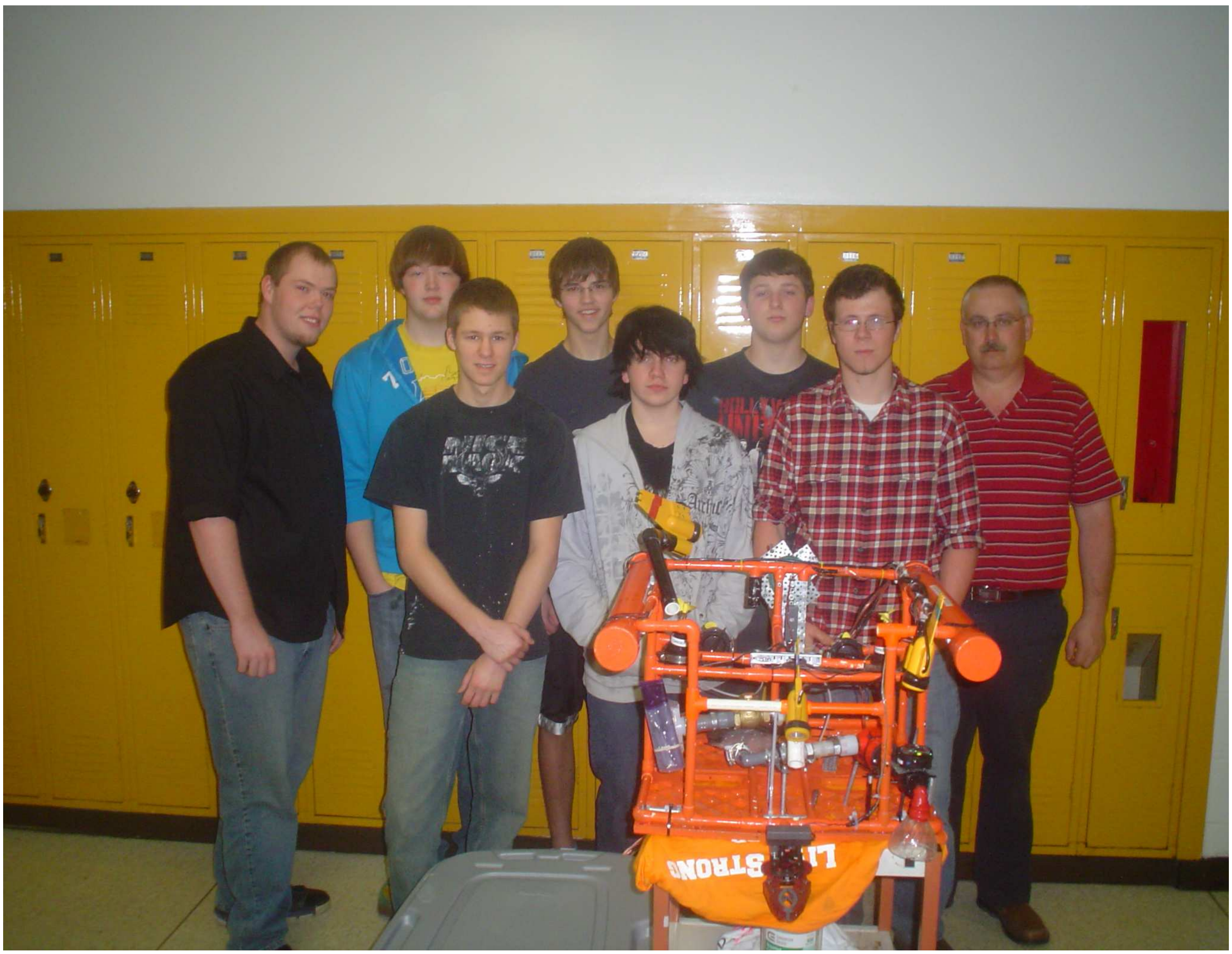
Panther Robotics
Stockbridge High School
Stockbridge, Michigan



Left to right- Ryan Montgomery, Michael Moore, Kevin Meier, Buck Poszywak, Chris Haines, Corey Lonchar, Patrick St. Charles.
Instructor: Bob Richards

Stockbridge High School
416 N. Clinton St.
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Abstract

Panther Robotics Company is composed of eight Stockbridge High School students. Our mission is to provide a low cost Remotely Operated Vehicle (ROV) that can be easily reconfigured to meet our customer's demands. In order to design an ROV to complete the oil spill training exercise, our company looked at the tasks that we were given. The first step we took after reading the mission directive was to build the mission props. This allowed us to view the mission tasks. Based on our research and the mission prop mock-ups, we designed the payloads our ROV needed to accomplish the mission tasks. Our research concluded that we needed the following attachments and payloads to accomplish the mission.

We designed an articulated, multi-purpose arm with gripper attachment and specimen basket. It is used to attach the hook to the U-bolt, pull the Velcro and collect specimens to place in the basket. The second payload we designed was a "Spinner" that we used to spin the valve on the wellhead 1080 degrees. The final payload attached is a water sampling device used to collect contaminated water; a depth meter is placed next to this to find out the depth of the contaminated water. Our ROV is equipped with three video cameras. We use these cameras to navigate and monitor the payload operations.

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Budget

Total Expenditures 1 February to 17 April 2011:

Cost of building the ROV: $
Cost of attending the Regional Competition: $
Total Expenditures: $

All funds provided by Mr. Richards not the Stockbridge School District.
No school funds have been used.

