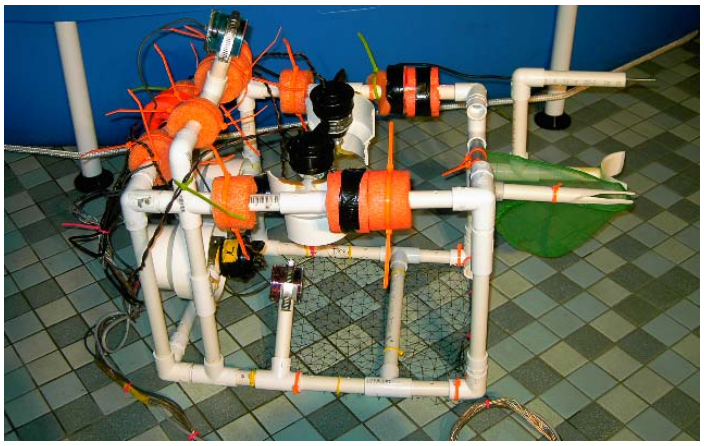
Technical Report
Ranger Class



Submitted by:

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Abstract

The Blind Squirrel (TBS) was created by the Gahanna Lincoln Underwater Robotics team to complete the tasks of the 2008 Marine Advanced Technology Education (MATE) competition. Started in 2007, the Gahanna Lincoln Underwater Robotics team is relatively new in the world of underwater robotics. This competition will be the first in which we have ever competed.

The best part of our design is its simplicity, modularity, and cost. Our ROV is constructed of PVC piping, two Mayair Marine 600 gph bilge cartridge motors for horizontal thrust, and two West Marine 1000 gph Bilge Pro motors for vertical thrust. Floatation noodles are used to keep the craft buoyant. Our control box is a set of four double pole, double throw switches which create a reliable and simple control system which is as good as other, more complicated systems. Because of our use of PVC, it is easy to replace parts and change our design if necessary. The use of PVC also keeps our costs down. A Vernier temperature sensor provides a reliable device for attaining vent temperatures during the competition. At the beginning of our project, we set a budget of $400 to build and design our entire ROV. We actually spent about $404, with a total cost (including airfare and our equipment for testing) of $5235.

Design Rationale

Frame

The basic frame of TBS is a box made of 1.25 cm Schedule 40 PVC. The Gahanna Lincoln Underwater Robotics team decided to use PVC pipe for its low cost, durability, and availability. We used T joints, elbow joints, cross joints, and three pronged elbow joints to create our frame for ease of building, making it simple to switch out parts if needed.

Control box

The TBS motors are controlled by a set of four double pole, double throw switches. The inner two switches control the altitude of the ROV while the outer two control lateral motion. The control box is specifically designed so that one person can sit on one side of the box and operate the up and down motion of the vehicle while another can sit on the other side and operate the left and right motion of the vehicle (See Figure 1).

Figure 1

Thrusters

Four motors propel TBS. The two motors which make the ROV go forward, backward, and control movement to the right and left are two Mayfair Marine 600 gph bilge cartridge motors. The two motors which make it move vertically are 1000 gph West Marine Bilge Pro motors. The bigger motors are used for the vertical thrust so we can have confidence in TBS's ability to lift the rocks. We attached two blade propellers (2 cm diameter) to all of the motors.

We ran a Bollard test on the motors. After hooking an ammeter in series with the motor, we attached a Vernier pressure sensor to the Bollard device in order to measure the force produced by the individual motors. The 600s pulled an average of about 2.5 amps and produced a force of approximately 2.5 Newtons (see Figure 2). The 1000s pulled about 4.2 amps and produced a slightly higher force of 4.3 Newtons. We used the motors with the higher power for our up/down directions because it has enough force to transport the extra weight from the rocks and crabs to the surface.

