Underwater Rescue Research Company

Rescue Robot Team:

Elizabeth Thomson: (Seventh Grade)

- CEO and Safety Officer

Breanna Domrase (Seventh Grade)

- Payload Specialist

Nathan Cosbitt (Seventh Grade)

- Pilot

Sam Beatty (Seventh Grade)

- Pilot

Savannah Thomson (Sixth Grade)

- Lead Engineer

Josh Beatty (Sixth Grade)

- Data Specialist

Bob Thomson

- Mentor

Mission

OUR COMPANY IS DEDICATED TO FINDING, PROTECTING, AND PRESERVING THE ENVIRONMENT

Technical Report

Marine Advance Technology Education

May 22, 2013

The Robot Factory 4-H Club

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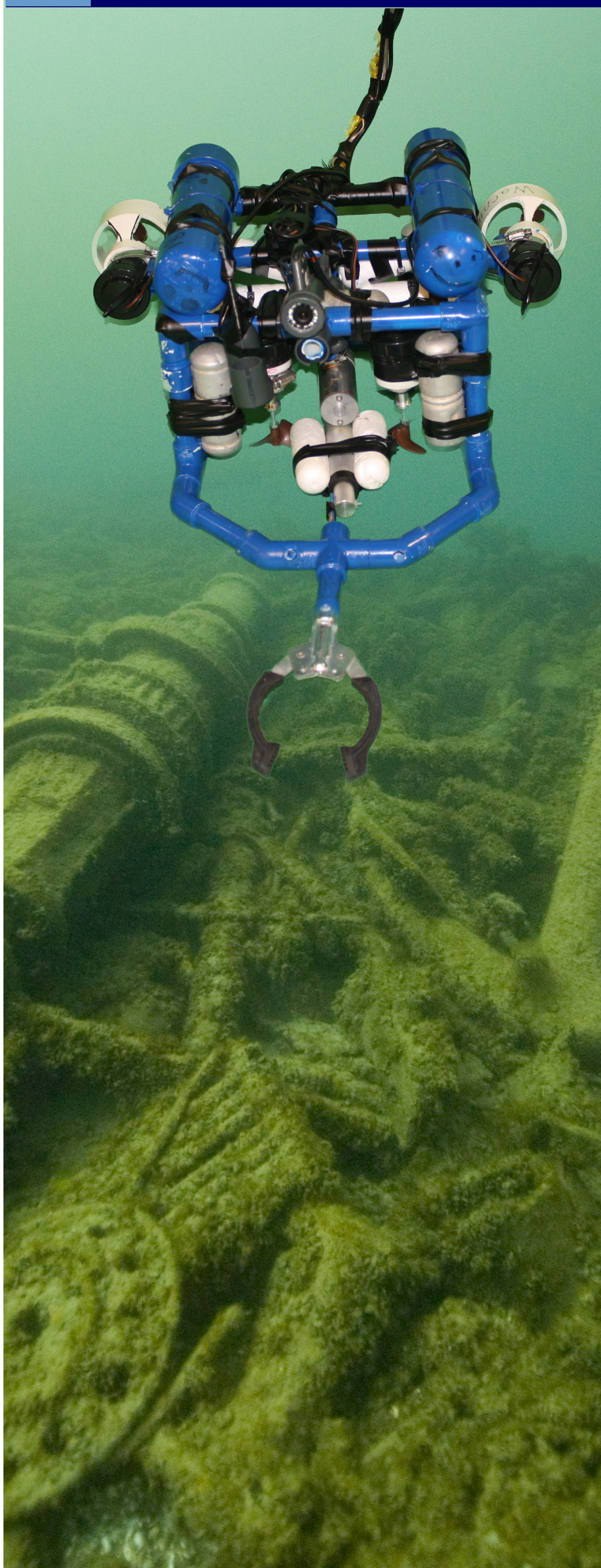

Abstract

We are a group of sixth and seventh grade students who are focused on “taking the pulse of the ocean”. We founded the Underwater Rescue Research Company two years ago. We have continued to grow and have built a more experienced company.

Our team designed a specially adapted remote control robot (ROV) for the purpose of completing this mission. We designed our ROV with specific payload tools to assess the equipment on the sea floor. We built it small (35cmx20cmx22cm), in order to have a quick response in the water. Furthermore, it is designed so our tools could be quickly delivered and used in the fixing and deploying of the scientific equipment. We have four thrusters each capable of five Newtons of thrust at full power. We have engineered multiple tools and sensors. They have been tested to ensure that our ROV is effective and capable of carrying out this mission successfully.