ROV Bill of Materials

Frame

	Item	Price	Quantity	Total Cost	Suppliers	Source of Funds
	PVC ½" X5'	$2.58	10	$25.80	Lowes	Shop Stock
	PVC-Elbow ½" PVC 90	$ .39	10	$3.90	Byrum Harware	Shop Stock
	PVC-T	$ .49	19	$9.31	Byrum Harware	Shop Stock
	Hose Clamps	$1.30	3	$3.90	Lowes	Shop Stock
	Zip Ties	$7.97	1pk	$7.97	Lowes	Shop Stock
	PVC cap	$ .83	4	$3.32	Home Depot	Shop Stock
	PVC 2x2x2	$1.75	4	$7.00	Home Depot	Shop Stock
	2" PVC DWV Cap	$4.29	2	$9.09	Byrum Hardware	Mr. Richards
	Total cost of frame			**$9.09**		**Mr. Richards**

Motors

	Item	Price	Quantity	Total Cost	Suppliers	Source of Funds
	500 GPH Bilge Pump Motors	$16.99	4	$72.04	West Marine	Shop Stock
	500 GPH Bilge Pump Motors	$19.99	2	42.38	West Marine	Mr. Richards
	Octura 1250 Plastic Prop	$ 2.99	10	$44.89	Funrcboats	Shop Stock
	750 GPH Bilge Pump Motors	$35.99	2	$38.15	West Marine	Mr. Richards
	Total cost of motors			**$80.53**		**Mr. Richards**

Payloads

	Item	Price	Quantity	Total Cost	Suppliers	Source of Funds
	VEX Claw	$19.99	1	$19.99	Vex Robotics	Shop Stock
	VEX Motor	$19.99	1	$19.99	Vex Robotics	Shop Stock
	¾ x 1-1/2 Galv Nipple	$1.58	1	$1.58	Byrum Hardware	Mr. Richards
	¾ PVC ball valve	$4.49	1	$4.76	ACO Hardware	Mr. Richards
	SC-420 Underwater Camera	$79.99	2	$171.97	The Evervue Store	Mr. Richards
	Total cost of payloads			**$178.31**		**Mr. Richards**

Electrical System

	Item	Price	Quantity	Total Cost	Suppliers	Source of Funds
	Speaker Wire	$19.99	4	$79.96	Kmart	Shop Stock
	250' Cat 5 cable	$49.97	1rl	$49.97	Lowes	Shop Stock
	Min. plug black	$ 2.99	2	$5.98	Radio Shack	Shop Stock
	Binding Post	$ 2.99	1	$2.99	Radio Shack	Shop Stock
	DPDT Toggle Switch	$ 3.69	6	$11.07	Radio Shack	Shop Stock
	Project Box 7x5x3	$ 5.99	2	$11.98	Radio Shack	Shop Stock
	Project Box 8x6x3	$ 6.99	1	$6.99	Radio Shack	Shop Stock
	Total cost of electrical system			**$168.94**		**Shop Stock**

Misc. Expenses

	Item	Price	Quantity	Total Cost	Suppliers	Source of Funds
	Printing	$ 87.00	1	$87.00	Kinkos	Mr. Richards
	Label Tape Blk/Wht 2pk M23	$21.99	1	$23.31	Office Max	Mr. Richards
	Premium S Enamel	$2.75	2	$5.83	Dollar General	Mr. Richards
	12oz Daptex Plus W/D Foam	$6.97	1	$7.39	Lowe's	Mr. Richards

	2.8oz Prem Waterproof WI	$3.99	1	$4.23	Lowe's	Mr. Richards
	Casting Epoxy	$13.99	4	$59.32	Michaels	Mr. Richards
	Wire Strippers	$1.99	1	$2.11	Harbor Freight Tools	Mr. Richards
	Heat Shrink Wrap	$4.99	2	$10.56	Harbor Freight Tools	Mr. Richards
	2-1/16x3 SS Clamp	$1.99	1	$2.11	Byrum Hardware	Mr. Richards
	11/16 x 1-1/4 SS Clamp	$1.49	4	$6.32	Byrum Hardware	Mr. Richards
	White Plastic TL Seat	$7.99	1	$8.47	ACO Hardware	Mr. Richards
	10pk Rubber Hose Washers	$1.99	1	$2.11	ACO Hardware	Mr. Richards
	Fasteners	$0.50	55	$29.15	ACO Hardware	Mr. Richards
	1.25oz White Lithium Grease	$2.79	1	$2.96	Byrum Hardware	Mr. Richards
	12oz Spray Enamel	$4.49	3	$14.28	Byrum Hardware	Mr. Richards
	12oz Foam Sealant	$5.49	1	$5.82	Byrum Hardware	Mr. Richards
	8oz Clear K&B Sealant	$4.29	2	$9.09	Byrum Hardware	Mr. Richards
	Poster	$10.00	1	$10.00	Main Street Printing	Mr. Richards
	¾ PVC Ball Valve	$4.49	1	$4.76	ACO Hardware	Mr. Richards
	¾ White 45 degree SxS	$.99	2	$2.10	Byrum Hardware	Mr. Richards
	Barb-Nyl P/H 3/4x3/4	$1.99	2	$4.22	West Marine	Mr. Richards
	Barb-Nyl P/H 3/4Fx3/4	$3.69	2	$7.82	West Marine	Mr. Richards
	Elbow-Nyl H/H ¾	$3.29	1	$3.49	West Marine	Mr. Richards
	Elbow-Nyl Npt ¾	$6.29	1	$6.69	West Marine	Mr. Richards
	34oz Soft Bottle	$8.95	1	$9.49	REI	Mr. Richards
	ProJ Box 4x2x1	$2.99	1	$3.17	Radio Shack	Mr. Richards
	Binding Post	$2.99	3	$9.51	Radio Shack	Mr. Richards
	PK2 Banana Plug	$2.99	8	$25.35	Radio Shack	Mr. Richards
	PK4 Binding Posts	$3.99	4	$16.92	Radio Shack	Mr. Richards
	20A DPDT SPG RETN	$4.99	1	$5.29	Radio Shack	Mr. Richards
	ProJ Box 6x3x2	$3.79	1	$4.02	Radio Shack	Mr. Richards
	ProJ Box 5 ¼ x3 C2 1/8"	$2.99	1	$3.17	Radio Shack	Mr. Richards
	ProJ Box 8x6x3	$6.99	1	$7.41	Radio Shack	Mr. Richards
	¾ Barb x3/4 MPT Adapter	$3.79	1	$4.02	Byrum Hardware	Mr. Richards
	¾ x ¾ x ¾ BRS Barb Tee	$4.49	1	$4.76	Byrum Hardware	Mr. Richards
	¾ Barb x ¾ FPT Adapter	$5.49	1	$5.82	Byrum Hardware	Mr. Richards
	4205BC 3/8 x 72 RND ROD	$7.99	1	$8.47	Byrum Hardware	Mr. Richards
	Task Force 23pc File Set	$18.08	1	$19.16	Lowe's	Mr. Richards
	¾" ML/ADPT Insert	$0.37	2	$0.78	Lowe's	Mr. Richards
	¾" 90D Elbow Insert	$0.72	4	$3.05	Lowe's	Mr. Richards
	¾" Tee Insert	$0.70	1	$0.74	Lowe's	Mr. Richards
	TF 4" Curved Jaw Locking	$1.98	2	$4.20	Lowe's	Mr. Richards
	¾" 90D Elbow Insert XM	$1.27	2	$2.69	Lowe's	Mr. Richards
	¾" Swing Check Valve	$8.93	1	$9.47	Lowe's	Mr. Richards
	Flush Kit	$3.34	1	$3.54	Walmart	Mr. Richards
	B. Out Plugs	$2.34	1	$2.48	Walmart	Mr. Richards
	MP1/4x 3/8100PVC Tubing	$0.29	36	$11.07	Byrum Hardware	Mr. Richards
	¾ x ½ Galv Coulping	$2.49	1	$2.64	Byrum Hardware	Mr. Richards
	5PK 20A Auto Fuse	$2.99	1	$6.34	Byrum Hardware	Mr. Richards
	5PK 10A Auto Fuse	$2.99	1	$6.34	Byrum Hardware	Mr. Richards