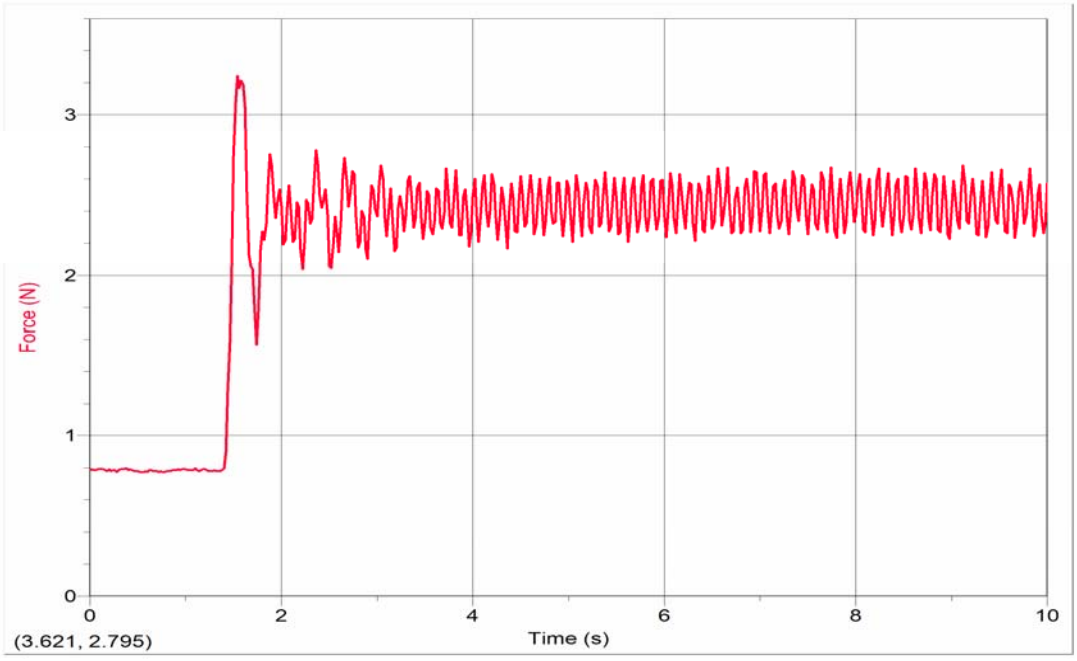


Figure 2

Power

As per the rules, The Blind Squirrel runs on 12 volts. Essentially we needed to power 4 motors, 2 cameras, and a temperature sensor. These were all wired in parallel. We put a 25 Amp fuse on the hot (positive) side of the battery in case of a major short. Our motors were run in parallel with DPDT momentary switches. These run on full power when on either a forward or reverse direction. The cameras were also run in parallel, and we added extra fuses in each circuit in case the camera cable itself was accidentally cut or nicked. Finally, we ran the temperature sensor in another parallel circuit, and fused it as well. This time we used a voltage regulator to reduce the voltage from 12 volts to 5 volts for the sensor. We connected the sensor power wire (orange) to our regulator output. The rest of the BTA cables were connected to our CAT 5 tether wires allowing sensors to output data to the computer (yellow and red) as well as allowing a resistance reference wire (green). The basic circuit diagram can be seen in Figure 3.

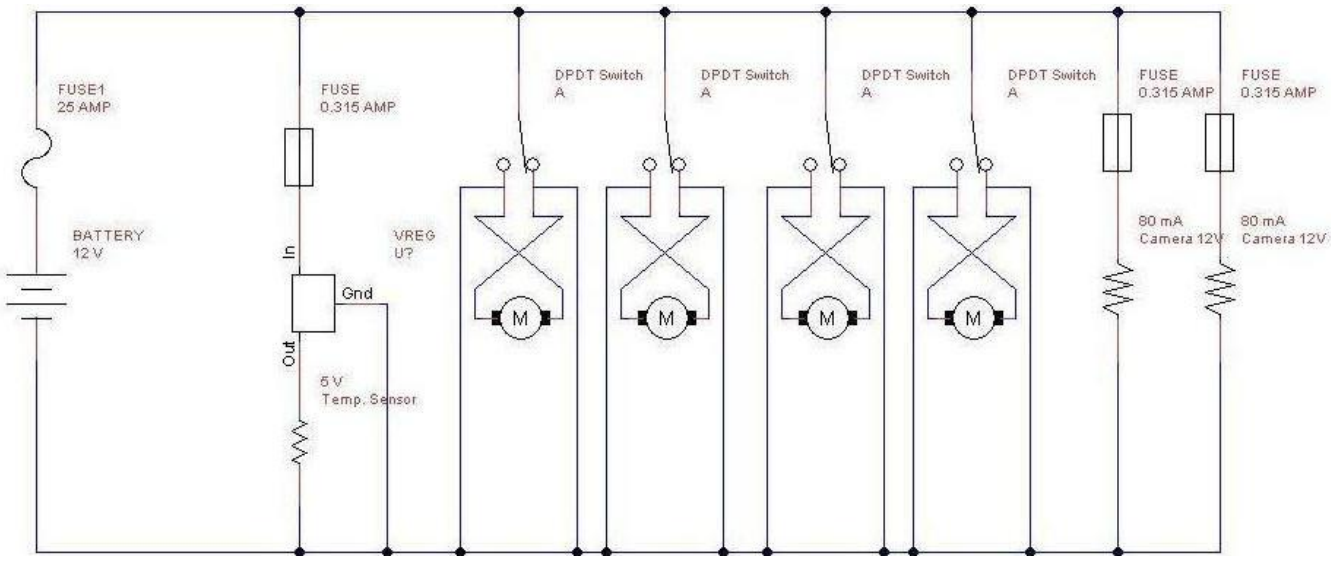


Figure 3

Cameras

Our cameras of choice were the X10 Anaconda cameras. These cameras were selected because of their ease of installation and the fact that they display in color. They also have the ability to focus and have a built-in 60 foot cable. One of the reasons we have a color cam is that it is easier to distinguish between dark rocks and the black Velcro behind them. We also chose color cameras because our ROV will probably be used in other applications in our community, such as an underwater robotics summer camp and our Ecology classes.

The cameras were easy to pot. We water-proofed the camera circuitry by removing the cameras and circuit boards from the housings and potting them in clear epoxy (see Figure 4). We wired the cameras in parallel with the other instruments and motors and fused each one just in case a cable got cut and shorted out. One camera is used for viewing our wedge tool and general driving. The other shows the bottom of the net, allowing our team to see whether the smoker material falls into the net, and also aids in navigation.

Figure 4

Tools

Our basic objective was to make the ROV efficient, yet inexpensive. Creativity is a valuable quality to develop as an engineer. Forcing ourselves to think creatively to develop inexpensive tools helps develop good habits for our team as we approach solving problems.

Wedge and Net

In order to obtain smoker materials, we decided to use a wedge device. A wedge is just a combination of two inclined planes, which are simple machines.

