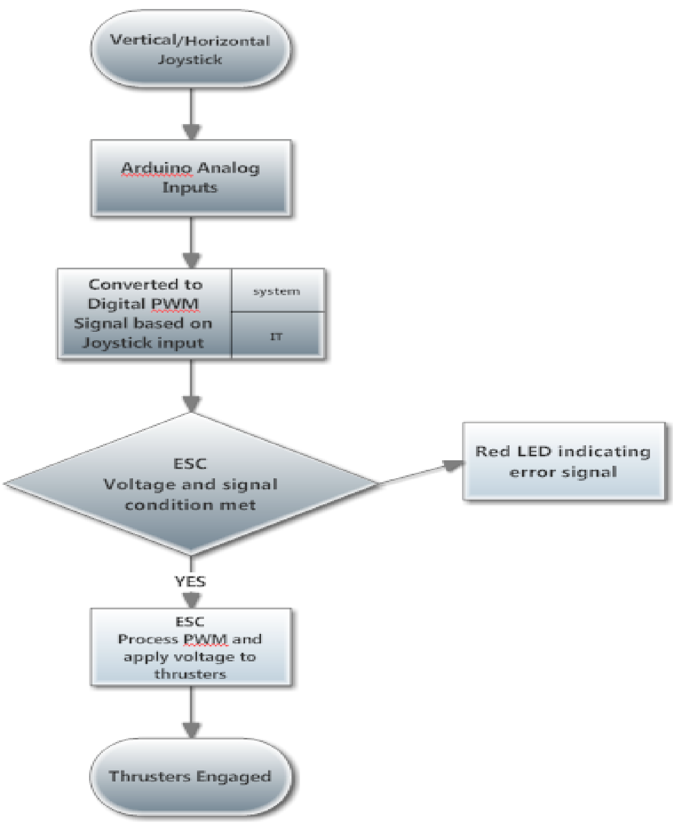
This year's mission criteria pushed us to take on a new frame design process. Over the last few years we have built our ROV frames out of different materials, but we continued to stay with PVC at some level of the design. In using PVC, it is very difficult to modify the frame after it is built. This year we committed to creating a frame with zero PVC tolerance. We worked with a local fabrication company to help us brainstorm different product materials, and learned about the product design process. The process began with a paper and pencil design to get a rough shape and sizes. Then we started modeling on SolidWorks to develop our original 3D frame design. We worked with product engineer, Quade Kimball, to develop the first prototype using a CNC machine to built an initial frame design from plywood. We used this design to verify size, fit, and if parts like our thrusters would fit correctly before cutting our actual product material.

The frame is the foundation of our design. We wanted to design the ROV by developing it based on the mission criteria. The construction material, High-Density Polyethylene (HDPE), was chosen because it can be used in a variety of climate conditions. From the icy waters of Europa to the intense heat of the Caribbean, it would perform without contracting or expanding in reaction to temperature changes like most plastics.

Our ROV was designed to be positively buoyant. We designed it this way to help the ROV lift the mission sensors, debris, and hold position in the water column in order to work on equipment and pipes. We placed the vertical thruster so they would be in the center of the ROV to maximize lift and stability. In addition to the use of the water proof enclosure for buoyance, we chose to use Subsea Buoyance Foam to trim the ROV and to be positively buoyant.

