Utica T.U.R.R.E.T. Presents

Walrobotus

TURRET [Technical Underwater Robotic Research Engineering Team]

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Abstract

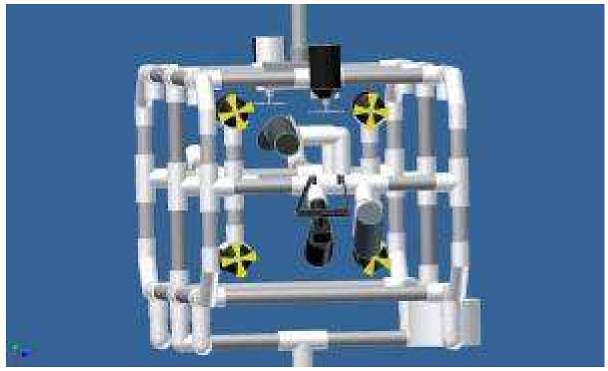
Our goal for TURRET's second year of competition with remote operated vehicles (ROV) was to successfully build an ROV that would successfully complete the tasks for the 2009 MATE Great Lakes Regional competition and to qualify for the International competition. After researching technical reports from past ROV competitions, we brainstormed ideas for this year's mission.

This year's main focus was to upgrade our propulsion system. We tested different motor types, motors, and props to effectively drive our ROV with minimal turning restrictions. We maximized our motor usage by having four motors pointing in the same direction. Furthermore, with tank steering we can turn on a sand dollar.

Jake and Zach working on control sticks

Design Rationale: Body

Propulsion System:



The basis of an efficient ROV is being able to sufficiently control driving. We kept this in mind when designing our propulsion system. Our goal was to give our ROV the capability of tight pivoting and speed. Our ROV uses six motors strategically placed to accomplish this task. First, four motors are set in the center of the body in the shape of a cube. On our control system the left and right control sticks operate the two thrusters on one side respectively. Therefore, we can run all four in forward and have a maximum speed forward. To drive in reverse we can run all forward facing motors in reverse pushing our ROV backwards. To pivot the ROV we run each side in opposite directions and our ROV turns on the spot. Paired with tank steering are two thrusters controlling the vertical movement of the ROV. One is in the front and one is in the back. With these thrusters we can control submerging and surfacing. Furthermore, by splitting the motors into two places when using one of the appendages at either end of the ROV especially the tusks for the ELSS pods we can compensate for this unequal weight distribution.

Thrusters:

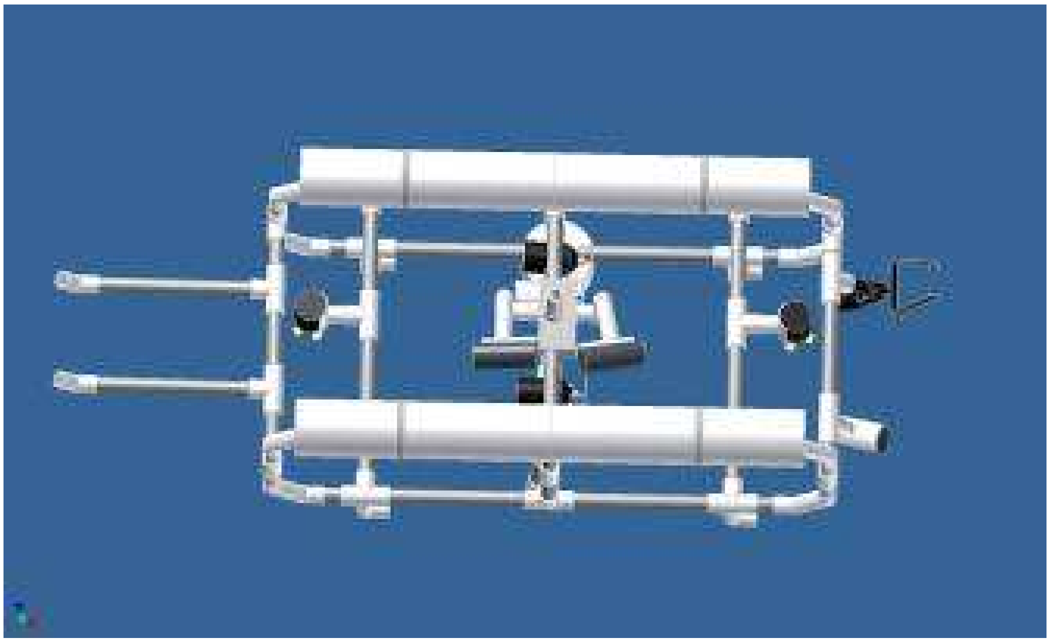
Our ROV uses Rule bilge pump motors. It uses four 4164 liters per hour (1100 gallons per hour) 6 amp bilge pump motors. Our two up and down bilge pump motors are 1893 LPH (500 GPH) and 2.5 amps, while the arm uses a 1363 LPH (360 GPH) bilge pump. All seven of the bilge pump motors are 12 volts.