Our first idea was to make a curved device which had a sharpened edge (see Figure 5). We made the curved wedge to fit around the smoker and our idea was to just use our down thrusters to slide behind the smoker rocks and "peel" them off of the smoker. The idea was great, but reality exposed a problem. We found that our thrusters were not powerful enough to slide down the smoker tube if there was more than one rock attached.

Figure 5

Going ‘back to the drawing board”, we decided to make our wedge thinner and only go after one rock at a time. We also decided to put the tool on the front of TBS, so we could develop more thrust as we ran up to the smoker, making it easier to pry of the rocks. We made our wedge longer, increasing the mechanical advantage. Although this worked well, we wondered if making the tool even longer would work better. Currently we have a very long thin wedge, which, due to increased mechanical advantage, enables us to use less thrust to pry off the rock. Figure 6 shows the different wedges and one of them hooked to The Blind Squirrel as it approaches a smoker. A simple fish net with a frame catches the rocks as they are peeled off.

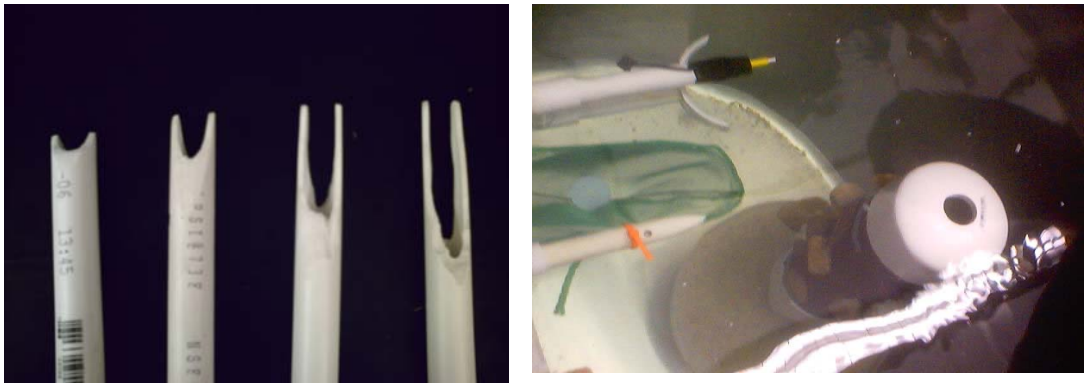


Figure 6

Temperature Sensor

At first our team tried to use a Lego RoboLAB temperature sensor. But we ran into difficulties powering the RCX (the control box for the sensor) from the battery. So we moved to a different sensor.

We chose to use a Vernier temperature sensor for gathering the water temperature above the smoker. We wired this in parallel with our other instruments. Since it is a 5 volt sensor, we used a voltage regulator to cut down the voltage. We also inserted a fuse on the positive side in case of a short. The sensor was placed inside a PVC pipe, allowing easy fitting into the main ROV body.

One of our challenges is to keep the sensor in the flowing stream of water above the smoker for at least 10 seconds. According to Vernier specifications on the sensor, it takes about 10 seconds for the sensor to reach 90 percent of the correct temperature, no matter what the range. We decided that rather than try using thrusters to balance back and forth to maintain our sensor in the flow of water, we should make a “fitted” device that would fit up against the smoker so

that the sensor would automatically be in the right position to take temperature. This way we could just drive forward up against the smoker and then just keep thrusting, keeping the sensor in place. An added bonus to this idea was that our first curved wedge idea which we had abandoned was a perfect fit for this apparatus, so all of the time and material that went into that device wasn't wasted. Figure 7 shows a picture of the sensor as well as the "fitted" curved tool to hold the sensor in place.

Figure 7

Crabber

We believe the crabs on the bottom of the pool will be fairly easy to obtain. For the task of capturing these crabs, we have a dual system. In the front, we placed a hack-saw blade, which is hooked to some netting. This provides the front of the net with a thin, stiff edge that can scrape along the bottom and collect unwary crabs.

Of course, it may be that some crabs are located in crevices between rocks or smokers, so we also devised a second crabbing tool for this option if needed. It is composed of a long piece of PVC with some wire similar to "barbed" wire coming out of the bottom (Figure 8). With this tool, we can reach down into crevices and drag the crabs with the wires. We usually hook onto their legs and then either drag them to the surface or at least get them out into the open where we can then scoop them up with our main crabber.

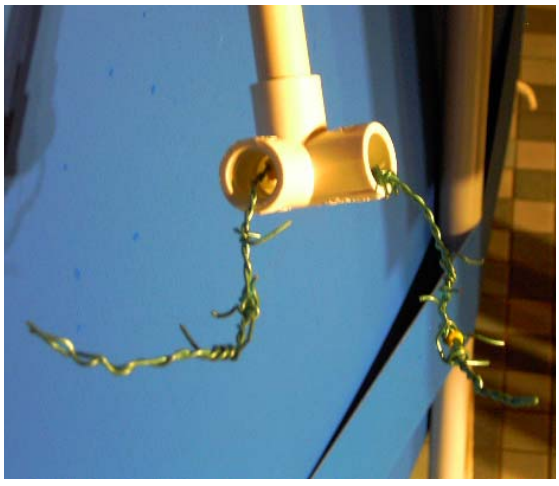


Figure 8

Floatation

Sticking with our “inexpensive” philosophy, we used Wal-Mart noodle material for floatation, both with our ROV and our tether material (see Figure 9). Using noodle material is an excellent option, as it is cheap, easy to work with, and can easily be adjusted when a swap in tool packages changes the weight of the ROV.