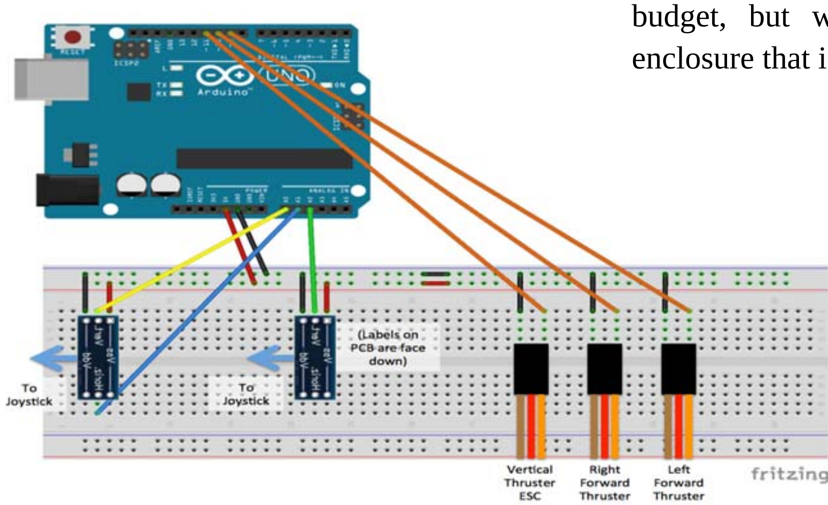
Control

Control System Flow Chart

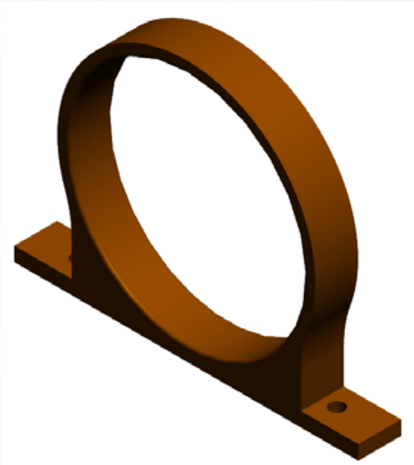


This year's mission criteria made us rethink and consider ways to make the ROV lighter. The heaviest part of our ROV in the tether and to reduce the weight require a change in size and number of conductors that we use in the tether. Also, something we never consider was the material the conductor was created from. Voltage drop across the length of our thirty-three meter tether caused our thruster control to drop-up. This year before redesigning our control system we research conductor material that had a high level of pure copper and a low level voltage drop. Understanding this process allowed to save time on control design by reusing many of the control system parts so that we could put more time on developing a waterproof enclosure for the ROV. By moving part of the control electronics to the enclosure, reduce tether weight and in effect allowed us better utilized last year's control design more efficiently.

The Arduino system accommodates us with a reliable processor control that was within our budget. The sketch converts the analog input from the joysticks to the electronic speed controllers needed to input power to the T100 thrusters. We redesigned the surface control system by adapting a Pelican waterproof case. The surface control system took twenty percent of our budget, but we now have a reliable and durable enclosure that is capable of being transport into space.

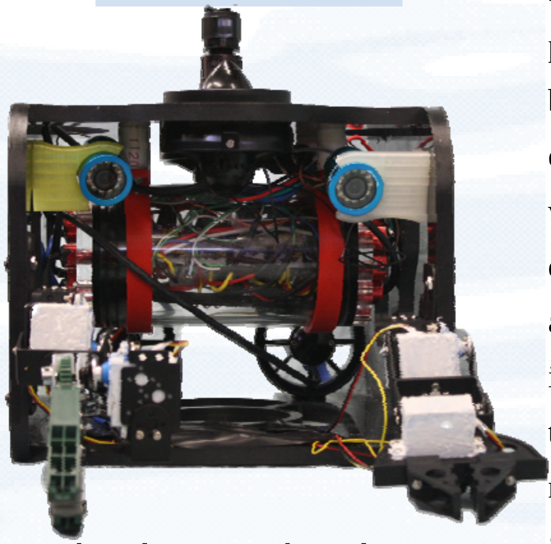


Using the Arduino board and a general circuit breadboard, we were able to use the technical support from Blue Robotics to develop our analog to digital conversation processor. The Arduino takes the voltage signal from the joysticks and creates a digit modulated pulse signal that is read by the ESC which in turn controls the output of the thrusters.



A 3D rendering of our enclosure mount that we developed to support and access the enclosure.

Waterproof Enclosure



The red stripes on the enclosure are the mounting brackets. The enclose was designed to be placed in the center to help with buoyance.

In the past, propulsion has been the one area that we spent the longest time developing a thruster that had more thrust. The conversion to the Blue Robotics T100s has solved our thrust issues, but created a variety of other time consuming design problems. To use the T100 thrusters they need ESC (electronic speed controllers) that were waterproof. Our first attempt to waterproof the ESC was to incase them in acrylic. This work, but it was very messy and did not produce a professional looking solution. Also, if the ESC had problems or issues that were solvable, encasing them in acrylic made it impossible to troubleshoot.