	Ceiling Hook	$0.69	1	$0.73	Byrum Hardware	Mr. Richards
	Hose Mender	$0.99	1	$1.05	Tractor Supply	Mr. Richards
	Tubing Vinyl	$0.29	20	$6.15	Tractor Supply	Mr. Richards
	Knob	$0.99	2	$2.11	Radio Shack	Mr. Richards
	1Meg Linear Pot	$2.99	1	$3.17	Radio Shack	Mr. Richards
	50K Linear Pot	$2.99	1	$3.17	Radio Shack	Mr. Richards
	Total misc. cost of ROV			**$515.42**		**Mr. Richards**

Great Lakes Regional Competition April 30, 2011

	Item	Price	Quantity	Total Cost	Suppliers	Source of Funds
	Lodging 4/30/11 @ Best Western	$231.03	3 rooms	$231.03	Best Western	Mr. Richards
	Dinner 4/29/11 @ Pizza Hut	$91.86	Dinner	$91.86	Pizza Hut	Mr. Richards
	Parking	$17.00	1	$17.00	Lansing Airport	Mr. Richards
	Van Rental	$280.66	1	$280.66	Avis Rent-A-Car	Mr. Richards
	Fuel	$170.68		$170.68		Mr. Richards
	Total cost of competition			**$791.23**		**Mr. Richards**