Figure 9

Tether

The tether was one of our bigger challenges. We felt that we needed to use 16 - gauge wire for our motors in order to insure we didn’t overload the wire with current. We also felt two cameras were essential, so we needed power to each of those. And finally, our temperature sensor needed power as well as wires for reference voltages and delivery of data, so a CAT 5 wire also needed to be used. Dragging this much material around was not a desired option, but for this year, there didn’t seem to be any other viable choice. Floats were also used on the tether to minimize drag and tangling problems when entering the lava “bubble” during the competition.

Challenges

By far the biggest challenge we faced was scheduling time together to work. Our team met most Mondays from 3 to 4:30, but many of us are involved in other clubs, sports, or jobs, so trying to get all of us together proved difficult. We did manage to get several of us together for extended times a couple of weekends and during Spring Break, which helped immensely.

Development of the actual tool to remove smoker rocks also proved to be difficult. Our wedge idea went through several prototypes before we finally

found something that worked consistently. But dislodging the rock is only part of the battle. Capturing the rock in the net has also been a "work in progress" and even at the writing of this report, this part of the mission seems to be our weakest area.

Because most of us had no electronics background, we found that early in the development of the project, we kept running into things we didn't know about. However, as the school year progressed, we were introduced to electronics in our Virtual Space Tech class, which helped us understand things like H-Bridges and series and parallel circuits, the need for fuses, and reasons for light or heavy wire. Many of us now enjoy spending time soldering or applying silicone and shrink wrap as it gives us a break from the drudgery of equations, problems, and homework!

Troubleshooting

On the first day of testing TBS in a pool, we discovered that the net at the bottom of the ROV which was meant to scrape the bottom of the pool to scoop up crabs did not work well. It only picked up one of the many crabs in the pool. This dilemma was quickly solved by the invention of the Crabber. The Crabber uses a stiff wire with hooks on it to hook the crabs onto it. With the Crabber we are able to potentially pick up to two crabs from the sea floor at a time.

Electronics has also given us chances to troubleshoot problems. Before soldering and hard-wiring things, we used breadboard and/or wire nuts to hook things together. Occasionally we would lose power or a camera and we would need to go through the circuit one component at a time to isolate the problem. Although it is time-consuming, our advisor assures us that learning to troubleshoot is time well spent.

Improvements to Consider

If we had to start over again, we would probably design our rover smaller with larger bilge motors so that it would be more maneuverable. Again, our VST class has given us some insight into making things smaller as we used much smaller motors to power our ROVs for our class projects. In addition, we had a smaller space to work in with our projects.

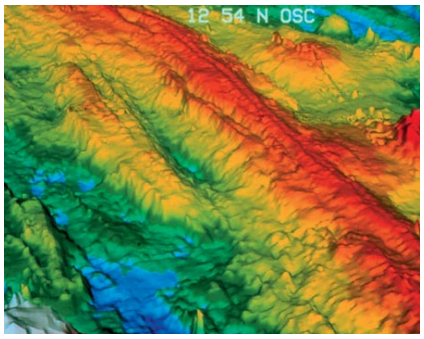
We also would like to either use a joystick or computer to actually control our ROV rather than the manual switches. After The Blind Squirrel competes at MATE, it will be re-tooled to serve in Biology and Ecology classes at our school. Using computer control would enable students to program a grid to be explored and as the ROV traveled that grid it could collect conductivity, temperature and

light data which would be helpful to explain life forms and patterns of plant growth in a pond. This could be repeated again and again, giving consistency and reliability to the collection of data.

It might also be interesting to tie a floating device behind the rover with a GPS sensor/recorder so that the readings that students collect from year to year could be coordinated and plotted at the same geographical spots using the GPS data.

Life in the Dark

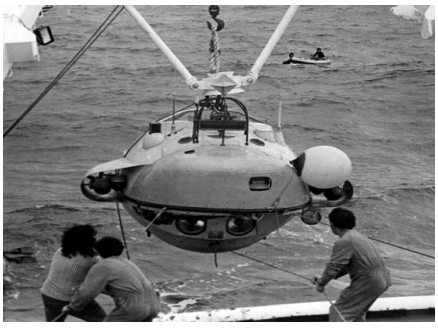
In 1974, a great expedition to one of the most exotic places in the world, the mid-ocean ridges, was attempted by a French and American team of scientists. Dubbed Project FAMOUS (for French-American Mid-Ocean Undersea Study), this study found new ecosystems and changed the world's perspective of life on earth.



Echo sound photo


Famous researchers

The aim of the project was to learn more about plate tectonics and their motions that occur in the mid-ocean. Maps of the sea floor were also made by the expedition. FAMOUS discovered that the rift valleys were created by faults in the earth's crust. Active underwater volcanoes (thermal vents) were also discovered. A greater understanding of what happens under water allowed scientists to figure out more efficient ways of finding the resources that the ocean has to offer.



Alvin

Team FAMOUS investigated the deep ocean floor in the American's Alvin and the French's Archimede and Cyana. With a fleet of three submarines, team Famous felt confident that they could cope with any unusual problems. They figured that if one submersible got in trouble, the other two could help. Of course, when you are using submersible subs with people in them, one must worry about the danger of the mission in much more personal terms. An advantage of using ROVs today is that scientists can take more risks as they explore the bottom of the ocean because they don't actually have a person on the ocean floor. Using sensors and cameras, we can project ourselves to deep sea vents and fissures using ROVs without the great risk of actually going there ourselves.