This year we incorporated into our design a water proof enclosure. Based on our need to keep the ROV small and time constrains, we chose to use the enclosure designed by Blue Robotics. The enclosure this year was by far the biggest challenge we faced. The frame design was created by our team and trying place a commercial product into our own design created many problems. Size was the biggest issue. We not only had to resize the enclosure to fit, but everything inside the enclosure had to be redesigned in order for the whole frame to meet mission criteria. Mounting the enclosure was difficult because the space we had to fit it into was limited. To save time and money we used plastic mounting straps. This turn to be very impractical. When we had to take the enclosure out to troubleshoot a thruster control issue, it took to long and was difficult to manage. We needed a way to mount the enclosure that allowed us an easier way to access the enclosure. Our answer was to create our own parts. The enclosure mounting bracket that we designed can be easily mounted with four bolts to the top of the ROV frame. This makes a reliable and professional looking way to safely mount the water proof enclosure.

Depth Sensor

Blue Robotics Bar30 High-Resolution 300m Depth/Pressure Sensor. This sensor allows us to accurately determine distances based on the pressure it senses.

Go Temp sensor that we modified to reach the required depth for the competition.

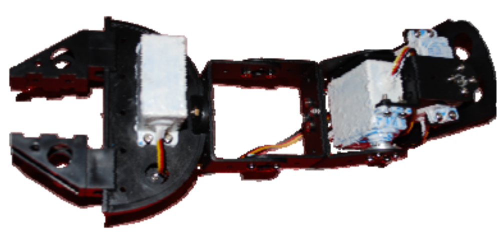
Our past attempts at accurately measure anything have all been failures and when we look back at them, they look crude compared to other systems we've seen. This year, we've switched to a more practical approach that is the Bar30 High-Resolution 300m Depth/Pressure Sensor. By using the pressure as our guide, we'll have a much easier time of measuring distances and the measurements will be more accurate.

One of the ways we tried to save money is to continue to reuse and modify previously used sensor for new tasks. We have had the Go Temp thermometer for years, but were afraid to alter it as it may result in it not working anymore. As our experience level has grown, so has our confidence. So, this year we took the Go Temp apart and turned it into the temperature sensor that we needed for this mission.

One of the goals, set by the team this year, was to develop some kind of mechanical grabber that we could control. Every ROV we have built has always had a fixed actuator-based grabber. The ROV had to be positioned to be able to retrieve equipment or take a biological sample. We were originally only going to design one mechanical arm, but in the process, we felt two would give us twice the sampling speed.

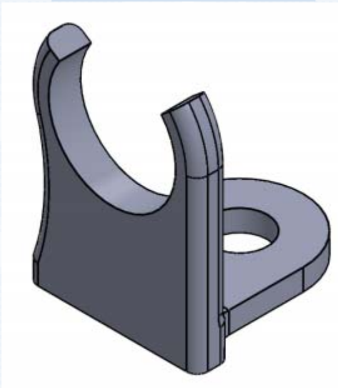
The process to create the mechanical arms start last year when began using an Arduino to control the thrusters. While doing this, we discovered the many use of an Arduino micro-processor and felt we could make it work. We quickly learned that developing a table top mechanical arm got way more complicated when you put it underwater. The parts and pieces for both mechanical arms were made from a variety of different elements. As we kept building proto types and trying different components, we became comfortable working with certain parts. Both mechanical arms are built around three Hitech waterproof servos.

Vertical Mechanical Arm

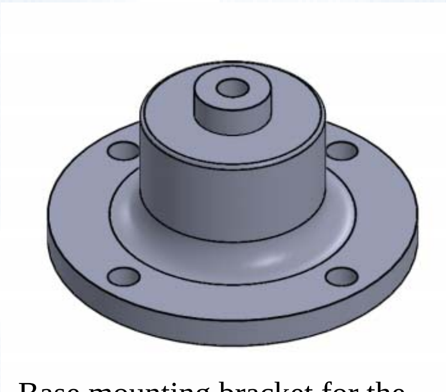


Horizontal Mechanical Arm

Camera



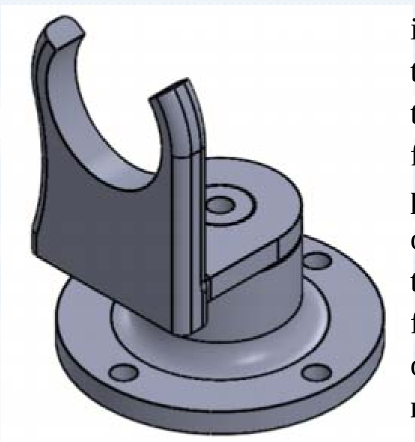
Top mounting bracket for the camera.