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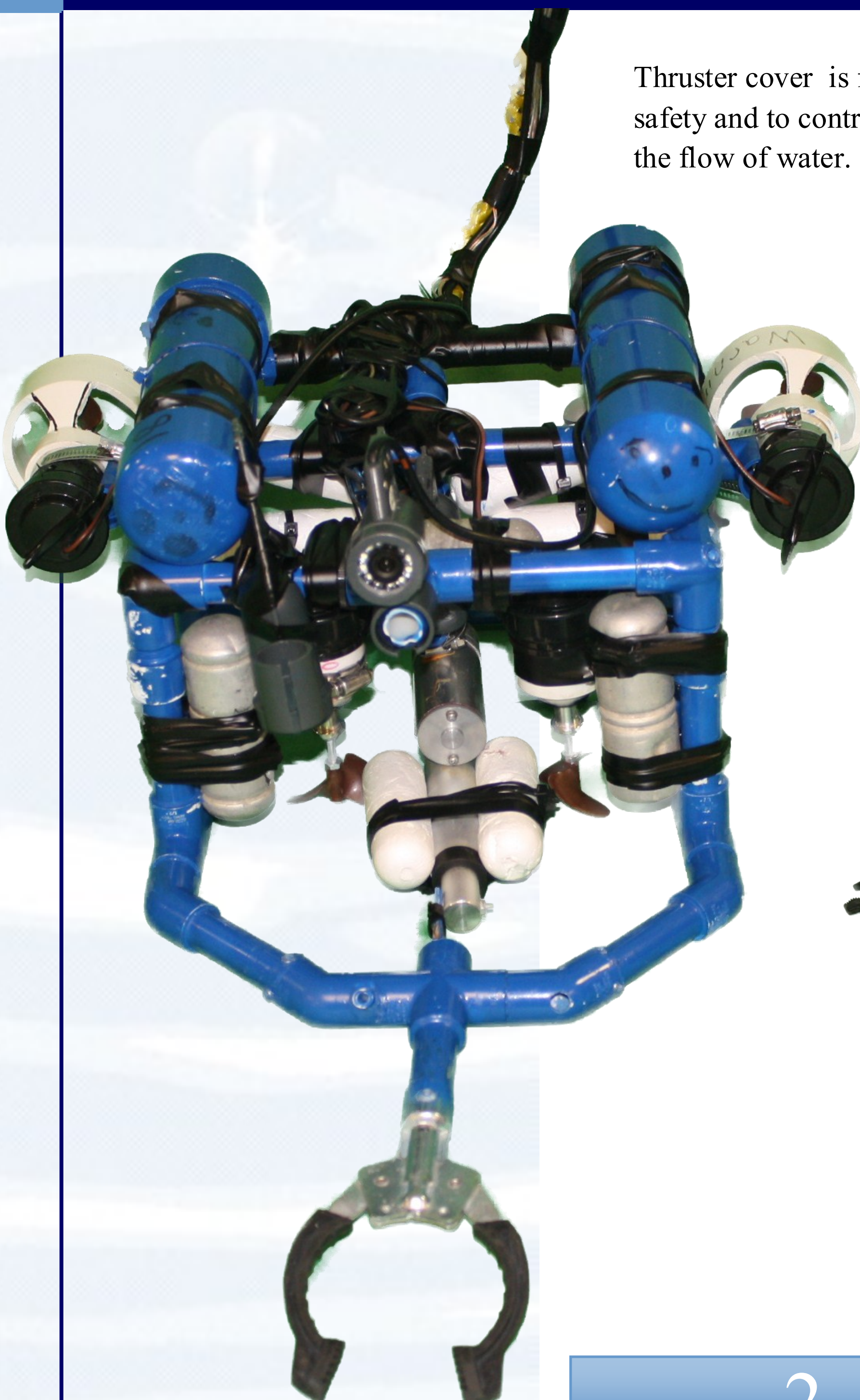
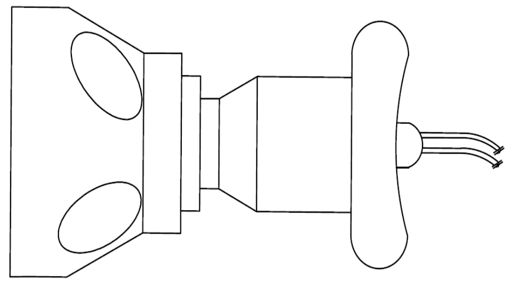
ROV Photo Profile



Thruster cover is for safety and to control the flow of water.