More can be learned about Project FAMOUS by exploring the following links:

http://www.time.com/time/magazine/article/0,9171,879344-2,00.html
http://www.whoi.edu/oceanus/viewArticle.do?id=2512&archives=true

Acknowledgements

We would like to thank several folks and companies for making it possible for us to compete in this year's MATE event. Schweitzer Engineering Laboratories and HIS Productions gave generous corporate gifts to help with trip expenses. Brenda Donelson and Beth Spieth gave significant personal gifts as well. The Gahanna Jefferson Education Foundation awarded a grant to help underwrite the instruction of underwater robotics in our school district this year, which helped pay for much of our equipment and provide a 16 x 4 foot pool which not only will be used by future underwater robotic teams but will also be used during summer underwater robotics camps for eighth graders in our district.

Many of our team members were also the recipients of donations from personal friends and family, without which some of us would not have been able to attend.

We are grateful for the generous travel/housing stipend given to us by the MATE Center, as well as all of the help they have provided throughout the year on the chat board.

We also want to thank the Columbus Metro School and Battelle Science for providing ***Pro Engineer Wildfire*** 3D modeling software for our district and for each of us. We also would like to thank ***SolidWorks*** for providing 3D modeling software and ***COSMOS FloWorks*** to use during the MATE competition for underwater analysis of our models. These two software packages have opened up a whole new world to us in design and modeling, and we are anxious to

continue using and learning how to use this software to test “on the screen” before “building in the shop.”

And of course, we want to thank our teacher/advisor Mr. Donelson for the countless hours he spent mentoring and instructing us. Christmas and spring breaks just wouldn’t have been the same without him!

The Blind Squirrels - Gahanna Lincoln High School
2008 Budget

I. Expenses

Quantity	Item	Unit Cost	Total Cost
	ROV Expenses		
3	1/2" PVC Elbow	$0.26	$0.78
12	1/2" PVC T	$0.29	$3.48
9	Side outlet 90 degree socket	$1.42	$12.78
275.3	PVC (cm)	$0.06	$16.52
20.9	Clear PVC (cm)	$0.12	$2.51
3	1/2" Clear PVC T	$4.66	$13.98
3	1/2" crosses	$1.30	$3.90
8	3 Joint PVC	$1.42	$11.36
2	Bilge motor cartridge 600 gph	$12.99	$25.98
2	Bilge motor cartridge 1000 gph	$19.99	$39.98
2	Camera	$40.00	$80.00
1	fishnet	$2.00	$2.00
1	Vernier temperature sensor	$29.00	$29.00
20	zip ties	$0.03	$0.60
1	Hack Saw Blade/Wire for Crab	$0.99	$0.99
1	Black Netting	$0.25	$0.25
1	20 amp 32 volt fuse (4 pack)	$1.99	$1.99
1	20 amp fuse holder	$2.69	$2.69
4	DPDT 20 amp momentary flip switch	$4.59	$18.36
2.4	18 Gauge Wire for Tether (100 ft)	$30.00	$72.00
1	12 Volt Car Battery	$39.99	$39.99
1	12-5 Voltage Regulator	$3.99	$3.99
3	In-line Fuse Holders	$2.99	$8.97
1	Breadboard	$4.99	$4.99
1	Project Box	$6.99	$6.99
	ROV Total Expense		**$404.08**
	Smoker Expenses		
1	3.5" PVC End Cap	$3.59	$3.59
1	3.5" PVC Pipe	$8.00	$8.00
1	Velcro	$22.00	$22.00
1	Bottle of Gorilla Glue	$5.39	$5.39
25	Rocks	Donated	$0.00
1	2" PVC Pipe	$4.00	$4.00
1	Plastic Cylindrical Container		$0.00
4	3.5"-2" PVC Adapter	Donated	$0.00
1	Concrete	Donated	$0.00

	Crabs		
6	Pipe Cleaners	$0.05	$0.30
2	1" PVC End Cap	$0.79	$4.74
1	Assorted Screws	$0.25	$0.25
	Smoker/Crab Total Expense		**$48.27**
	Trip Expenses		
2	Estimated Taxi Expense	$40.00	$80.00
8	Room/Board on campus in California	$175.00	$1,400.00
5	plane tickets Columbus - San Diego round trip	$421.50	$2,107.50
3	plane tickets Columbus - San Diego round trip	$398.50	$1,195.50
	Travel/Room/Housing Total Expense		**$4,783.00**
	Total Expenses		**$5,235.35**