Frame:

Our frame is constructed from 1.27 cm (1/2”) PVC pipe. We used PVC because it is cost effective, practical, and strong. We used screws to hold the pipes together for ease of interchangeability and maintenance.

Ballast:

Our ROV benefits from a fixed ballast system. Our system is slightly positively buoyant. Weight can be added easily to adjust for different pool chlorination levels. Adding weight is much simpler than adding more buoyancy. In our supply kit we have metal weights ranging in mass to adjust our ROV’s buoyancy.



Ballast Positioning

Design Rationale: Appendages

Claw:

Our claw is modeled after a pick-bot arm from our sister mechatronics class. We could not simply take the claw from the pick-bot and mount it on our ROV because the motor would cease to work while submerged in water. Therefore, we fabricated a mount and motor attachment using a bilge pump motor to turn the screw drive, opening or closing the claw. The claw's purpose is to hold the airline while traveling to the downed submarine. The claw is mounted at an angle to easily maneuver into the air lock to deposit the hose.

Tusks:

Our tusks are made out of PVC and protrude from the front of our ROV. They are set at the correct height so that our ROV can drive while sitting on the pool floor and maneuver into the Emergency Life Support System (ELSS) pod handles. Therefore, the purpose of the tusks is to transfer the pods from the pod carousel into the open hatch. On the tip of the tusk there is a 45° PVC adapter to prevent the ELSS pods from sliding off of the tusks. To deposit the tusks into the hatch we drive the ROV over the hatch and lower the ROV so that when the ROV is driven in reverse the pods slide off safely depositing them into the escape tower.

Rotisserie:

The rotisserie is also made from PVC and hangs from the bottom of the ROV. Our unique tool allows us to open the wheeled hatch using our ROV's driving capability of rotating. The design is a simple pitchfork that is spaced to fall between the opposite gaps in the wheel. The mount was engineered to pivot up into the ROV. Therefore, it does not restrict or ROV from receiving a maximum depth.

Alternative Ideas:

Before construction, we discussed using a hydraulic arm to complete the tasks. Last year's ROV team used this type of tool in their competition so we knew that we could easily duplicate this process. However, due to the difficulty of this type of arm or an electrical arm we decided to adopt the motto of "keeping it simple." Therefore, we developed the simplest appendages that would most successfully complete the mission without malfunctioning. Our claw is also considered simple because it is a simple screw drive running on a motor to open and close and has no pivoting capabilities. For this movement we instead rely on our driving abilities.