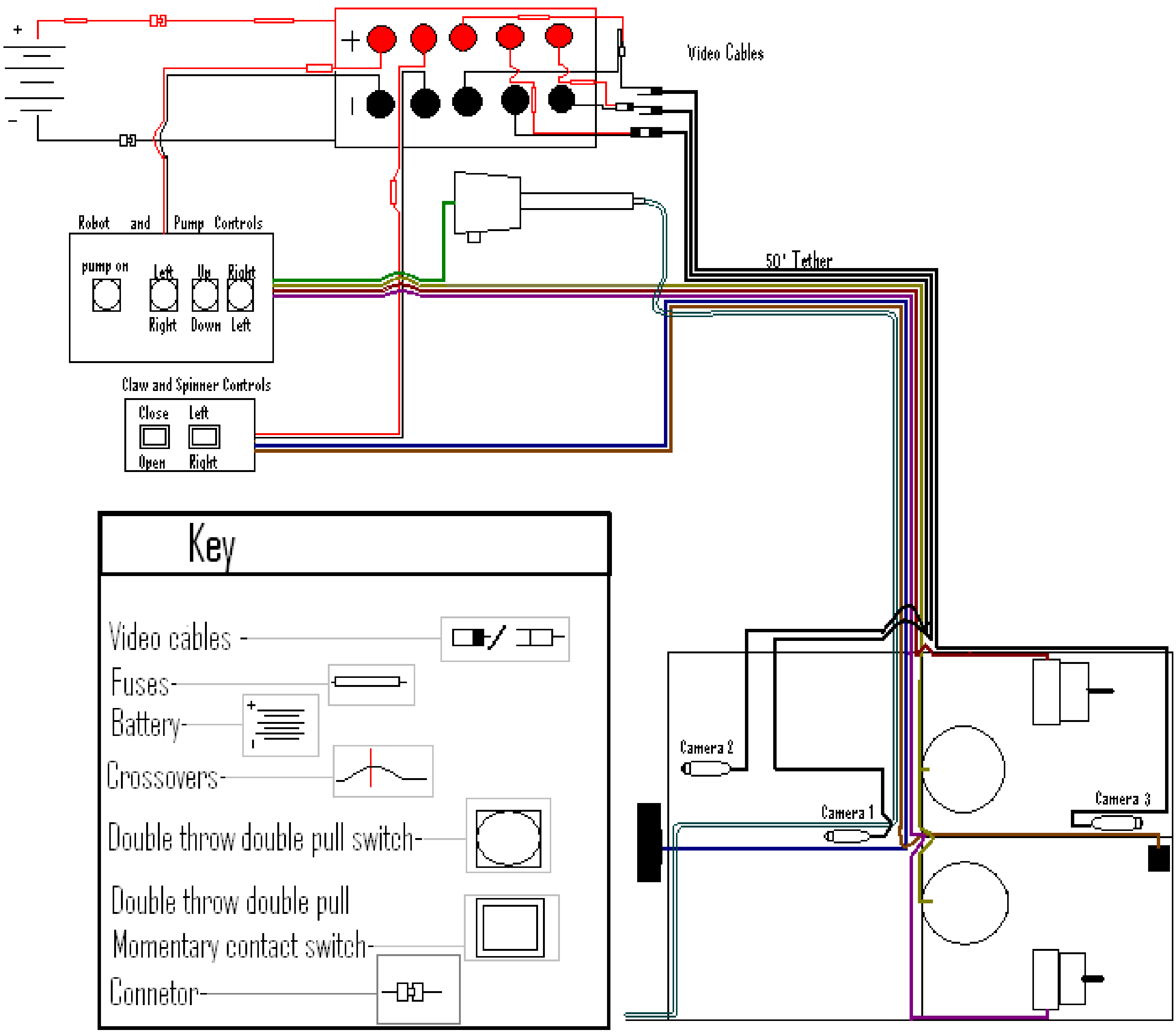
MATE International ROV Competition

	Item	Price	Quantity	Total Cost	Suppliers	Source of Funds
Expenses						
Item	Price	Quantity	Total Cost	Suppliers		
Shipping (ROV)	$100.00	2	$ 200.00	U.P.S.		
Air Fare round trip Flint to Houston, TX	$299.30	8	$2,394.40	Delta Airlines		
Houston, TX – Hotel	$65.00	3	$780.00	Holiday Inn		
Meals-						
Total Cost to go						
Shipping						
Total			$3,374.40			

Income Statement/Source of funds

Date	**Name of donator/source of funds**	**Amount**	**Balance**	
5-9-11	Balance Robotics Account	Beg Bal	168.46	
5-9-11	American Legion	250.00	418.46	
5-9-11	Paul DoBos, DDS	60.00	478.46	
5-10-11	Audrey Price	25.00	503.46	
5-13-11	Roberta and Gary Ludtke	100.00	603.46	
5-16-11	Misc. Cash Donation’s	80.00	683.46	
5-18-11	Ken Skrent	25.00	708.46	
5-18-11	George H. McDaniel	20.00	728.46	
5-18-11	Richard & Kathleen Mullins	100.00	828.46	

Electrical Schematic



Design Rationale

Deciding on a design took a significant amount of time. The first step we took after reading the mission directive was to build the mission props. This allowed us to view the mission tasks. Based upon our research and the mission prop mock-ups, we designed the payloads our ROV needed to accomplish the mission tasks.

Based upon our research, we concluded that we needed the following attachments/payloads to accomplish the mission.

1. An articulated arm with gripper attachment and specimen basket.
2. An attachment to turn the valve on the wellhead “spinner.”
3. A depth gauge to read the depth of the contaminated water.
4. A water sampling attachment to retrieve the contaminated water.

After designing our special attachments or payloads, we designed our ROV to carry them. ½” PVC pipe was used to form the frame. We reinforced the bottom with plastic cut from milk crates. Next, we decided to use four 500 GPH bilge pump replacement cartridges for our thrusters; these are already waterproof and easily adapted for the task. We machined down aluminum rods, which were drilled and tapped them to create our own propeller mounting adapters.

Vehicle Systems and Challenges

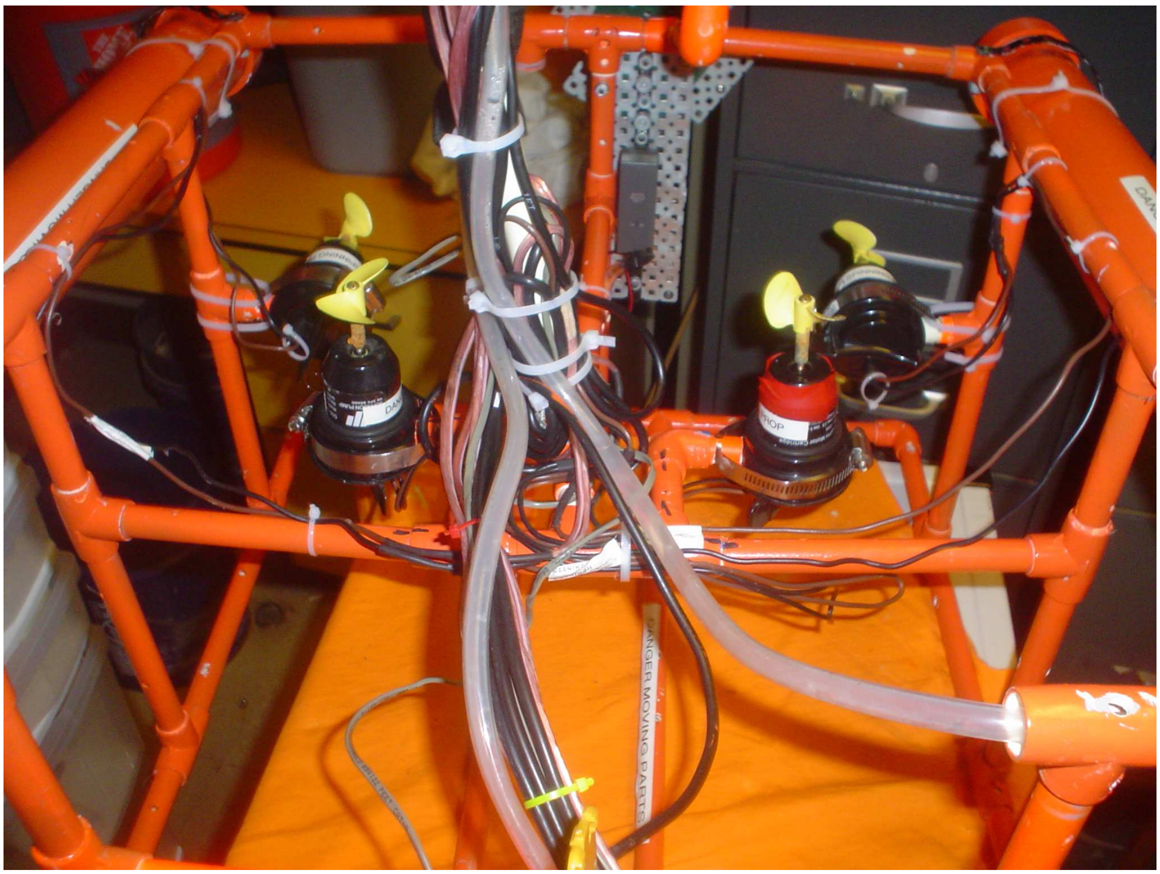
In addition to the mission requirements, we had to deal with the following constraints: a budget of $500, 90 minutes of classroom time per day to work on the robot, and limited instructor support. Our instructor also had to teach a class of 20 robotics students who were building VEX robots at the same time we were working on our ROV.