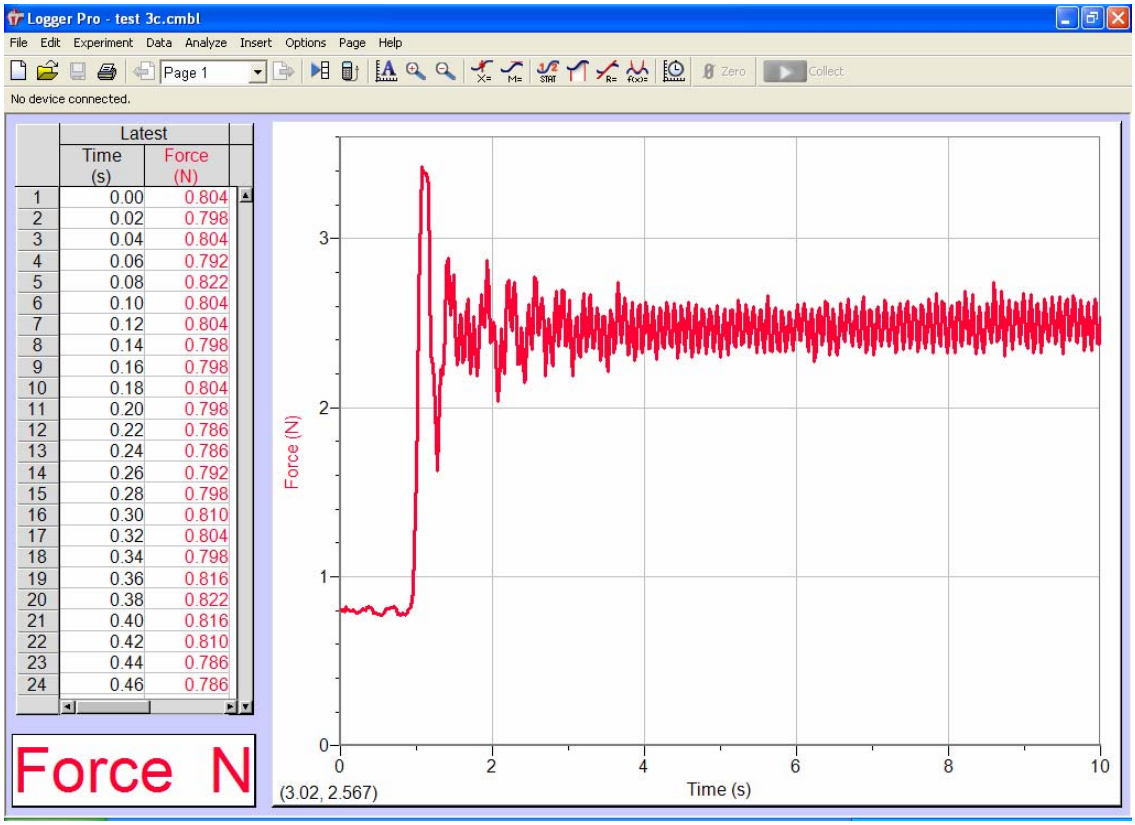
II. Donations/Income

Quantity	Item	Unit Cost	Total Cost
	Corporate/Individual Sponsors		
1	HIS Productions	$700.00	$700.00
1	Brenda Donelson, Pampered Chef	$140.00	$140.00
1	Schweitzer Engineering Laboratories, Inc.	$100.00	$100.00
1	Beth Spieth	$200.00	$200.00
	Total Sponsor Money		**$1,140.00**
1	Gahanna Jefferson Education Foundation Grant	$600.00	**$600.00**
1	Travel/Housing Stipend from MATE	$500.00	**$500.00**
8	Cost for Individual Students/Teacher	$390.00	**$3,120.00**
	Total Income		**$5,260.00**
	Total Expenses		**$5,235.35**
	Excess Funds		**$24.65**

Appendix

I. Bollard Test Results Sample

Below is a sample of one of the tests run on our 600 gph bilge motors as it was first turned on and then run for 10 seconds. A Vernier force probe was hooked to the motor to measure thrust and an ammeter was hooked in series to measure the draw of amps. As it first started, the force approached 3.4 Newtons, but then averaged out around 2.5 Newtons. It pulled about 2.5 amps as well.



	Time (s)	Force (N)
1	0.00	0.804
2	0.02	0.798
3	0.04	0.804
4	0.06	0.792
5	0.08	0.822
6	0.10	0.804
7	0.12	0.804
8	0.14	0.798
9	0.16	0.798
10	0.18	0.804
11	0.20	0.798
12	0.22	0.786
13	0.24	0.786
14	0.26	0.792
15	0.28	0.798
16	0.30	0.810
17	0.32	0.804
18	0.34	0.798
19	0.36	0.816
20	0.38	0.822
21	0.40	0.816
22	0.42	0.810
23	0.44	0.786
24	0.46	0.786

Figure A1

II. FloWorks Analysis Pictures

Below are three sample views of our ROV and the turbulence created when it drives backwards. The original design was developed in Pro Engineer Wildfire and then converted to a SolidWorks model and placed in FloWorks. As can be seen from the diagram, there is minimal disturbance of flow velocity around most of the engine housings, cameras, and PVC tubing. The most appears around the front edge near the rounded fitting for our temperature device, but considering this ROV is not going to be used in flowing water, the turbulence is negligible.

Unfortunately we didn't get this modeling software till late in the year, but are looking forward to doing more of our design before starting to build next year!