CAD image of one of the horizontal thrusters

Side View

UR²

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Expense Sheet

ROV Expenses

Item	Cost	Source
Scheduled 40 PVC Pipe	$45.00	Besser Foundation
Tether and Control Panels	$75.00	Besser Foundation
Thrusters		Reused from last year.
1 Camera & Monitor	$150.00	Besser Foundation
1 Camera & Monitor	$150.00	Besser Foundation
Temperature Probe	$34.00	The Robot Factory
Data Collection Device	$1,000	The Robot Factory
Mechanical Grabber	$18.00	The Robot Factory
Linear Actuator	$120.00	Ossineke Building Supplies
Electrical tape/wire ties	$17.50	The Robot Factory
Small trim floats	$8.00	The Robot Factory
Pool Time	$300.00	The Robot Factory
Total Team Cost for ROV	$0	Donated = $1,917.50

Projected Funding Source	Money Raised
Bottle Drive	$1,100.00
Personnel Donations	$1,000.00
Spaghetti Dinner Fund Raiser	$1,300.00
Alpena Rotary Club	$300.00
Alpena Mall ROV Showcase Event	$550.00
Optimist Group of Alpena	$500.00
Ossineke Chamber of Commerce	$100.00
Alpena Booster Club	$300.00
Total	$.5,250.00

