The Blind Squirrel II

Technical Report
Ranger Class

Submitted by:

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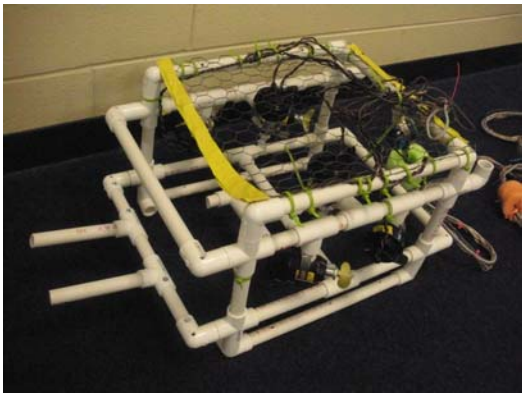

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Abstract

Gahanna Lincoln Underwater Robotics team created The Blind Squirrel II (TBSII) to complete the tasks of the 2009 Marine Advanced Technology Education (MATE) competition, *ROVs: The Next Generation of Submarine Rescue Vehicles*. Expanding on last year's ROV design and experience gained from last year's competition, the Gahanna Lincoln Underwater Robotics team hopes to surpass last year's performance.

TBSII, like last year's model, uses PVC, to make the ROV simple, modular, and cost effective. Yet the new TBSII has improved its design by adding a more sophisticated control system. The team experimented with a LEGO NXT interfaced with a controller similar to a PS2 controller, and MOSFET amplifiers in H-bridge configurations to make the ROV easier to maneuver than previous designs. TBSII's budget aimed at $600, making it similar to last year's budget but with the addition of a much improved control system.

An added feature was to make our vehicle multi-functional. Not only can TBSII work with a pilot, but it has the added feature of using the NXT memory to enable autonomous missions by running a predetermined grid controlled via feedback from a compass sensor. This will enable ecology and biology classes to use the ROV to collect real time data such as temperature, pH, conductivity, and dissolved oxygen as well as work our mission for the MATE competition.

The team members of the Gahanna Lincoln Underwater Robotics team experienced significant problems while building their new controller and with their changing team dynamics. The influx of younger members and stricter adherence to deadlines had a significant effect on how the team functioned. This year's team learned many lessons and hopes to turn those lessons into valuable team habits in the future.

Design Rationale

One of the team goals for the mission was to produce not only an ROV that could accomplish the submarine rescue task but a vehicle that could have a greater purpose. In addition to performing the submarine rescue mission, the team aimed to construct a vehicle that could autonomously run a grid and perform scans with sensors to collect data on ponds or creeks for biology or environmental classes.

Because we wanted a multi-tasking ROV, our design included plans enabling TBSII to be easily broken down into components that would fit in a rolling suitcase or duffle bag. Components were also designed in modular packages that could easily be switched out, depending on the required function at the time of use.

Control

The parallel goals of building both an ROV and an AUV required the use of a Lego NXT to assist the control of the ROV, and it requires transistor relays to effectively operate ROV motors. The NXT controls motors using pulse width modulation (PWM), which rapidly turns on and off motor power over certain time intervals. The motor speed is determined by the average voltage applied to it. If a motor is to run at seventy percent of full power, the NXT will send electrical pulses at seventy percent on and thirty percent off over its time interval. The duration of the PWM cycle is 128 micro seconds, fast enough to create a linear relationship between motor speed and applied voltage.

The NXT outputs about 700 mA of current with a maximum of nine volts of power using standard batteries. This output is insufficient to operate 12V ROV motors, meaning that transistor relays are required. The team explored MOSFET (metal oxide semiconductor field effect transistor) amplifiers to serve as relays because the MOSFET transistors switch fast enough to match the NXT's signals. The transistor contains three metal leads called the source, the gate, and the drain. Current flows through the source and the gate until the NXT's signal over four volts switches current flow to the drain, which closes the second circuit containing the motors. The MOSFETs can control variable motor speeds, but they only conduct in one direction (See Figure 1, next page). H-bridge relays are required to control both motor speed and motor direction. A bipolar MOSFET amplifier contains the necessary H-bridge. The H-bridge consists of four MOSFETs and a motor, which create an H pattern. An N-channel MOSFET sources current and a P-channel MOSFET sinks current. A pair of N-channel and P-channel MOSFETs runs a motor forward, and an additional pair runs the motor in reverse.