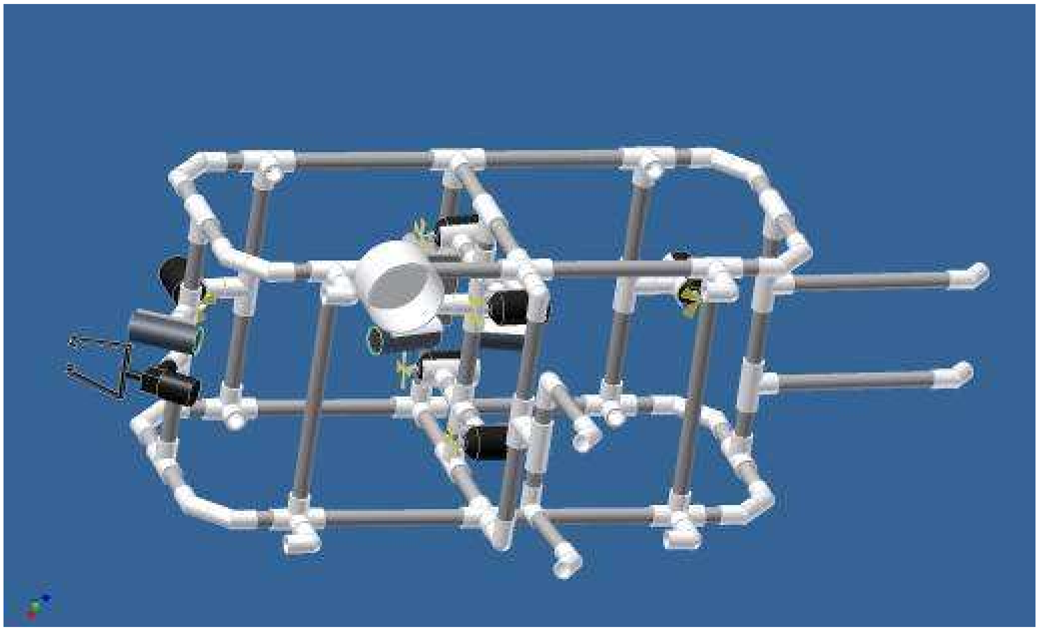


Figure 1: Underside of ROV

Design Rationale: Controls

Cameras:

Our ROV uses total of three infrared underwater cameras. They have a 3.6 mm lens and a 22.86 (9”) focus. We chose these cameras because they used infrared for viewing so we did not have to worry about dark conditions or installing lights on the ROV. They are also small, light, robust, and affordable. We use three cameras and three screens. Our first camera is positioned to view forward, giving us a view of the tusk while also seeing directly in front of the ROV. Our second camera is positioned to view the opposite direction when driving the ROV in reverse. This view also shows the claw. Our last view is aimed at the rotisserie on the bottom or our ROV. This screen is also used to view the skirt when docking with the downed submarine.

Tether:

Our tether bundles ten 18-awg wires necessary to run power and signals to each of the motors. Also included in the tether are 3 camera wires that attach directly from the camera to the screen. To wrap the tether we used a polyethylene diamond braided mesh. This mesh can be tightened or loosened depending on how it is stretched. This allows us to bundle our wires so they do not cause a problem. Our tether is ballast with closed cell foam tubing. The foam ballast is strategically placed in sections so that our tether horseshoes in the water preventing it from interfering with our ROV’s movement.

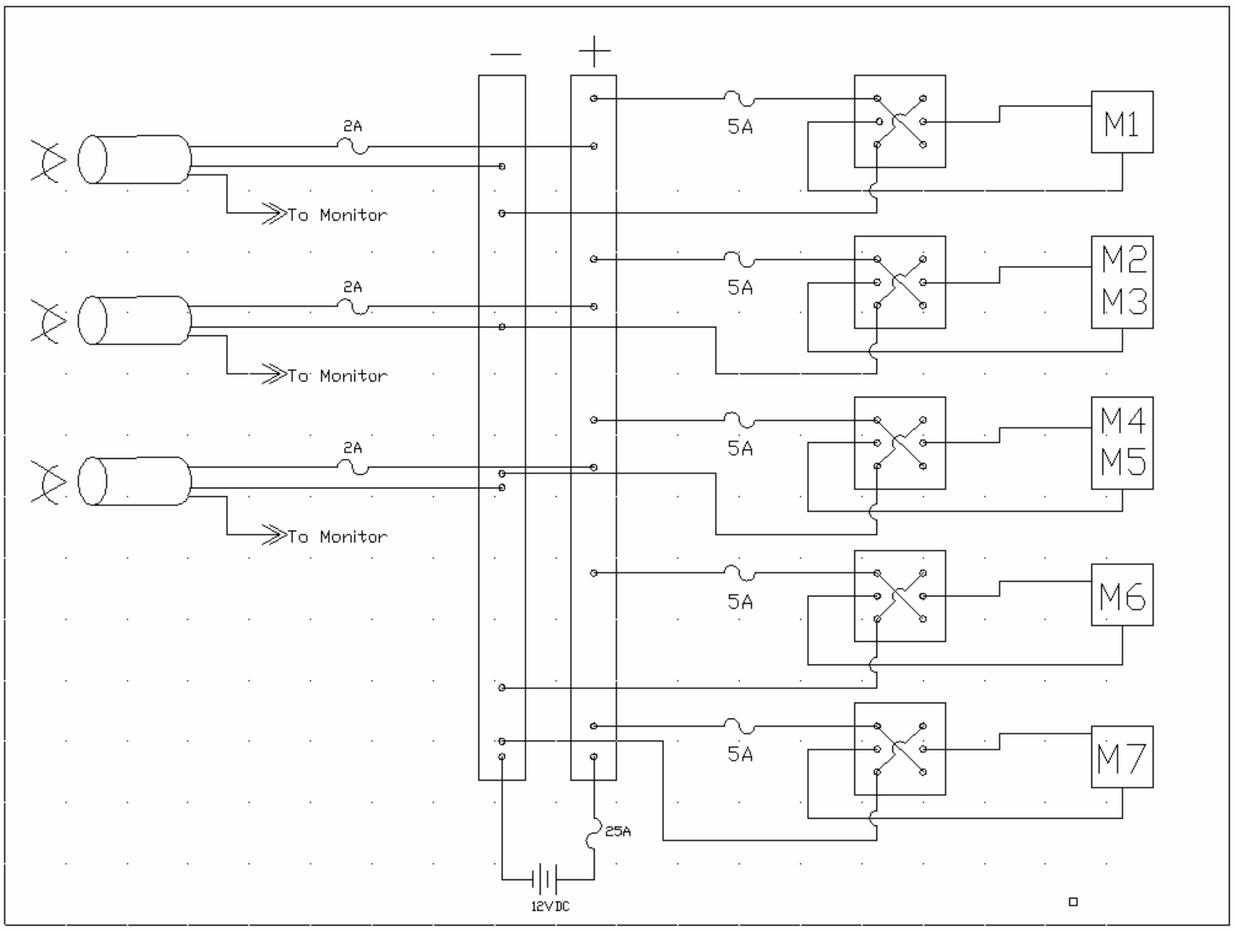
Control Box:

Our control box is a brief case that houses all electrical wires outside of the water. This also includes housing the fuses for each individual motor control and the claw. At the end of the tether we added a quick connect to the surface and manufactured the other quick connect end into the side of the briefcase. Therefore, the tether can be quickly and easily connected and disconnected from the control box.

Mechanical versus Software:

Our team decided with our limited programming background that a software system would cause more problems than we needed. Our strengths are in mechanical design and application. With our unique propulsion system, we felt that speed controllers would not be necessary because we would not see a big difference in controls. Our num-chuck controls allow us to tank steer and complete the missions quickly and effectively. We felt in our system the more electronics added, there would be a greater probability for something to fail.

Electrical Schematic



Challenges

Challenge I: Dynamic Ballast

Our original ROV plan included a dynamic ballast system to submerge and surface. Included in our tether was a 0.635 cm (¼”) inner diameter plastic air hose as the ventilation hose. A 0.9625 cm (3/8”) compressed air line was used to blow out the water from the ballast tanks. In the bottom of our ballast tanks we drilled numerous holes to let the tanks fill with water as the air is pushed through the vent tubes. When we placed the ROV back in the pool, it floated at the top because the water pressure filling the tank did not have enough force to push air up the small diameter air hose. Some possible solutions we discussed were running another 0.9625 cm tube down the tether but we felt this would add to much weight to the tether. Another possible solution was adding up and down motors to control depth. This was the solution we selected and we added a motor in both the front and the back of the ROV to control possible tilting when picking up the ELSS pods.

Challenge II: Claw

The motor that drives the screw drive of the claw started out as a geared up brushless DC motor. The gear ratio was 64:1. However, we encountered problems with this motor because we had to use a step down for the amps. The motor was a 5 V motor therefore, we had to step down the 12 V battery source. We encountered problems with our heat sink overheating. We even tried using a small fan and an even bigger heat sink but the claw system continued failing. Because of this electrical problem, we decided to switch to a 12 V bilge pump motor. This substitution eliminated the problem with overheating.

Challenge III: Frame Stability

Another problem we encountered was frame stability. While cutting the PVC with PVC cutters the edge of the PVC would not always be straight. Therefore, when we reconstructed the frame, we switched to cutting the PVC ends with a hack saw and holder.

Troubleshooting

When encountering any problems we used a ten step process:

1. Identify the process/problem
2. Define the working criteria/goals
3. Research and gather data
4. Brainstorm for creative ideas
5. Analyze
6. Develop models and test
7. Make the decision
8. Communicate and specify
9. Implement
10. Prepare post-implementation review and assessment

Sources:

Gomez, Alan G., MS, William C. Oakes, PhD, and Les L. Leone, PhD. *Engineering Your Future*. 2nd ed. Wildwood, MO: Great Lakes Press, Inc., 2006. Print.