Projected

Travel Expenses

for International

Competition

Total $7,000

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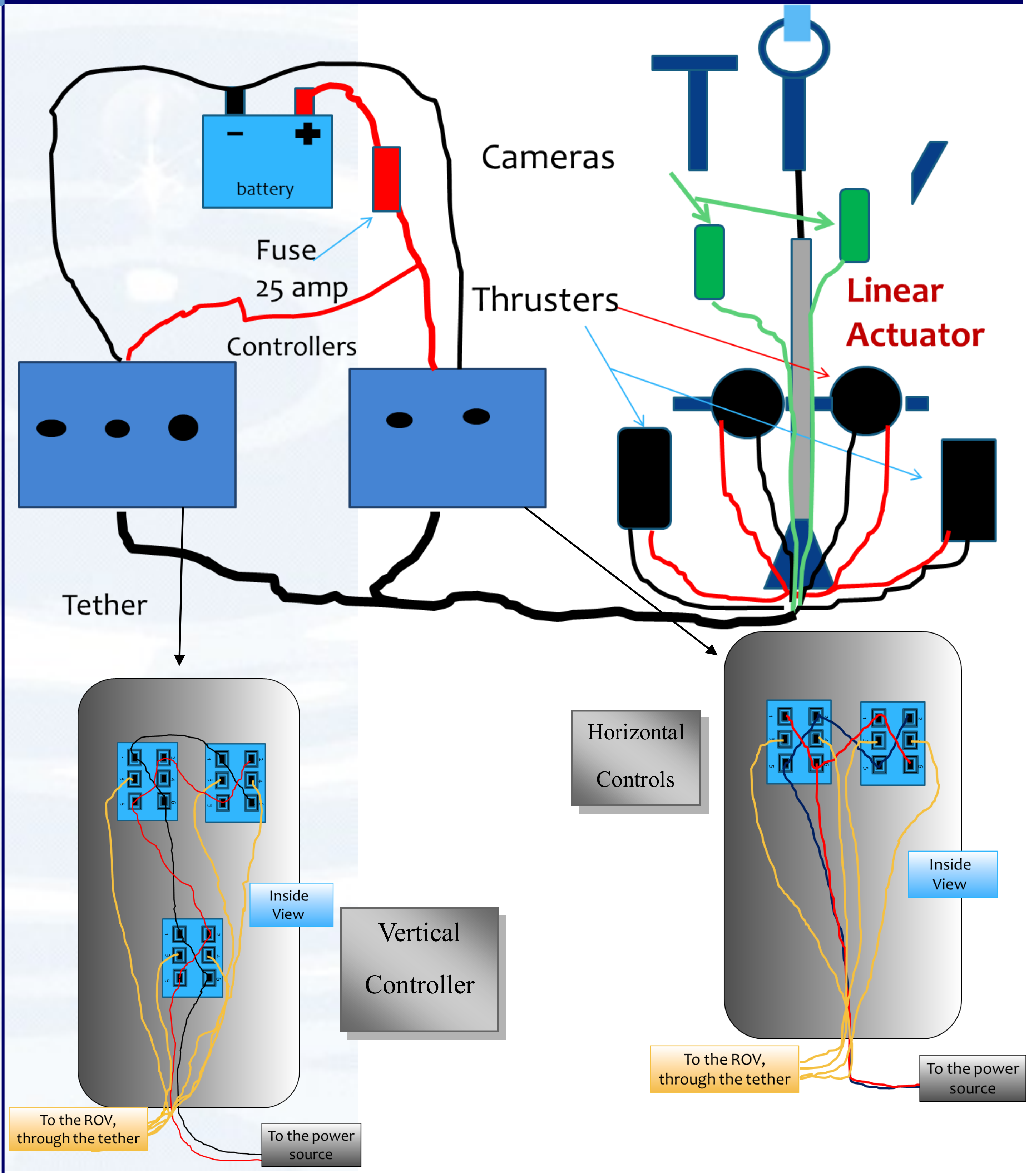
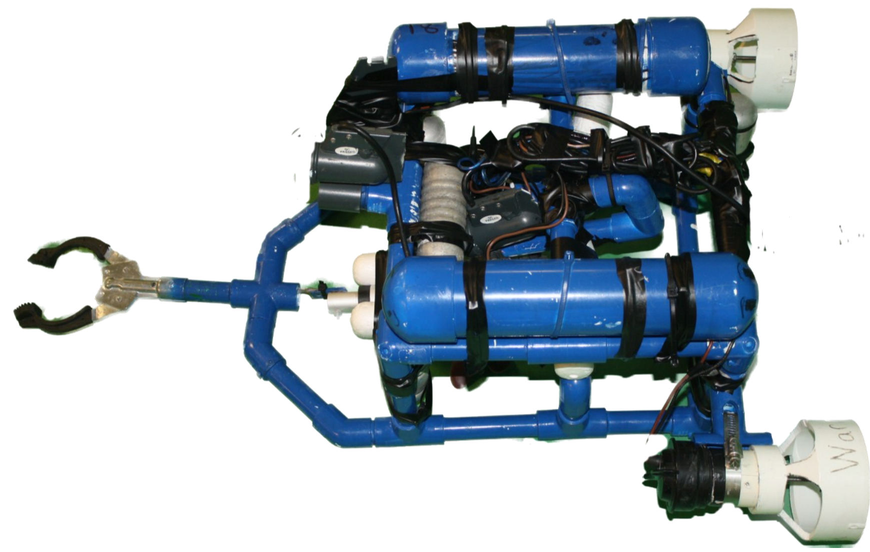

battery
Fuse
25 amp
Controllers
Cameras
Thrusters
Linear
Actuator
Tether
Inside
View
Vertical
Controller
To the ROV,
through the tether
To the power
source
Horizontal
Controls
Inside
View
To the ROV,
through the tether
To the power
source

UR^2



Major Systems

- Frame
- Control
- Propulsion
- Ballast
- Sensors
- Camera
- Payload Tools

The engineering behind our robot has more to do with function rather than flash. We have built our robot with components that we can fix. During our three years of competing, we have seen some pretty cool robots. Mr. Thomson always tells us that if you can fix it, you can use it. That is why we stick to simple components that we understand and can fix.

Each of our major components are listed in our design rational and we briefly discuss our design and why we used the material that we did. This year's mission has a lot of movements and requires a robot that is small and can move quickly. We believe our design and the reliability of the components that we used to build our robot, make it a sound design and very competitive.

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Structure

We used a combination of 5mm plastic fitting to give our frame it's small unique shape.

Our team of tether engineers developed our tether and frame structure to reach the depth of 15 meters. We constructed the frame out of half-inch schedule 40 PVC pipe. We chose these materials to construct the frame because of its strength versus its cost and how easy it is to use, cut, and build. The structure is strong enough to effectively complete low depth research. This allows us to offer low cost research to nonprofit organizations. In July, we will be working with USGA to place some retrieval hook on some equipment so it can be retrieved. This type of community work provides proof that our robot is not only a successful competitive robot, but useful to our community.