The process of constructing an effective bipolar MOSFET amplifier is still underway. For the submarine rescue mission, the ROV is intended to be controlled by a handheld controller that wirelessly transmits to the Lego NXT. The controller operates the NXT signals which transmit through the MOSFET amplifier that turns on the ROV's motors. Currently single MOSFET amplifiers have been successfully developed, but this circuitry does not contain an H-bridge for forward and backward motion. The single MOSFET amplifier will upgrade to the bipolar MOSFET amplifier, which does contain the H-bridge. If for any reason the team cannot successfully develop an operational and reliable bipolar MOSFET amplifier that contains the necessary H-bridge, double pull, double throw switches will need to be utilized as a backup control system.

Single MOSFET amplifiers without H-bridge

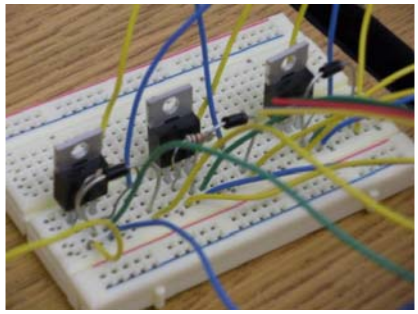


Figure 1

If the ROV is to run a data collecting grid for a biology class, the NXT would directly run a preprogrammed grid with the use of the MOSFET amplifier and a Hitechnic compass sensor for navigational feedback. On-land testing allowed the development of a program that could eventually run the ROV's grid with its compass sensor in the water. A Hitechnic Lego compass sensor was attached to a Lego test vehicle (See Figure 2), and the program (See Appendix Figure 17) was created. The vehicle tracks its desired direction by running either the left motor or the right motor, depending on whether the vehicle's directional value from 0 to 360 degrees is greater than or less than the programmed direction. The motors run for only a small fraction of a second at a time, meaning that the vehicle appears to drive perfectly straight when it actually weaves slightly back and forth across the directional line.

Figure 2

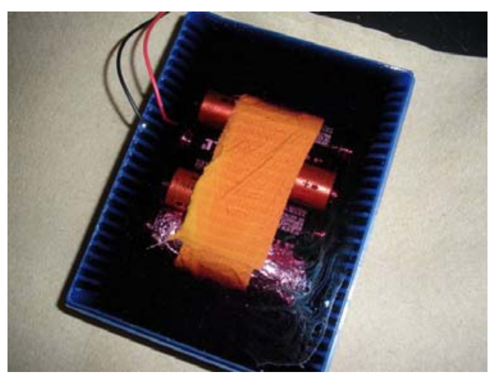


Figure 3

Unfortunately, the 4.3V of electric power emitted by the NXT is too weak to travel the length of tether because the tether's length provides too much resistance. To solve the problem, three 1.5V AA batteries were linked in series, waterproofed with epoxy (See Figure 3), and soldered to the sensor's power wires merely centimeters away. The batteries were placed on board the vehicle, and the shortened distance for the current to travel provides the necessary power for the compass sensor to operate.

Frame

TBSII is 68 centimeters long and 32 centimeters tall (Figure 4). The basic frame is made of 1.25 cm Schedule 40 PVC pipe, T-joints, elbow joints, cross joints, and three pronged elbow joints in its frame. Because PVC was used in TBSII's construction, the frame is rather boxy, but is very maneuverable. Round PVC also has a low drag coefficient (.47), so water resistance is not a significant factor. The use of PVC allowed TBSII to be easily built at a low cost, is durable, and allows the simple exchange of parts. Figure 4 shows the basic structural design in Pro Engineer with placement of thrusters and one of the cams.

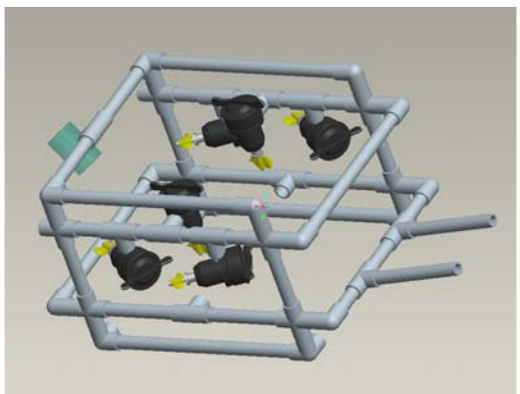


Figure 4

Tether

TBSII's tether contains four 16 – gauge speaker wires, each containing a positive and negative strand. There are also two camera cords, and a CAT 5 wire. Working in pairs (the positive wire and negative wires), three of the speaker wires provide power to TBSII's six motors. Pairs of thrusters for right, left, and up/down are wired in parallel and then connected to one of the main strands. These connect to the ROV end of the tether and the other ends connect to the MOSFET boards, so that each board turns on both motors at the same time and same direction. We decided to keep an extra speaker wire in the tether just in case one might get accidently cut or broken. This step would result in a speedier recovery time, and in a worst case scenario of our controller completely failing, we can use our old DPDT switch box. The extra wire does not seem to cause the tether to be less flexible. Hence, we used the same tether last year with good results.