Skills Gained

When accepting this mission, we did not realize the dedication it would take to accomplish our goals. As soon as the mission tasks were released, we tried to create a payload that would be simple but complete the tasks efficiently. This was much easier said then done. After countless brainstorming sessions we learned that it would take the entire group to generate ideas. Every team member's ideas were valuable and even if they were not used would add to a greater understanding of our mission.

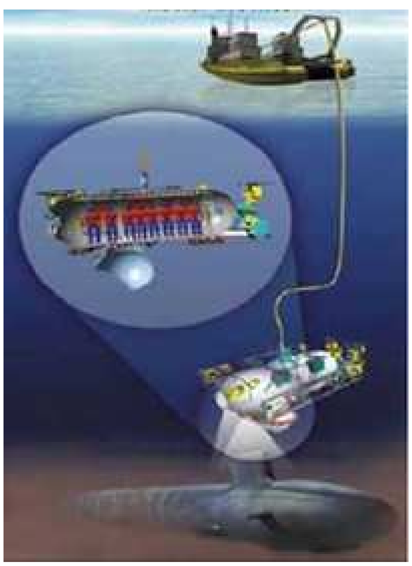
We had the most difficulty with developing an appendage for the air line. We discussed using a springing mechanism but this would be a one-shot deal. We also discussed creating a holder made from PVC to lift the air line. The issue of how the air line would float or sink in the pool negated this idea. In the end we had to stray from simple but still manufactured a basic pincher design.

Even with an uncomplicated claw design, we ran into problems with overheating motors and speed issues. In the end our design relied on the operator's ability to control the claw extremely carefully making sure it did not open too far and lock itself in place. From this challenge, we learned that sometimes simplicity must be sacrificed in order to complete a goal.

Jake testing the tusks

Remora Sub Rescue System

The Remora is a Submarine Rescue System (SRS) that consists of a tethered Hyperbaric Transfer Chamber (HTC). The chamber is used to rescue trapped crew members in a pressurized disabled submarine. Along with cameras the ROV is also equipped with sonar to help locate the submarine in need of rescue. The key feature of the Remora SRS is the elaborate mating skirt. This skirt allows attachment at up to 45°. With this wide range this HTC does not need a complex ballast system, similar to our ROV which also does not use a complex ballast. The skirt fits right over the hatch on the disabled sub and pressure is equilibrated so that the trapped crew men can be moved into the HTC by help from the two assistants that traveled down in the chamber. 16 crew members can fit inside the chamber on each rescue mission.



The HTC uses its tether as a trail to surface near its mother ship. There the HTC is picked up by crane and docked so that the crew members can be depressurized. With the HTC home base being located on a mother ship it can be used to rescue downed submarines anywhere in the world. Specifically the Remora has been used by the Royal Australian Navy. The Royal Australian Navy also deploys smaller ROV’s to transfer supplies to downed submarines before the Remora can be moved into place to complete rescue missions.

Sources Cited:

Stewart, Cameron. "Robot to rescue in sub disasters." *The Australian* 05 Oct 2006 Web.16 May 2009. <http://www.theaustralian.news.com.au/>.

Submarine Rescue Systems. OceanWorks International. 16 May 2009 <http://www.oceanworks.com/submarineRescueSystems.php>.

BUDGET

EXPENDITURES

Propulsion

Qty	Item	Cost	Total Cost	System
4	Rule 1100	$39.99	$159.96	Propulsion
2	Rule 500	$27.99	$55.98	Propulsion
1	Rule 360	$18.99	$18.99	Propulsion
1	Tsunami 800	$11.88	$11.88	Propulsion
4	Switches DPDT	$20.00	$80.00	Propulsion
10	Hose Clamps	$1.00	$10.00	Propulsion
			$336.81	

Frame

Qty	Item	Cost	Total Cost	System
3	1/2 inch PVC 10'	$1.79	$5.37	Frame
10	PVC 1/2" T	$0.29	$2.90	Frame
10	PVC 1/2" 45	$0.29	$2.90	Frame
10	PVC 1/2" 90	$0.29	$2.90	Frame
10	PVC 1/2" X	$1.10	$11.00	Frame
12	PVC 1/2" Special	$1.25	$15.00	Frame
1	Spray Paint	$8.63	$8.63	Frame
1	Screws	$3.99	$3.99	Frame
1	T Condiut	$2.27	$2.27	Frame
			$54.96	