Control

The control system is not that high tech, but it gets our ROV where it needs to go. The ROV is controlled by individual toggle switches. We have two control panels and our ROV needs two pilots to control them. One pilot controls forward and back and the other pilot controls up and down along with the mechanical grabber. The controls are linked to the ROV by the tether. We have eight conductors total on our ROV's tether.

We decided to design our controls for two pilots because in the other competitions it was too hard for one pilot to do it all.

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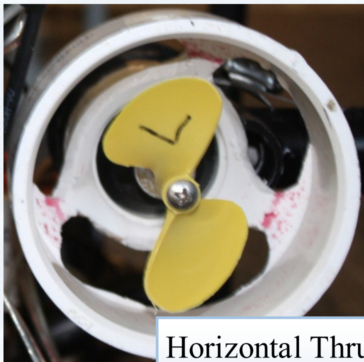


Horizontal Thruster with large propeller

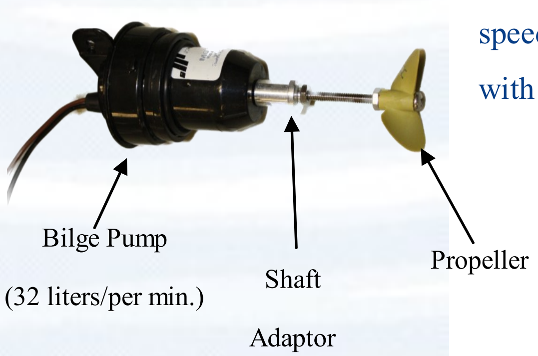
Propulsion

We have four thrusters. Both forward and reverse thrusters are matched to have equal amount of thrust. We tested each thruster to match them. Each thruster has 5 Newton's of thrust. Each thruster, at full power, pulls 3 amps. We placed the up/down thrusters in the center of the ROV to increase our lift speed to get to the top of the water. Our forward/back thrusters are located on the outside of the ROV to give us better turning ability. When we first designed the ROV, we placed the vertical thruster on the inside of the frame, but when we tested in the water it turned really slow. This is why we moved them to the inside.

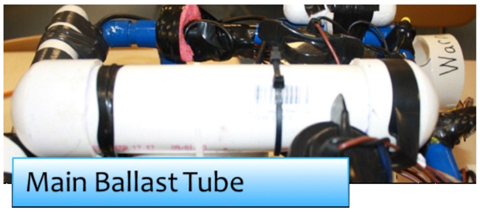
To increase our ROV speed we used a larger propeller on the horizontal thrusters. We found a propeller that was just a little smaller than the propeller guard. This change gave us an additional two Newtons of thrust on the thrusters.

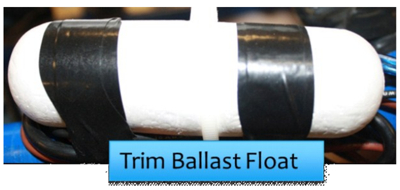
With these type of thrusters our robot can maintain an average speed of 0.3 k/hr. This not crazy fast, but we can get the job done with out damaging payload by going to fast.

Basic Thruster Design



Ballast


Main Ballast Tube


Trim Ballast Float

Our ROV was designed to be neutrally buoyant. We designed it this way to hold position in the water column to deploy scientific equipment. The buoyancy is made up of PVC pipe and plastic floats to trim it. The buoyancy of our ROV makes it stable. The ROV remains on the same plane as we utilize the driving tools of our ROV, so we are able to complete the tasks we need to, just like in real life. Stability is important because if the ROV isn't stable, it won't go in a straight line and it will be going wild. When working with expensive scientific equipment, it is important to be in control or we will cause damage and have more problems than we are trying to solve. Stability is key in ROV research.

Out of the water our robot weighs 5.8 kgs. When the robot is in the water, it only takes 1.5 newtons of force to lift it. This means that the majority of the thruster power is used for payload.

Sensor

We have a single sensor on our ROV. We have a digital thermometer that records temperature over a period of time. We are using a Vernier Go-Probe with the Lab Quest data collection recorder.