Each of the camera cords provides power to TBSII's two cameras. The CAT 5 wire allows TBSII to add a variety of sensors and instruments. Although not used in the actual competition, this CAT 5 feature makes TBSII more versatile and adaptable to differing working environments. Typical applications place Vernier sensors on the ROV end and a Go-Link connector and a computer on the other end, allowing measurements such as temperature, conductivity, pH, or dissolved oxygen. Depending on the sensors, we can usually run two at a time on each CAT 5. Pieces of a flotation noodle were used to float the tether to keep it slightly above the ROV.

Thrusters

Six motors propel our rover. The four motors which make the ROV go forward, backward, and control movement to the right and left are four Mayfair Marine 600 gph bilge cartridge motors (See Figure 5). 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 our rover's ability to lift the hatch open and closed. We attached two blade propellers (2 cm diameter) to all of the motors.

We ran a Bollard test on the motors. After hooking a voltmeter in series with the motor, we attached a Vernier dynamic force sensor to the Bollard device in order to measure the force produced by the individual motors. The 600s pulled an average of about 2.37 amps and produced a force of approximately 2.5 Newtons (see Figure 6). The 1000s pulled about 2.5 amps and produced a slightly higher force of 3.1 Newtons (Figure 7). We used the motors with the higher power for our up/down directions. The other four motors are arranged to help the rover turn easier. This will help us work at a faster pace without sacrificing quality work.