Vision

Qty	Item	Cost	Total Cost	System
3	LCA-7700	$230.00	$690.00	Vision
3	3-2 Amp Fuses	$2.99	$8.97	Vision
1	Portable DVD Player**	$100.00	$100.00	Vision
			$798.97	

Power Source

Qty	Item	Cost	Total Cost	System
1	Marine Battery	$79.99	$79.99	Power Source
1	Battery Charger	$39.99	$39.99	Power Source
2	Battery Terminals	$0.99	$1.98	Power Source
			$121.96	

Tether

Qty	Item	Cost	Total Cost	System
60	60' Teather 18-18awg	$4.46	$267.60	Tether
50	50' Diamond Braid cover	$1.00	$50.00	Tether
3	Pipe Insulation	$1.99	$5.97	Tether
			$323.57	

Controls

Qty	Item	Cost	Total Cost	System
1	500' 18 awg Wire	$30.00	$30.00	Controls

1	Briefcase	$70.00	$70.00	Controls
1	Liquid Nails*	$0.00	$0.00	Controls
1	Box 5 Amp Fuses	$2.99	$2.99	Controls
3	12 Count Female Connector	$2.79	$8.37	Controls
1	12 Count Male Connector	$2.79	$2.79	Controls
2	Electrical Tape	$0.60	$1.20	Controls
1	Box of 10 Amp Fuses	$2.99	$2.99	Controls
1	25 Amp Fuses	$2.99	$2.99	Controls
6	Fuse Holders	$3.99	$23.94	Controls
			$145.27	

Ballast

Qty	Item	Cost	Total Cost	System
10	3" PVC	$1.00	$10.00	Ballast
4	3" PVC Caps	$1.20	$4.80	Ballast
1	PVC Glue*	$0.00	$0.00	Ballast
			$14.80	

Arm

Qty	Item	Cost	Total Cost	System
2	Switches DPDT	$5.00	$10.00	Arm
			$10.00	

Miscellaneous

Qty	Item	Cost	Total Cost	System
1	Poster Display Board	129.99	$129.99	Display
4	Hotel Rooms	101.50	$406.00	Room and Board
2	Gas	250.00	$500.00	Transportation
4	Hotel Room	80.00	$320.00	Room and Board
2	Rental Cars	50.00	$100.00	Transportation
2	Gas	40.00	$80.00	Transportation
			$1,535.99	
		TOTAL	**$3,342.33**	

***Signifies a donated item.**
****One DVD player was purchased; the other was lent by a team member for the competition.**

INCOME

Organization	Contribution
Michigan Tech	$1,000.00
Utica Community Schools	$2,000.00
Doughnut Sales	$150.00
Pop Can Drive	$250.00
TOTAL	**$3,400.00**

Expenditure	**-$3,342.33**
Income	**+$3,400.00**
GRAND TOTAL	**+$58.00**

Future

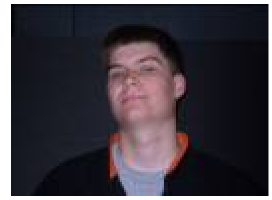
Designing and constructing our ROV has been a great engineering experience for the entire team. Not only did the project allow us to develop engineering skills but it also inspired some lasting friendships. However, the future is still unclear. All but two team members graduate at the end of this year. However, the two juniors on the team will provide a solid foundation that will surely lead a future ROV team to success.

Although the future is undetermined, there are many improvements that can be implemented on next year’s ROV team. Managing the team’s time can greatly improve the rate at which we design and build. Minimizing disorganization and working harder will produce quality teamwork. One of the main organizational problems we encountered was that we did not divide the team specific subgroups until late in the building process. Because of this no one became an expert at a particular area until much later on in the design. For next year, each team member should find the particular niche in the building process and stick with it. When the team has experts in particular areas, things get done.

As last year’s team encountered, size was an issue. Our original design was drawn up to be small but with the addition of appendages to complete the tasks our ROV size significantly increased. Therefore, next year’s focus should also be to keep the ROV as compact as possible while still effectively accomplishing the mission.

Team Bios

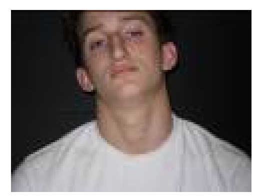
Adam Bolton: CEO
Grade: Senior
College Selection: University of Michigan
Intended Major: Engineering-Undecided
"The experience was awesome and I really was able to better my own leadership skills."