Our team researched many different concepts, and the design we chose appeared to be the simplest and most effective concept to perform the tasks of the contest. We mostly used trial and error until the most effective design was apparent. Leftover PVC piping was used for the frame. The claw took a lot of time and effort to decide what to use or create. We decided to go with the VEX robotics claw. This claw was easy to waterproof and seemed to have the best maneuverability for picking up different species of sea creatures and cutting the riser pipe for the MATE competition. The device to turn the valve off was limited to VEX parts; we used a modified gear train to get the torque we needed to spin the valve. We purchased the pump and pump attachments, containing PVC pipe and a cut bottle, for the water sample.

The special features that we implemented into the structure of the ROV consist of a claw attached to the frame of our ROV to obtain a sample of the under water species and a spinning mechanism that is small in structure but powerful in its ability to spin the valve on the riser pipe. There are multiple cameras to view all angels of the robot's movement and speed. We strategically placed four motors onto the ROV so it is able to move in multiple directions. Also, we have a pump to remove the contaminated water from the bucket at the bottom of the pool. All of these mechanisms on the ROV are going to contribute to our success on the course.

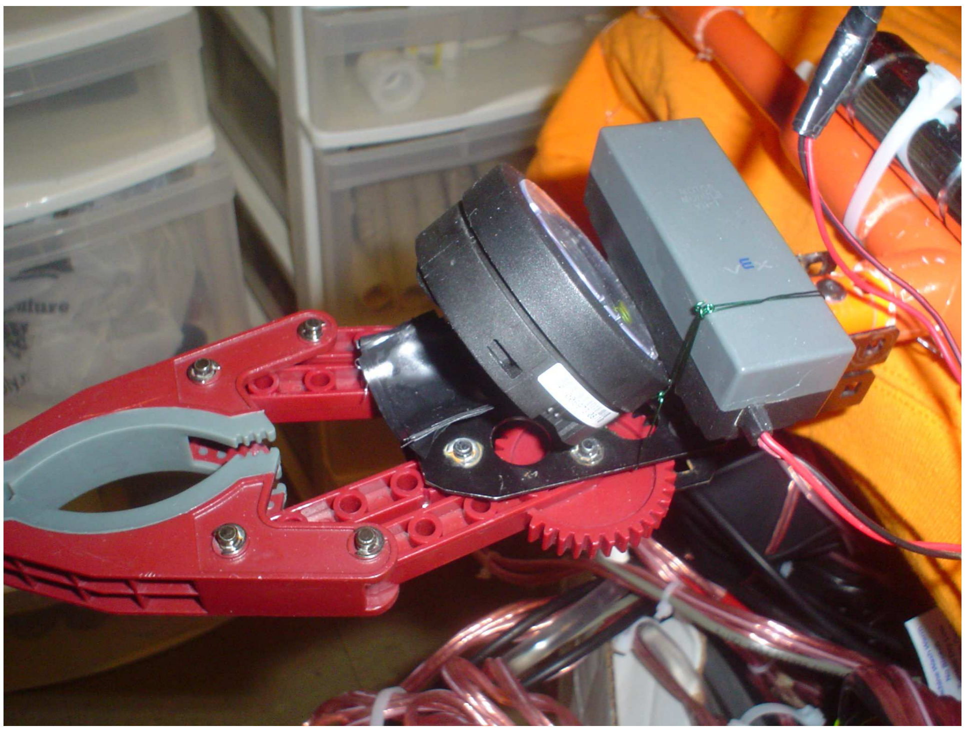
Frame

Our team started off with three bins full of PVC pipe for our frame. We used PVC pipe because it's cheap, lightweight and versatile as far as placement and maneuverability. Everything was carefully placed for the best efficiency. The robot was originally smaller and less sturdy, so we added two support beams to the side, adding strength and durability.



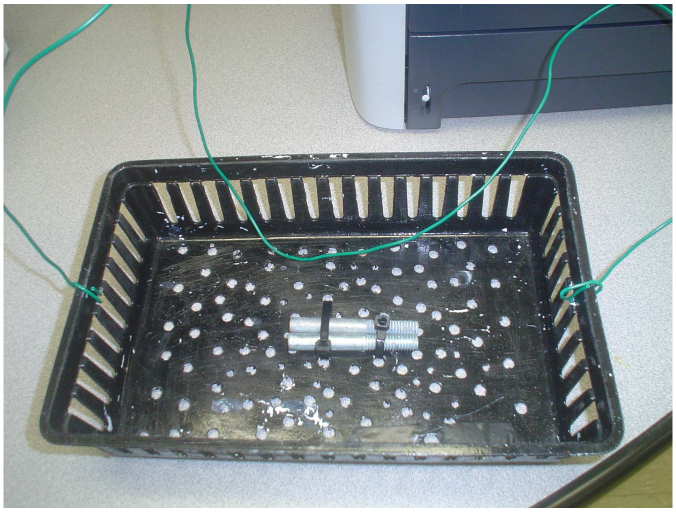
Payload Description: Claw

The claw is one of the most important parts of the robot's features. It grabs and picks up anything that needs to be moved around or sampled. It also has been equipped with a depth gauge. The claw is now equipped with a simple wrist joint attached to the base structure of the ROV, though it once was an entire arm and claw set. The arm worked perfectly until we tried to waterproof the motors; the costs proved prohibitive. We went back to the drawing board and moved on to a much simpler form of the claw. The design that we had moved on to next is the current design. Its components involve a regular DC motor and a standard VEX claw kit.