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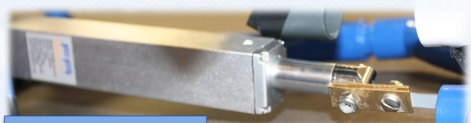
Payload Tools

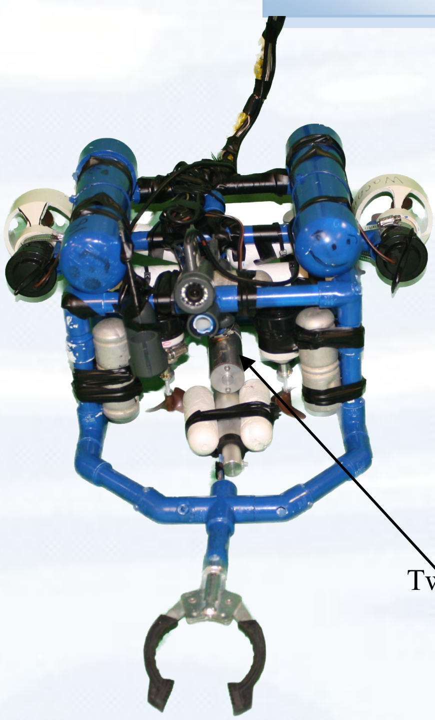
Mechanical Grabber



Linear Actuator

We took a grabber stick and cut the pole off which left just the jaws. We took the linear actuator that we used last year and designed the frame around it so that it was in the center and balanced. The actuator opens and closes the jaws of the gripper. The actuator only moves about six centimeters. This is just a little more than what we need to open and close the grabber. The pilot has to make sure he doesn't over drive the actuator because the actuator is strong enough to break the ROV frame. We know because it has happened twice, but I think we got it redesigned so it doesn't happen again. We positioned the actuator to be open all the way and then attached the arm. This way it won't seperate the ROV frame.

Cameras



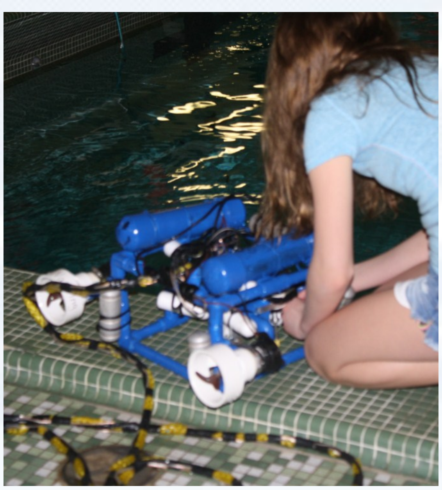
Two camera locations.

We designed our ROV to support two cameras. Both cameras have a depth rating of 20 meters. We placed one camera in order to operate the mechanical grabber. The second camera is placed so we can use it to scan the bottom to locate equipment locations and have a clear view of the forward motion of the ROV. The cameras are black and white, but they work great when there is not a lot of light.

Company Safety

Company Safety Responsibilities

Whether on a NOAA research vessel like the Storm or at the pool, we need to practice the same safety procedures each time we are out doing research or preparing our robot for competition. Safety is #1.



Elizabeth Thomson CEO and Safety Officer

As the CEO and the Safety Officer it is my job to oversee all of our safety practices. I must be sure that my crew is working in safe conditions either on the pool deck or the research boat. My role is to make sure that we don't lose any team members or equipment because of an accident that could have been prevented. Everyone on the team is responsible for following our safety rules.

In addition to the safety rules, we have done several things to make sure our robot is not only reliable, but safe to use. We have added strain reliefs to our control boxes to avoid damage to switches and possible electrical shock.

Our Team's Safety Practices Include:

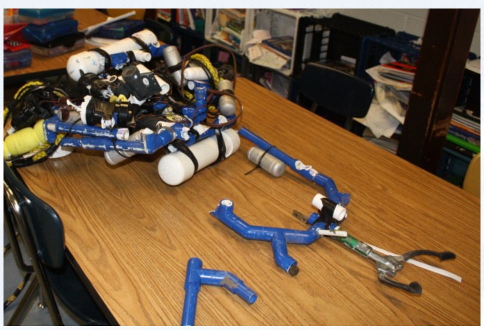
1. Safety goggles must be worn at all times when working on or with the robot.
2. Closed toed shoes must be worn when handling or working on the robot.
3. Each member is responsible for knowing the safety check-off sheet for robot operations.
4. One hand rule is in place when connecting and disconnecting the robot from the power source.

* See appendix for the companies safety check sheet.

The Big Challenge

"On your worst day, you can sometimes find out what you are really capable of doing."