Marc-Andre Henry: Lead Designer and Driver
Grade: Senior
College Selection: University of Michigan
Intended Major: Mechanical and Electrical Engineering
"This project has re-enforced my love for engineering and I know I will be happy in my career field."

David Weyland: Tether Manager
Grade: Senior
College Selection: Michigan Technological University
Intended Major: Biomedical Engineering
"The skills I gained working on the ROV will no doubt help me in my future."

Jake Suchoski: Lead Designer and Driver
Grade: Senior
College Selection: University of Michigan
Intended Major: Mechanical Engineering
"The ROV helped me get into the field of engineering and how to work with others."



Jen Henige: Budget
Grade: Senior
College Selection: Michigan State University
Intended Major: Undecided
"Through this project I learned how fast money can be spent and how to properly manage it."

Sherwin Thomas: Public Relations
Grade: Senior
College Selection: University of Alabama-Birmingham
Intended Major: Biology/Pre-Med
"I have learned various ways to display information to different audiences; I feel this will help me in any career I embark into.

Sebastian Sznitka: Construction
Grade: Junior
"This was an eye-opening experience and it helped me see what could be my future. This has brightened my high school experience and I can not wait for next year."

Zach Elie: Construction
Grade: Junior
"This experience has just re-enforced my interest in mechanical engineering and I can not wait for next year's competition."

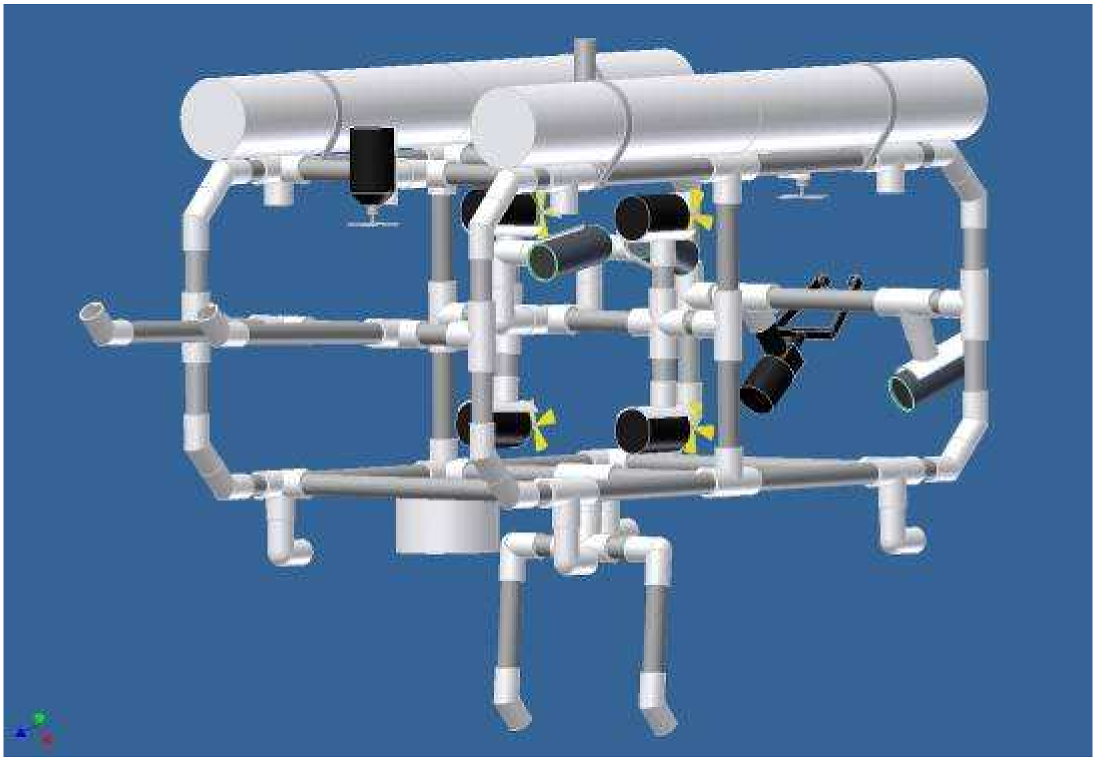


Figure 2 : Final 3D CAD Drawing

Acknowledgements

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- Marine Advance Technology Education (MATE) Center- Great Lakes Regional ROV Competition and International Competition