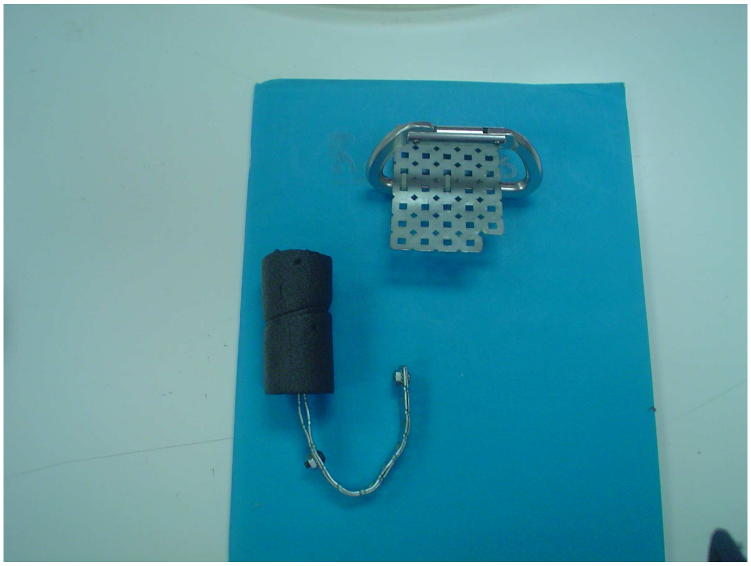
Basket

The basket has had two initial designs. The first was a small plastic basket with holes in the bottom. We drilled the holes out with a portable drill. This was zip-tied onto the front of the robot. It worked out well until we discovered that the motors on the arm for the claw could not be waterproofed. We put a hook on the frame of the robot that will carry the basket to the floor of the pool to be used to gather underwater specimens. When it is ready to be taken to the top of the pool, the robot will pick it up by the wire and carry it to the top.



Payload Description: Hook

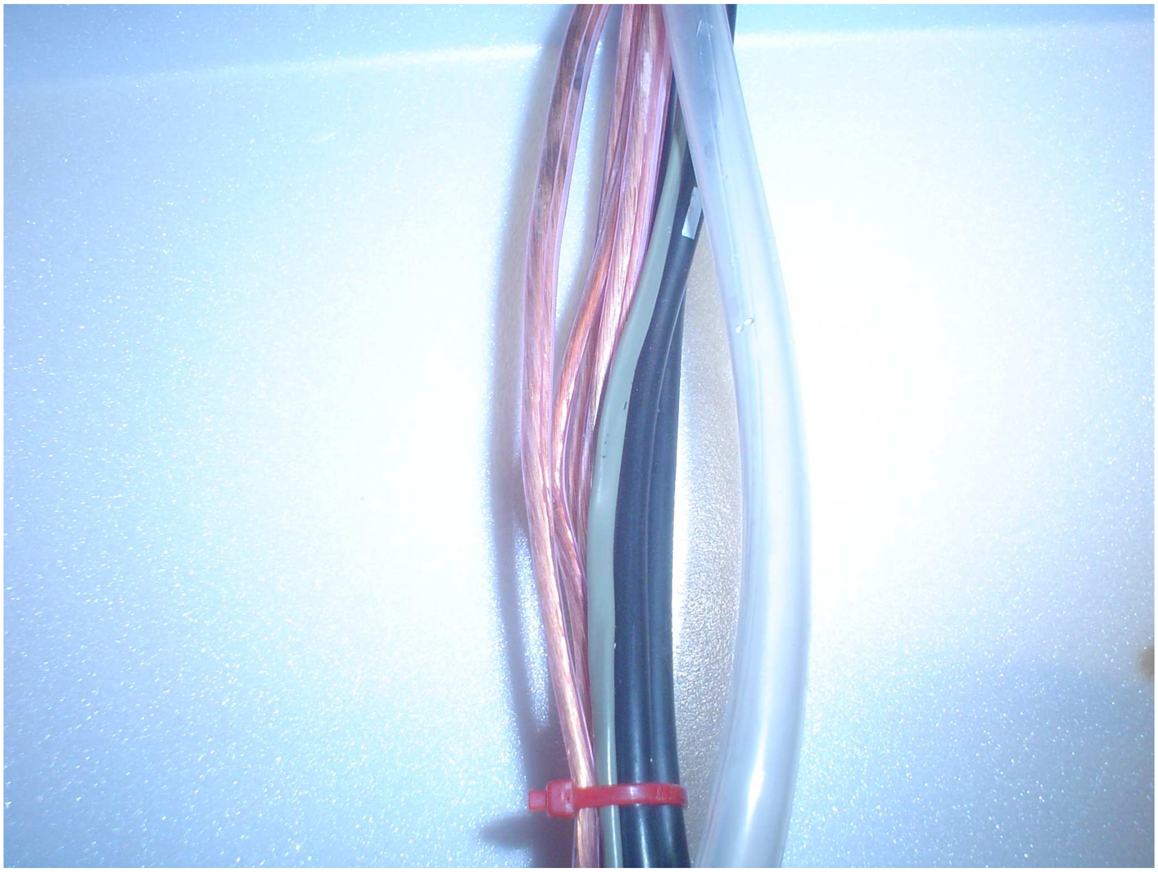
The hooks original design was a carabineer that the robot would push down onto the u-bolt; however, the robot did not have enough force to attach the carabineer to it. The hook was then re-designed, containing two VEX long bars, a few screws and a piece of foam. The two VEX long bars were bent into a “U” shape and screwed together afterwards. A rope was attached to the long bars and a piece of foam



was put over the rope that was tied to the long bar. The foam was added to the hook as a way to give the hook positive buoyancy, making it float and remain in the u-bolt even after being released by the robot.