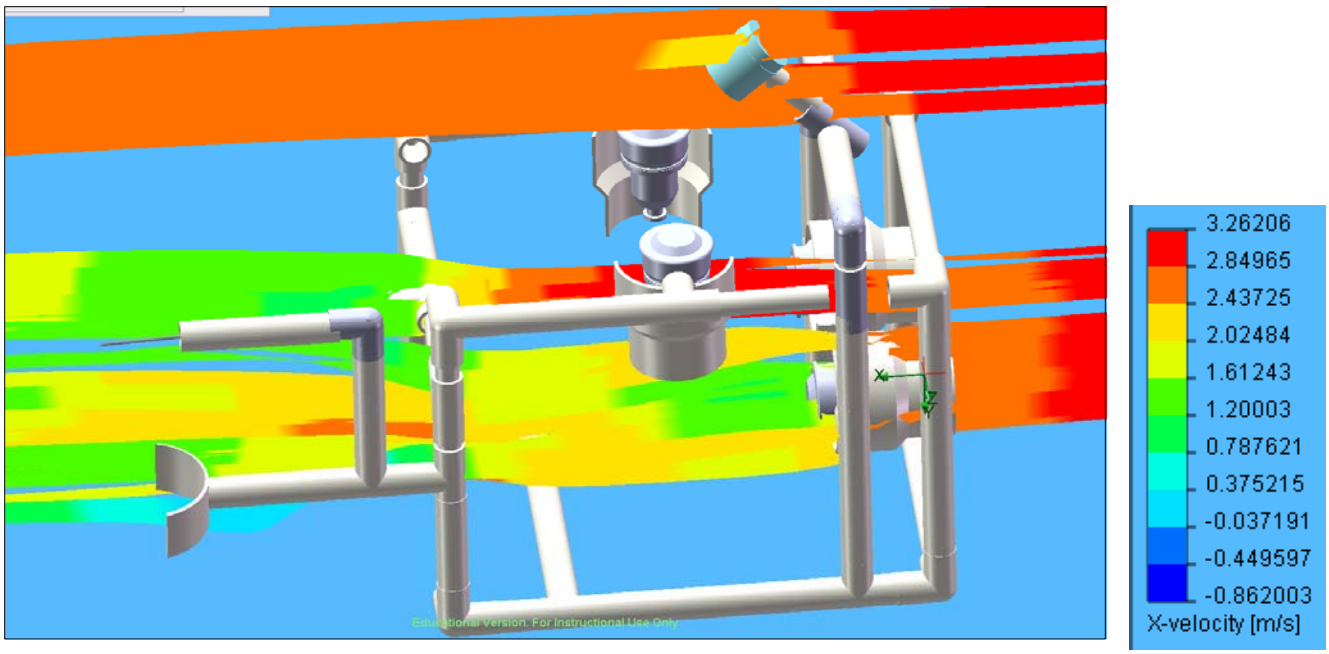


Figure A2

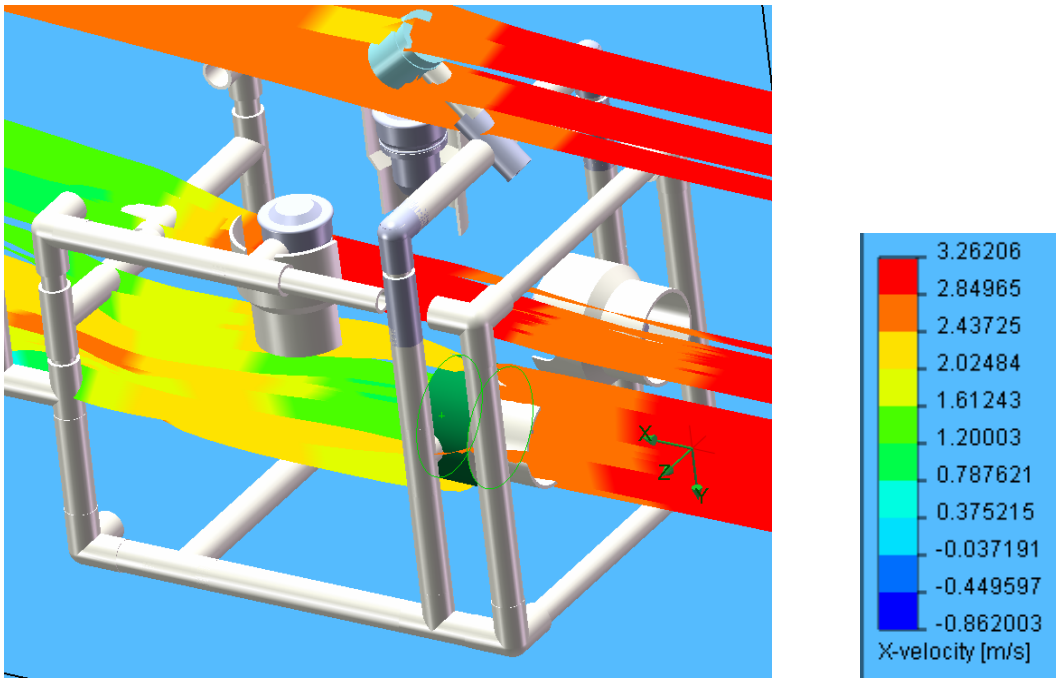


Figure A3

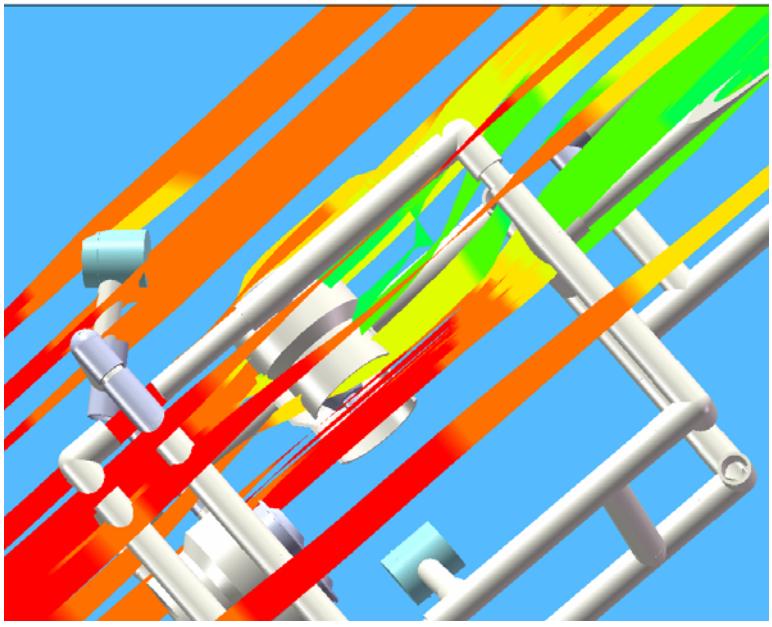


Figure A4

III. Team Bios

Jenny aka J-Man
Role: Team Leader/Website Builder

Favorite Color: Blue
Favorite Music: Techno, Rock, Alternative
Favorite Movies: Donnie Darko, V for Vendetta, Monty Python and the Holy Grail

Reason for joining: It sounded really interesting and challenging at the same time, so I thought I'd try. Turns out it's a ton of fun and a hilarious way to spend some of my afternoons after school.

Additional Comments: Despite my nickname "J-man" I assure you I am most definitely a girl/woman/lady/female. That nickname came about when a comment was made on how I'm not a very "girly" girl and that's why I'm the only girl in our robotics class, and on our team. So Joe said I might as well be a guy. And there you go.

I quite proud of my X chromosome though. It keeps all the guys in check, don't tell them I said that though :D.

Joe aka Angus
Role: Builder

Favorite Color: Blue
Favorite Movie: Currently Iron Man
Favorite Music: Hip-Hop, R&B, late 70s and 80s Funk

Reason for Joining:
My basic reason for joining was because I LOVE robotics and Mr. D's courses. I wanted to compete and test my skills against other schools to see how good we really are. Also I think this will be good experience for college and will look good on a college application. Also I'm really good with video editing so I thought that my abilities could be best used on this team opposed to wasted at home.

Random Comments:
I am probably one of the only African American, Football playing, Breakdancing, Underwater ROVing, Car audio enthusiast, Mac fan in the world.

Nathan aka Shaquisha
Role: Builder

Favorite color: Green
Favorite Music: Rock, Metal, Techno/Electronica
Favorite Movies: Tron, Drumline

Reason for joining: Mr. D talked about an underwater robotics team one day in Space Tech. I instantly took a shine to the idea and wanted to join immediately. I love robotics and I wanted to experience what it would be like to be on a team.

Additional Comments: Well, not much here since i don't have nickname yet (But now it's Shaquisha) and I don't have any other comments. Well, here's one. ALL YOUR BASE ARE BELONG TO US!

Collin aka Cquelen
Role: Builder

Favorite Color: Blue
Favorite Movie(s): Action/Adventure movies...Apollo 13, Michael Clayton, The Departed, Ocean's 11, and the Bourne movies are a few at the top of the list.
Favortite Music: 70s Rock

Reasons for Joining
I have always loved to build things and solve problems. I plan to pursue a career in engineering, and I felt this would be a great experience to do exactly what engineers do. I feel that it will help prepare me for engineering in college and in the future, while having fun in the process. Besides, this is just cool stuff!