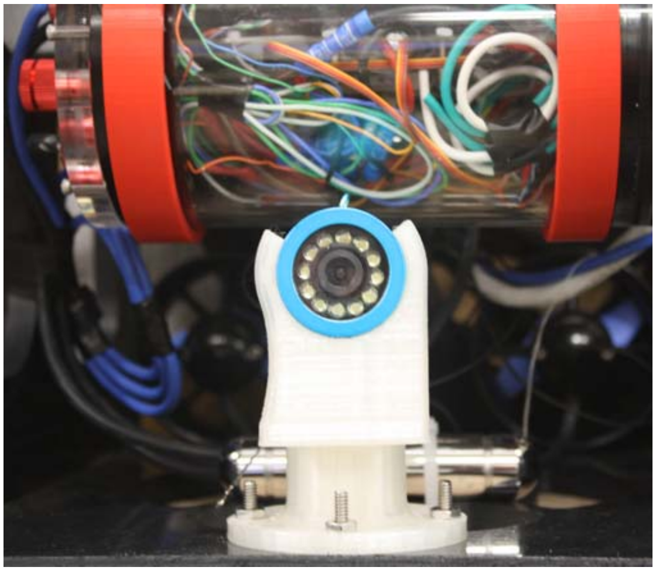
Base mounting bracket for the camera.

Mounting the cameras has always been one of the last things we attempt to do on the ROV. Being the last thing, it gets the least amount of effort and design consideration because we are trying to get the ROV in the water to test it. Space was the first thing we had to consider. We purchased two new cameras that had depth rating of one hundred meters. The team has never had any luck in developing our own cameras. Our last attempt was last year and it failed at the International Competition in Newfoundland. That failure cost us several mission points. We did not want that to happen again.

The challenge was mounting the cameras. Space and viewing capacity were the two variables the design team had to focus on. The solution was to create our own parts again. Working with one of our mentors, the design team created a custom camera mount that was designed for the camera and the ROV needs. We developed two prototypes and settled on the design pictured on this page. The assemble mounts vertically or horizontally and allows for one axis of positioning. We originally designed for both axeses, but space was an issue.



Pictured to the left is the rendering of the first print and to the right is the first printed prototype on one of the EDU ROVs that we designed for students to use on classroom research projects.



Waterproof Enclosure

We used the four inch water tight enclosure from Blue Robotics. We ended up shortening the tube size and modifying the end camps to fit our needs.

In order to fit inside the 48cm size requirements for this year's ROV design, we needed to fit an enclosure into our ROV. To gain experience using an enclosure, we built a test enclosure to make sure we understood the process and then we used a hand pump to make sure the enclosure was pressurized correctly. The first problem we encountered on the competition ROV was that the enclosure fit inside the ROV frame only when it was placed in a certain direction. This made putting everything else inside the ROV a challenge. In order to combat this issue, we modified the enclosure to fit horizontally inside the ROV through trial and error. The wires caused another issue because we needed to run all of them inside the enclosure but there was limited space so the enclosure had difficulty fastening. Through brainstorming, we rerouted the wiring so that the enclosure could properly seal. Once everything was properly fitted, we used pressurization air to check for leaks. Even though we were confident going into the pressurization check, the enclosure was not sealed.

To find the leak, we pushed continuous low pressure air into the enclosure and listened for leaks. We could hear the air leaking out, but we could not find the location. Then one of the team members watched how her dad looked for a air leak in her bike tire by using water and dish soap. We spread the soapy solution on with a paint brush and started looking for bubbles. We found three penetrator plugs not sealed completely. We tightened everything up and tried the hand pump again, and it still would not hold pressure. Frustrated, we mounted it onto the ROV frame to make sure it fit and moved on to something else for the rest of the day. The next day we checked again and hoped that maybe it just needed to settle into place. We added pressure and it held the 400 pounds for ten minutes. The solution focused on the positioning of the

At our company work space, we work to maintain a safe and friendly work environment. Robot Factory Research teams have their own assigned area to store equipment and projects.

Our goal is to make every member of our company aware of situations that may lead to an injury or damage to equipment.

The Underwater Research Robot Company's goal is to provide a safe and positive working and learning experience. Each company member must practice our three safety rules. First, proper clothes must be worn while working on and with the ROV. This includes safety goggles, closed toed shoes, and long pants when working with cutting tools, soldering equipment, and industrial glues. The second rule is to work with a positive attitude. Show-up to work with the intention to get something accomplished. Our last rule is to clean-up after yourself. Most injuries around the company come from someone slipping or tripping on something that was left on the floor and not put away. It can be as simple as some pieces of PVC tubing that got left on the floor.