Back in the classroom we starting taking it apart and looking for parts that were still good



A challenge our team, The Underwater Rescue Robots, faced was when we worked to rebuild our R.O.V. back together after it got run over. It was a normal day at the pool. We were practicing for the up coming regional competition and we set our R.O.V. next to our car to pack up. Then, a white suburban, went to pull ahead and ran it over. Monitors were smashed, cameras were crushed, and the frame was beyond repair. Later, after the shock of the wreckage, the team gathered for a moment of silence, and then jumped into full repair time. Girls were rewiring, boys were rebuilding and together we were determined to rebuild for the next practice time, tomorrow at 11 a.m. It was 7 p.m. We had less than twenty four hours to do this. We rolled up our sleeves and pulled back the hair for it was a long night ahead. We gathered old pictures and built it as identical as possible. It took lots of tape, glue, and pipe. At 1: 30 a.m. we called it quits at half way done and ready to report back later after some sleep. At 6:30 a.m., we slowly walked through the door, dragging some feet, we finished up quick and headed to the pool; ready for another day at the pool. I can report that there have been no further accidents and we are ready to compete against the other teams so bring it on.

Moments after the run-over.

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Troubleshooting (A team effort)

Last year we worked a lot on trouble shooting and it helped us a lot. Mr. Thomson would break our ROV and have us find what happened. This helped us this year because we didn't have Mr. Thomson around much because he was working with younger teams and would only come around when we were really stumped. The best way to troubleshoot is to start at the source. So, lets say the actuator is not working, this happens every so often, you start with the power. Does anything else work? If nothing else is working like a thrusters than it has to be a main power problem. Maybe the plugs are not in all the way or the fuse is blown.

This year we have a power jumper that plugs into the battery and it has a switch and a fuse (see picture to the left). Each camera and control box has its own power cord that plugs into the jumper, this lets us hook-up quickly and the plugs can only go one-way, so no one can plug something in wrong. This has saved a lot of fuses this year because last year it seemed like we needed a fuse every time we powered up.

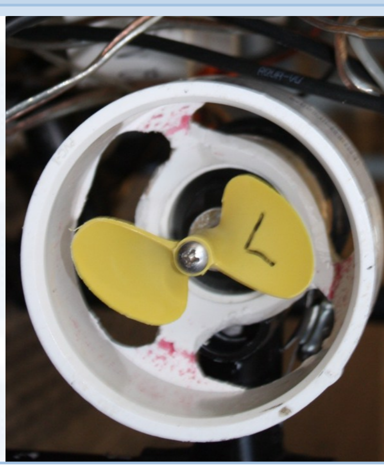
Once you know you have good power, than it is either a loose wire (this is usually what happens to us) or the part is broken. We took care of the loose wires by soldering them together and sealing them. So, I hope we spend less time troubleshooting and more time getting the mission completed.

Morgan (an assistant) and Nathan soldering wire connections together.

Comparing

Thrusters

Above: this thruster will produce about 10 newtons of thrust, but only in one direction.



This is the thruster we are using now. It will reach 5 newtons of thrust in both directions.

The next step we need to take is developing better thrusters for our robot. The hardest part about using our robot is that we sometimes do not have enough power in our thruster to lift and move heavy objects under water. This year our robot has struggled to get the BIA in the correct position because our robot does not have enough power to move the BIA quickly.

We have two solutions to this problem. One, we are looking at what it would cost the team to invest in commercial thrusters. Commercial thrusters would give us that competitive edge that we need to compete against other teams at Internationals. So many teams are using commercial thrusters that we seriously need to look at this problem. The other solution is to design our own thrusters that have greater strength. We worked on thrusters last year that had twice the strength of the thrusters we are using this year, but it was only in one direction. The other problem is that they weight a lot with all the extra PVC fitting to take up the gap between the propeller and the housing.

This year we started designing a new thruster cover that increased thrust and didn't weigh much at all. We got the idea from a team that had made there own thruster cover and they had great success. So we took their idea and tried to make our own version out of PVC. We are still working on it. It is not reliable yet, but we will have it ready for next year.

Reflections on the experience

Last year it took us forever to get the frame done, everyone was bickering over the dumbest things, but this year when our R.O.V. got ran over accidentally, we started out with our old frame. We made the add-ons permanent and nobody argued about that because we thought that with last year's frame winning second place; it is a good frame. We thought that the frame was good for the mission because it was small, fast and we didn't waste any time building a new frame. Because of the accident, we were able to engineer the R.O.V.'s frame more towards this year's mission.