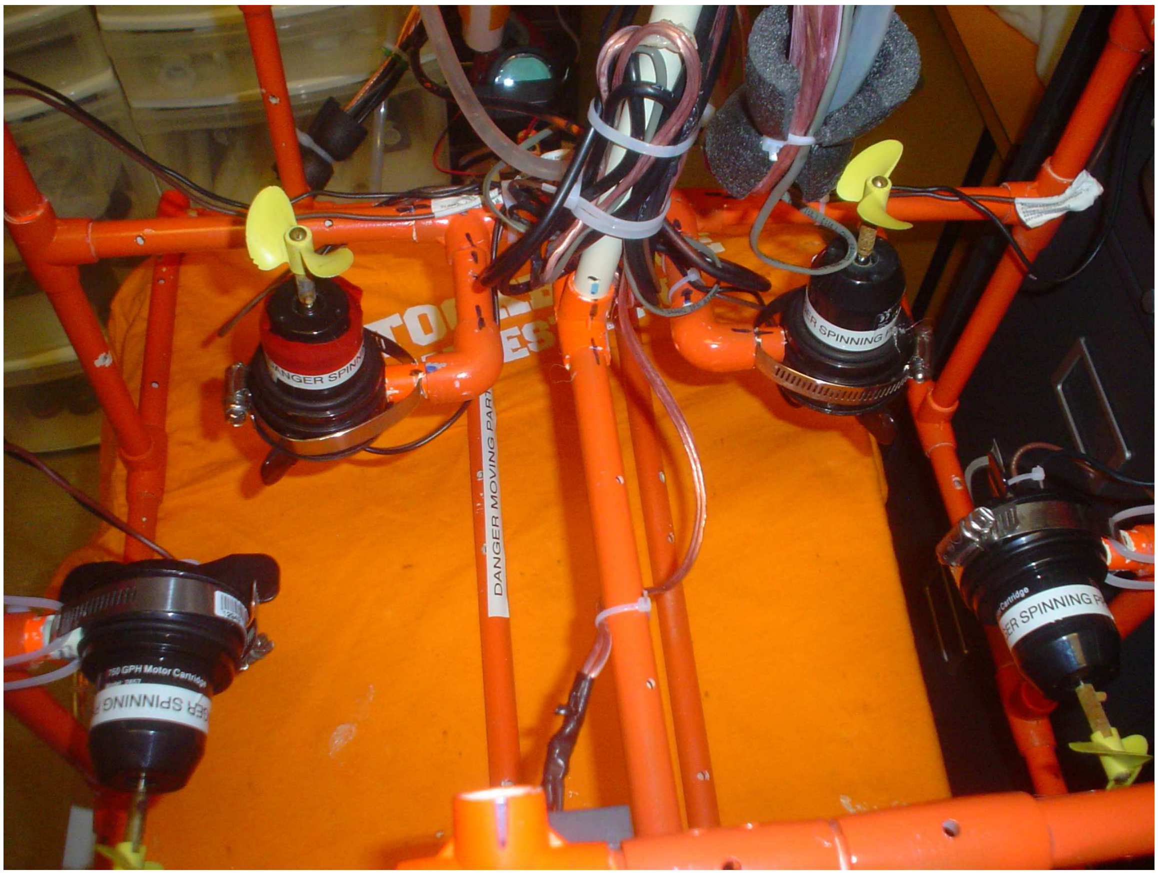
Payload Description: Pump

To complete the water sample task, we started off looking at past designs for ideas. We wanted to use a solenoid, but we couldn't find one cheap enough. After a while, we constructed a very complex piping system made up of plastic couplers, plastic fittings, 90 degree angles and a brass check valve all connected by a ½" clear plastic hose. There was also a 500 GPH 12v aerator pump on the robot; however, that was way too much weight, so we stripped it all off the robot and ran a clear ¼" hose through the tether with the same pump above the water surface sucking the water sample all the way up the hose into our sample bag. Then, we decided that we needed a bigger hose, so we upgraded to a 3/8" hose.

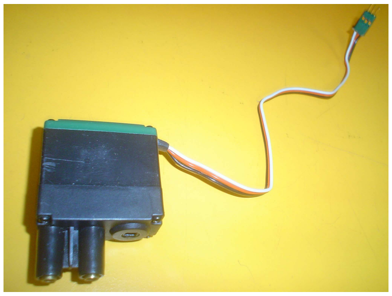


Propulsion

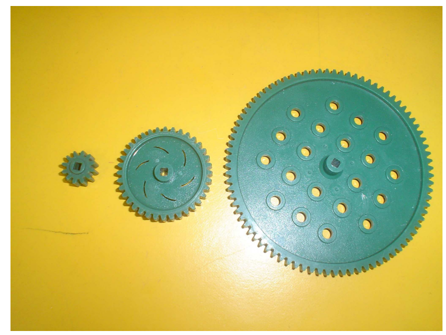
For the propulsion, we needed as many and as powerful thrusters as we could afford within our budget. There are four waterproofed thrusters on our robot that are securely attached to the frame by hose clamps. They don't obstruct the water flow because we calculated where the turning thrusters would be, without being in the flow from the ascending and descending thrusters. We needed our robot to be fairly large, so the thrusters wouldn't obstruct any water flow.