Our motto is a safe company is a happy company that leads to positive productivity. We have a great company, but if we don't have everyone on the team working together, that puts us at a disadvantage. This is why it is important for us to have consistent safety practices. Our Safety Check Sheet (Page 17) is an example of our dedication to maintain a safe working environment. Also, we have appointed our CEO as our safety officer. She has our company's permission to stop work at anytime if an unsafe condition occurs.

Safety features that we added to our ROV focused on improving strain reliefs. This year's ROV is designed with a strain relief position on the ROV's center of gravity. This provides a direct level of effort that focuses all the ROV's weight in one direction limiting undue stress on weaker points of the frame. In addition all edges are rounded. covering sharp edges/parts, warning signs, and keeping all equipment inside of the frame of the ROV.

UR^2 Safety Check-off Sheet

Checklist Items	YES	NO	Action Required
Electrical schematics & power distribution diagrams	☐	☐	☐
Technical report	☐	☐	☐
RANGER CLASS SAFETY CHECKLIST (safety inspection)	☐	☐	☐

Part 2: Physical

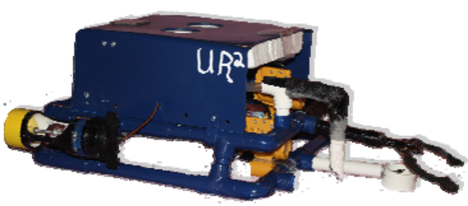
Checklist Items	YES	NO	Action Required
All items are secure to ROV and will not fall off	☐	☐	☐
Hazardous items are identified and protection provided	☐	☐	☐
Propellers are enclosed inside the frame or are shielded that they will not make contact with items outside of the ROV	☐	☐	☐
No sharp edges or elements on the ROV that could cause injury to personnel or damage to pool surface	☐	☐	☐

Part 3: Electrical

Checklist Items	YES	NO	Action Required
Single attachment point to power source	☐	☐	☐
25 amp single inline fuse, no frays in tether or conductors.	☐	☐	☐

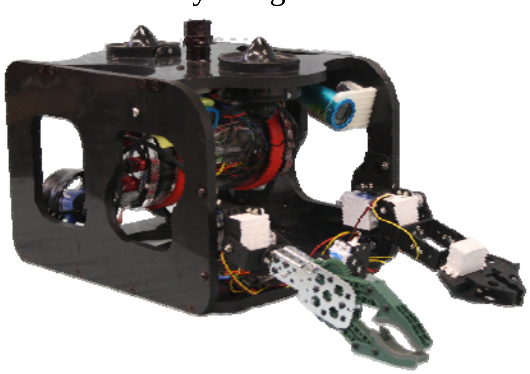
The Big Challenge

In 2011, 2012, and 2013 our ROVs were completely made of PVC.



By 2014, we started designing with other materials, but kept the same basic design.

In 2015, we worked with the same materials, but tried to alter the box shaped ROV design that we had been continuously using.



In 2016, we have left the world of PVC.

Two of our greatest challenges were working to make our robot better then last year's and working around everyone's schedules in order to meet the demands of creating a better engineered ROV. Everyone of our team members are very busy with academics and sports. We have to meet after school and not everyone can make it all the time. This makes it hard to develop and share ideas. We try not to miss sporting events, or extra curriculum activity, but some days this occurs in order to meet the responsibilities and needs of engineering our ROV.

Due to the challenges of having student athletes on the team, we had a long time teammate leave the team in order to take advantage of some sport's opportunities that came her way. We've had the same team for nearly five years. This left us short handed and we all had to take on more responsibilities. This year we took the opportunity to pull in some new people and make the team bigger and bring in people with different strengths then we already had. We asked five new people to join the team and they were all major contributions.

One of the most difficult technical challenges for the team this year was the new servo arms that we had decided to put on. We had a difficult time understanding how they worked at first, but once we started working with the servos more, it started to come together. It was an understanding that came with time and experience due to the fact that we had just started learning about a digital system. Once we understood how to program and power servos we could accomplish more for the ROV. We are still working out bugs, but we have made progress.