Additional Comments

GO BUCKS!

Ravi aka Snickerbar
Role: All Around guy =D

Favorite Color: Black
Favorite Movie: Norbit, Ace Ventura, and The Little Man, all funny movies
Favorite Music: Hip Hop, RnB, Rap, and Punjabi music is my life, can't live without them.

Reason for joining:

I joined this team because I want to do something extra than my regular school activities. And I'm also interseted in Robotics. I want a career in this field. And we gotta have Indian somewhere in Robotics.

Andrew aka Afropuff
Role: Research

Favorite color: Black
Favorite Music: I will take almost anything but country but if I had to pick Nirvana or the Vandals
Favorite Movie(s): That's a loaded question do I say Chasing Amy because it is the best of all the movies made by my hero Kevin Smith or do I go with Almost Famous one of the most fun and relatable movies not only for teens but for adults as well or maybe I would have to go with something more cult classic like Donnie Darko though confusing still a good movie or something more action filled like Die Hard four or Spawn or one that really makes you think like Bickford Shmeckler's Book of Cool Ideas I guess I really can't pick any movie to be my favorite

Reason for joining
Well I think the main reason I joined is because I like to play with robots I mean come on who doesn't but there was a lot to it I think it will help a lot in my futrue since I am thinking about going into a robotics field but I love robots and the people on the team are pretty cool too.

Additional Comments
Though I am here because I am giving thought to working in robotics my true passion is in film I love watching, writting, recording, editing, or any other thing you can do to a movie it is so much fun for me I love it all and this is just one important stop that I will never forget on my long way to the top.

Robert aka Roberta
Role: Research

Favorite movie: Big Fish
Favorite color: Blue
Favorite music: Rock/ emo

Reason for joining: It sounded like a cool club and I had nothing better to do. I've always liked to work with mechanics, so this club was my thing.

Random comments: Seeker of the truth; follow no path; all paths lead where; truth is here

Tim aka French Fry
Role: All Around

Favorite Color: Red
Favorite Music: Just about anything new.
Favorite Movies: Boondock Saints, I Am Legend, Ocean's Eleven

Reasons for joining: When Mr. D first said something about underwater robotics, I was instantly hooked. I loved making toy robots when I was a kid so I thought this would be the perfect thing for me.

Additional Comments: I am trying to fit this after school activity in with sports and school. I don't know how I'm keeping up with it all!