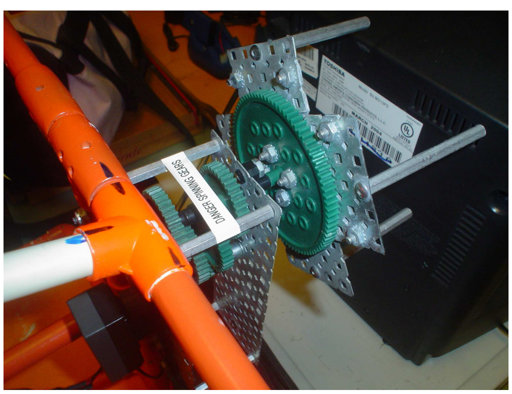
Payload Tool: Spinner



Our original idea for making a device to spin the valve was to take VEX long bars and attach them to a 500 GPH Cartridge Aerator Pump. After testing that idea, we had several questions that needed to be answered. The first question was whether or not the 500 GPH motor had enough torque. The VEX long bars were too weak to handle the turning of the motor. The first question we tried to answer was, “If the VEX long bars were too weak.” We took a large 84 toothed VEX gear, which has holes for bolting things to them. Using the holes in the gear we, attached two VEX panels in a cross formation. Then we attached four, three inch VEX beams and made sure they were spaced evenly apart to the panels. We attached this device to the 500 GPH motor and tested it. From that test, we knew that the 500 GPH motor didn’t have enough torque to turn the valve.



We decided that it needed a better gear ratio for more torque. We started off by taking two 25 x 5 VEX panels and attaching them together with four inch VEX beams, one in each corner. Then, we took the large 84 toothed VEX gears and the small 12 toothed VEX gears and arranged them from small to big for maximum torque. We then attached the 500 GPH motor and tested it again. The motor was useless to use with the spinner design that we had made. We went with a VEX motor module, which just means it can turn continually in either direction. When we attached the VEX motor to the geared spinner, it worked. The motor with the gears turned the valve fast and was strong enough to do it; however, the design had a flaw. It was too heavy for the robot and we had to line it up almost perfectly with the valve. To solve these problems we took apart the whole gear system that we made up and



created a new one that only required 15 x 5 VEX panels, which already helped with the weight problem. The next problem we worked on was the centering issue. The solution was to use small 3 x 5 VEX panels which wasn’t a real size offered by VEX. Patrick went to the school’s shop class to custom make panels to fix the problem. We attached four of the custom made panels on each end of the VEX panels that were already on the spinner design. From extending the VEX panels, we were able to move the VEX beams farther apart. Then, testing came, and we were very pleased with the results. It had much more torque and all we had to do was get the four VEX beams inside of the valve, and the spinner would turn it. The only downside with this design was that it was a little slower when turning than the first gearing system we made; however, the new design works just fine.

Troubleshooting/Improvement/Reflections

This year, our robotics team worked very hard to accomplish the goals that were set for us. We had many successes and also many failures. In both cases, we tried our best, but sometimes we just fell short of succeeding. Every time we fell down, we picked ourselves back up and made adjustments to complete our tasks. In the end, we did our best and had a great year. The team as a whole surpassed any struggle we faced. One of the big issues we had to deal with was having an extremely tight budget of only $500; also, we were only able to work on our ROV for 90 minutes a day with very limited instructor presence, due to the fact that he taught a separate class during our work time. Our instructor, Mr. Bob Richards, was simply a consultant on how we should go about certain things such as designs. Somehow, we figured out how to overcome all of this and construct an effective design that completed all of the tasks given to us.

A major setback we had with the actual vehicle system of the ROV was waterproofing the VEX micro-controller located in the middle of our robot. We tried multiple different methods, one of which included filling the box that held the micro-controller in foam. We used trial and error to troubleshoot because that was the most accurate way we could think of to solve our problems. We used grease around the outside of the control box to identify our problem; however, it would have been out of our budget to solve these problems. Our solution was to essentially tear our entire control system out and start over. Instead of the VEX control system, we now have DC motors to power our claw and spinner as well as bilge motors to power our propellers. If we had a bigger budget we could have made an improvement to the ROV by making the micro-controller waterproof. However, this would have complicated things tremendously. Also, this would have made it much harder to fix our control system if there was a last minute failure at the competition. Currently, fixing our control system would be a matter of tightening a screw or soldering something back into place. Overall, we felt that, as a team, we did an amazing job at overcoming a nearly catastrophic problem.

Teamwork

Teamwork was a huge part of our team. We believe that the small town nature of Stockbridge has helped us work together since we all come from such a close-knit community. We may all be from different walks of life, as you can see from our future plans, but when our small clan was thrown together we rose to the occasion. From an airplane mechanic, to a professional photographer, we all have a future that we are passionate about. This passion for our future is what drives us to do well and work our hardest in everything we do now so that our future is set up for success.

Lessons Learned

A major lesson we all learned this year is to have confidence in ourselves. In the beginning of the year, when we practiced in a pool 20 miles away from our school we realized that there were numerous problems with our ROV and its buoyancy. After a very hard day, we began to think that our ROV and our team weren't going to do well in the regional competition. However, after much hard work and dedication, our team went back to the same dreadful pool to see how things were coming along. We were all pleasantly surprised at how well our robot handled in the water. It was much easier to drive, making the Great Lakes Regional competition in Alpena, Michigan that much easier as well. Overall in the competition we placed 2nd. Now we're headed to the International Competition at The Johnson Space Center in Houston, Texas. We have made slight modifications to our ROV, such as strengthening the claw that broke during the regional competition. We can only hope that we do just as well in Texas as we have done in Michigan. Houston, here we come!

Acknowledgements

The Stockbridge High School Robotics Team would like to thank all of our sponsors that made it possible for us to attend the International Competition in Houston, Texas. Also, we would like to thank the following people or groups for their help and guidance along the way:

The MATE Center
Duane Watson for technical help
Jay Langone for artistic advice
Rick Cook for proof reading and editing assistance
John and Nancy Ocweija for financial support
Chelsea Community Pool for use of their pool for practice
Fred Cattell for use of depth gauge

THANK YOU!