Lesson Learned

Consistent Determination

Our first year qualifying for Internationals, second place.

Our second year qualifying for Internationals, first place.

Our third year qualifying for Internationals, first place.

Our fourth year qualifying for Internationals, first place

This year we learned that not everything can be learned in the course of a week. We took on a big challenge and switched our systems from analog to digital. We thought that it would be an easy switch, but we greatly under estimated the change. It took us several months to understand what we were getting into. After many lessons on coding we finally understood the basics to get our servo arms to work. We also learned that we could no longer do everything on our own with just five teammates left from the original team, we all decided on expanded our team with an additional group of five: Katie Nicholson, Ian Shriner, Tara Myers, Kady and Alyssa Gherke were added to the team because we knew we could only benefit from their strengths. Together we were able to do a more thorough job.

After having a year where safety was enforced, but still injuries that varied from broken arms to finger cuts. We realized, as a team, that our safety procedures need to be adjusted. We started from the source and created a JSEA (Job Safety and Environmental Analysis). This helped us narrow down the sources where someone could get injured and so far this ROV season no one has been injured. Everyone on this team serves a purpose and if we lose someone because of a safety issue that could have been prevented, the team suffers. As a team we need to take safety very seriously and take any precautions we can to reduce injured while working with the ROV.

Future Improvements

Shipwreck Discovery is a project that has started to become more of a platform for students lead research projects. Last year we focused on own projects this year we are trying develop better educational tools for the community.

The *Oscar T. Flint* is again one of our targets this year with Shipwreck Discovery. We turned the project over to group of fifth graders that are researching the wrecks history and will use the EDU ROVs to be able to get a first hand look at the artifacts that are in question on the *Oscar T. Flint.*

This year's ROV improvements have all focused on designing and building a stronger and more technically advanced ROV than we have ever attempted before. Our company may have raised the bar a little to high, but we took on the task. This year we are using an Arduino processor to control our ROV. This year's goal was to get the thruster working and learn as much as we can for future years. We have watched a lot of teams at Internationals design some amazing technology and our company though it was time for us to start taking some bigger risks. In the past, we always agreed that simple was best because if simple breaks, it's easier to fix. We have seen many teams be successful and watched a lot of teams never make it to the water because loss of programming. With no risk, there is no reward and the Arduino opens a lot of learning opportunities including creating our own sensors, developing more advanced control systems, and experimenting with robotic manipulators. This is the next step we need to take.

A second improvement goal is focused more on the team than the ROV. We are using our knowledge and experience to help support our community and grow the ROV program in our area. This has given us a great opportunity to give back to our community, get some practical work experience, and to mentor other students. The PVC framed ROVs with the home-made thruster do not work well in the open water of Lake Huron and depth is limited. We are using the same technology we used to create our own competition robot to build the two education ROVs. Our team will be responsible for the maintaining the EDU ROVs and repairing them when needed. By encouraging more students to became interested in marine technology, we are improve our own experience level.

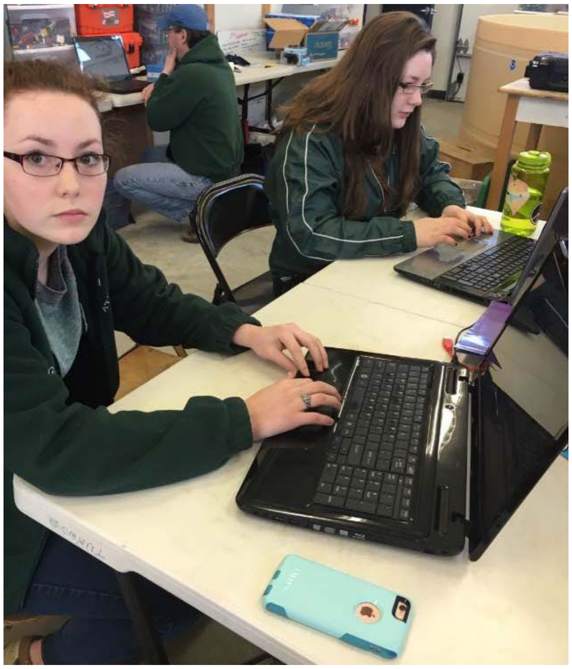
Since our previous competitions and experiences, our team has improved in almost all areas, such as teamwork, knowledge, confidence, skill sets, and problem solving. We have been attending these competitions and using the opportunities given to us by the wonderful people that presented them to us. We have developed so much since our first competition back in fifth grade, but that does not mean that we are using our potential to its fullest extent. Our team strives to continue rise in position in these competitions, drawing people and opportunities to us, letting us improve more and giving us experiences that we can reflect on and use to our advantage.