This year we understood that we had to pull it together and work as a team. We made pretty good choices, because our team has been together for three years. We finished first place against high school kids and that is our second time winning in our regional competition. I mean, we did pretty well for junior high students, who have had many problems and more, but we got through them. We did it the right way and that's why are company is successful. Now look at us, we just got first place and had to deal with some big problems, we got through them, and we still won. As a team we have learned that it takes sharing and compromising on your ideas, so that everyone feels good about the solution. This is so hard, but I think this is one thing that has made us better.

Our team receiving the awards for high score on the poster, high score on the mission, and the first place overall award. It was a special day because Dr. James Delgado was one of the judges that interview us for the engineering report. We scored the second highest score that day. Missing our fourth first place by five points. Also, pictured with us is Mr. Jeff Gray Superintendent of the Thunder Bay National Marine Sanctuary.

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As a whole, our team has matured and grown together. We have made a lot of improvements since last year. We have gained experience, improved our skills, knowledge, confidence & team work. Critical thinking is another important gain that our time has improved on. When we work together, we can do just about anything.

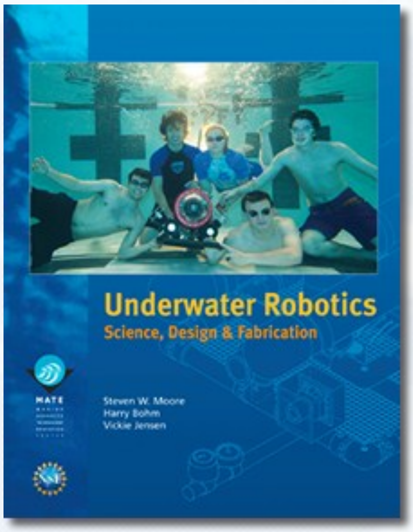
Our team has improved at presenting our ROV missions to the public. We have gained confidence presenting to small and large groups of people. When we do a presentation, we are very confident with our words and answering questions. All members are ready to answer questions as needed. The team has had an excellent experience with our ROV from interviews at schools to interviews around the state. We have been interviewed on our local television news station. In addition to being interviewed on the local news, we were interviewed on two different radio stations.

We have been a dedicated team while meeting, working on and practicing missions. Our team works well together and encourages one another. Each member is of equal value. Our team recognizes that we need each other to be the best that we can be. We even got invited to present at our State Capital after winning the Regionals.

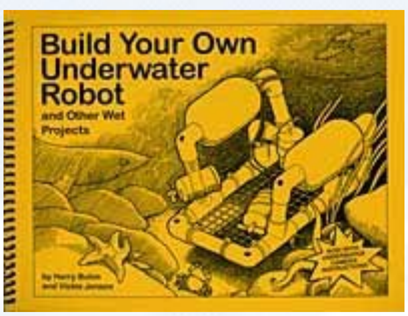
Our team at Michigan's Capital being honor for winning the Great Lakes Regional and for our teamwork.

"The team's success shows how important skilled trades learning opportunities can be, even starting at a young age," said Pettalia, R-Presque Isle. "These kids have generated great pride in our part of the state and their talent, teamwork, and determination have earned the respect of ROV followers and teams elsewhere in Michigan."

References



Reference: Underwater Robotics: Science, Design & Fabrication. Chapter 2: Design Toolkit. Chapter 3: Working in Water. Chapter 12. pp. 643 Safety Note:



Reference : Build Your Own Underwater Robot and other wet projects, by Harry Bohm and Vickie Jensen

Acknowledgements

Thank you very much to:

- Marine Advanced Technology Education Center
- The Robot Factory 4-H Club
- Thunder Bay National Marine Sanctuary
- Ossineke Building Supplies
- Besser Foundation
- NOAA
- Alpena County 4-H
- Thank to our Families for getting us to practice and helping us fund raise our trip to Seattle.
- To our Mentor: Mr. Thomson for helping us become the best we can be.

Appendix

Appendix A: Company Safety Check Sheet

UR^2 Safety Check-off Sheet

1. Safety Goggles and closed –toed shoes on
2. Two person carry on robot
3. Unravel tether and place away from traffic area
4. Plug in monitors and tether to power jumper
5. Make sure all toggle switches are set to off position
6. Using the one-hand-rule plug banana plugs to battery
7. Place jumper switch to reset
8. Give the all-clear before testing systems
9. Run system checks on thrusters, cameras, and payload tools.
10. Place robot in water