Our knowledge and experience has reached a level that given us opportunities to share and teach others in our community and beyond. We were asked to assist at a teacher workshop given by The Thunder Bay National Marine Sanctuary. At the workshop all team members were assigned a team of teachers from all over the state. From there we spent the day encouraging and teaching teachers the techniques to building a ROV and key points of being on a ROV team. Another project we were fortunate to be part of was the Montana project. Stephaney Gandulla originally from Montana, asked if we could create 3 ROV in a bags for her to take with her when she went to Montana. She wanted to spread the education of ROV and show it to her hometown. We gladly accepted and were honored to help kids from another state expand there ROV knowledge. We also helped mentor other young teams that are in Navigator and Scout levels of the competition. Being able to help younger members of the competition makes us better students and competitor. We learn how to problem solve better and how to work with others in a large age gap. This competition has also given us a chance to give back to the community. We owe our community so much. They have supported us in ever endeavor and continue to support us.

Members of the UR^2 team teach teachers who are interested in starting ROV teams at their schools.

Member of the UR^2 team mentoring sixth graders at a summer workshop hosted by the Thunder Bay National Marine Sanctuary.

This year, our team really came together to build an amazing ROV, so we can advance in the rankings and ditch the old well known and less functional design. Our ROV’s frame was designed by Savannah Thomson, and it is made of high density polyethylene (HDPE) that doesn't compress and expand as other plastics do. The frame is made to fit within the 48cm space requirement and still has enough room to fit everything else in it. Our enclosure was wired by Ian Shriner and Josh Beatty, fitting all of the wires together through, some miraculous work on their part. The enclosure has the motor and arm controllers for our switch from analog to digital, a more complicated and functional approach than we were previously comfortable with. The wiring to these systems goes through the tether that we have painstakingly made to fit all of the cables that we need to go to our ROV. Elizabeth Thomson, Savannah Thomson, and Katie Nicholson all contributed to make it happen. Connecting the controls to the ROV is essential, so we made sure to have all connections between the two were secure. The controls were put together by Nate Cosbitt, Elizabeth Thomson, Sam Beatty, and programmed by Katie Nicholson. The wiring for the controls was difficult, but what was really difficult was the programming. We have had little to no programing experience between all of us, so programming was a challenge that we had to overcome. Katie really pulled through with it though, as she put lots of work into figuring everything out and making it work. The ROV isn’t our only responsibility, though, as we still had to create our sales presentation board and write our technical report. Everyone worked on these jobs, but the main contributors are Tara Myers, Alyssa Gehrke, Kady Gehrke, and Elizabeth Thomson.



Kady and Alyssa working on this very document for submission to the Great Lakes Regional

Josh and Nate working ROV-in-a-bag kits to be used by a class of sixth graders in Montana.

Thank you very much to:

Our SolidWorks Mentors

- Chris O'Bryan
- Quade Kimball

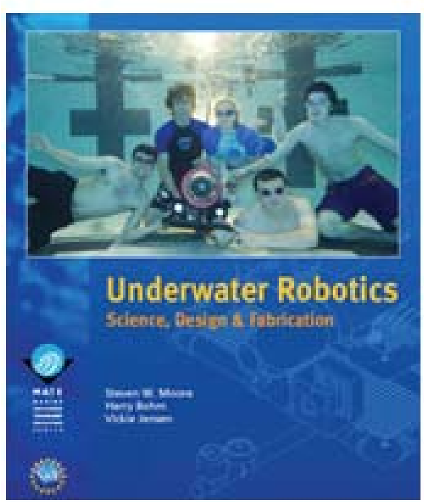
Technical Advisors

- David Cummins: Alpena Community College
- Bob Richards: Stockbridge High School

Team Support

- Thunder Bay National Marine Sanctuary
- Marine Advanced Technology Education Center
- SolidWorks Corp.
- Oceaneering
- All the volunteer divers and NOAA staff members that make everything possible.

References:



Underwater Robotics: Science, Design & Fabrication : by Steven W. Moore, Harry Bohm, Vickie Jensen

Underwater Research Robot Company

Meeting Schedule