Figure 5

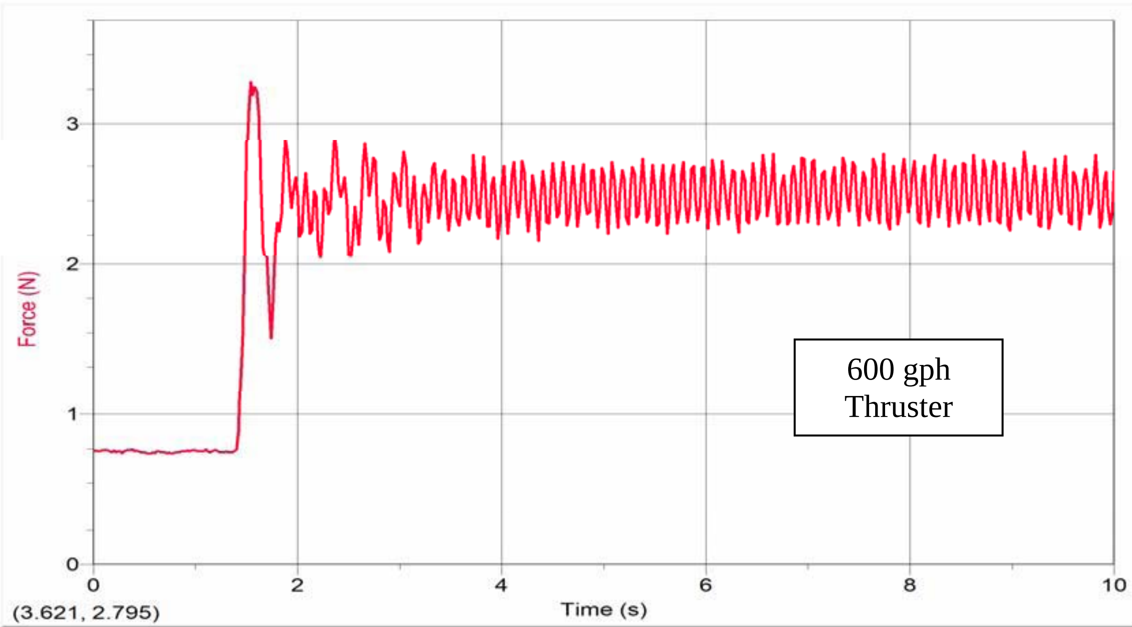


Figure 6

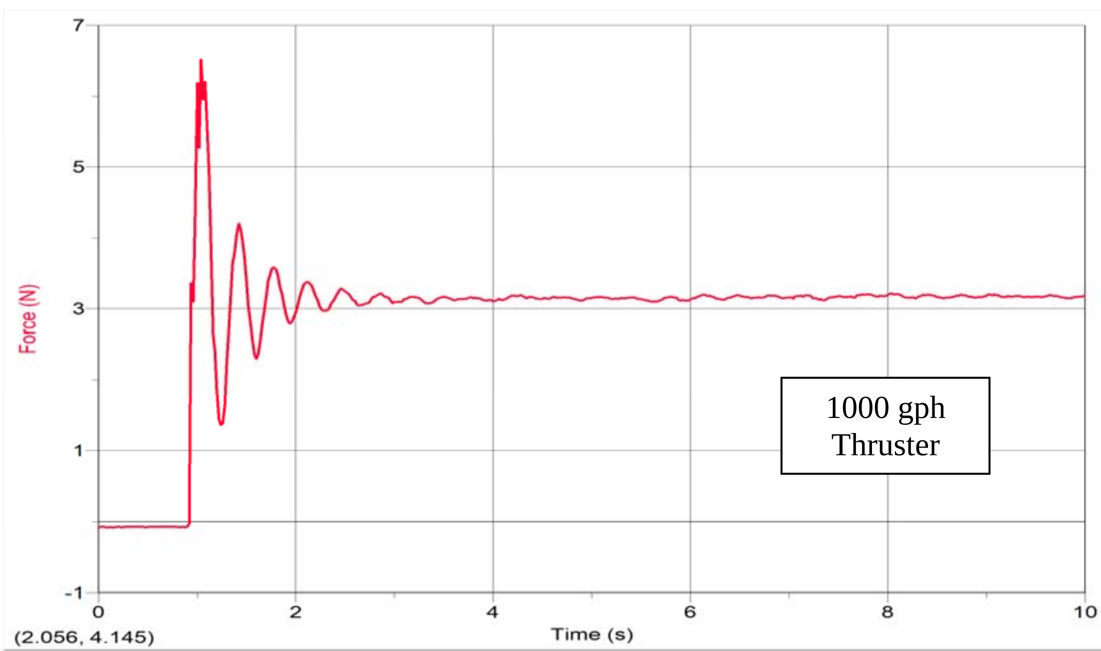


Figure 7

Power

Like last year, TBSII runs on 12 volts. Six thrusters are needed, plus two cameras. The thrusters each use about 2.5 amps each, so even if all of them are running at once, they will draw less than 16 amps. Even if they draw a bit more when they first start up, there is still some “head room” before we near our 24 amp limit. Cameras draw very little current, so we are well within our power limits. The main line is fused with a 25 amp fuse on the positive side of the load, and the cameras also have fuses (.317 amp) for added protection.

In order to obtain both forward and reverse directional control with the NXT, a bipolar MOSFET amplifier (See Figure 8) was constructed, using n and p channel MOSFETS to construct an H-bridge which allows the current direction to change as it passes through the thrusters. Each motor output from the NXT hooks to one of the MOSFETS. As the NXT passes its voltage to the MOSFETS, the relay circuit allows voltage from the battery to travel down the load wires to the thrusters in the correct direction. When the NXT motor output is off, no voltage travels from the NXT, and the relay no longer passes current from the battery, causing the motor to stop.

The wireless Play Station style controller sends a radio signal to a special receiver on the NXT, allowing the pilot to essentially turn motors on or off and go in both forward and reverse direction for all the thrusters. Thus, the NXT essentially turns on right thrusters, left thrusters, and up and down thrusters from its three motor ports, giving excellent control. An overview of the circuitry is given in Figure 9.

The beauty of this setup is that the NXT could also be loaded with a predetermined program and it can autonomously run that program and the rover without having a real-time pilot. We essentially have the capability for both pilot and autonomous control on the same ROV.

Bipolar MOSFET amplifier with H-bridge

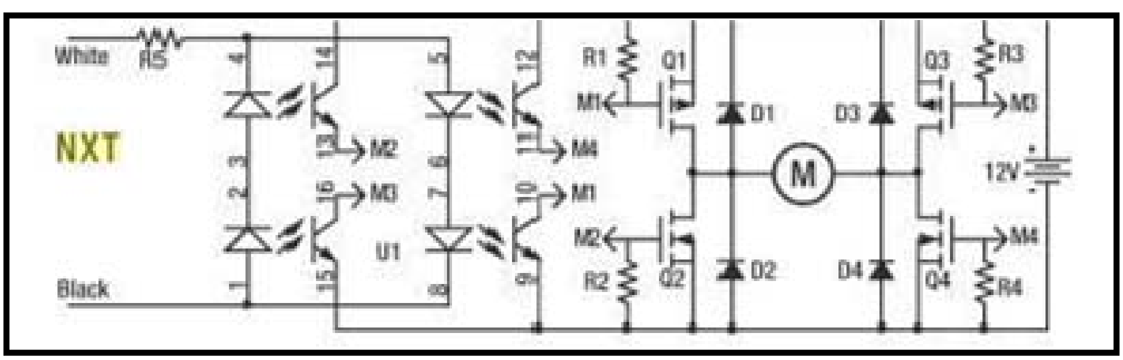


Figure 8

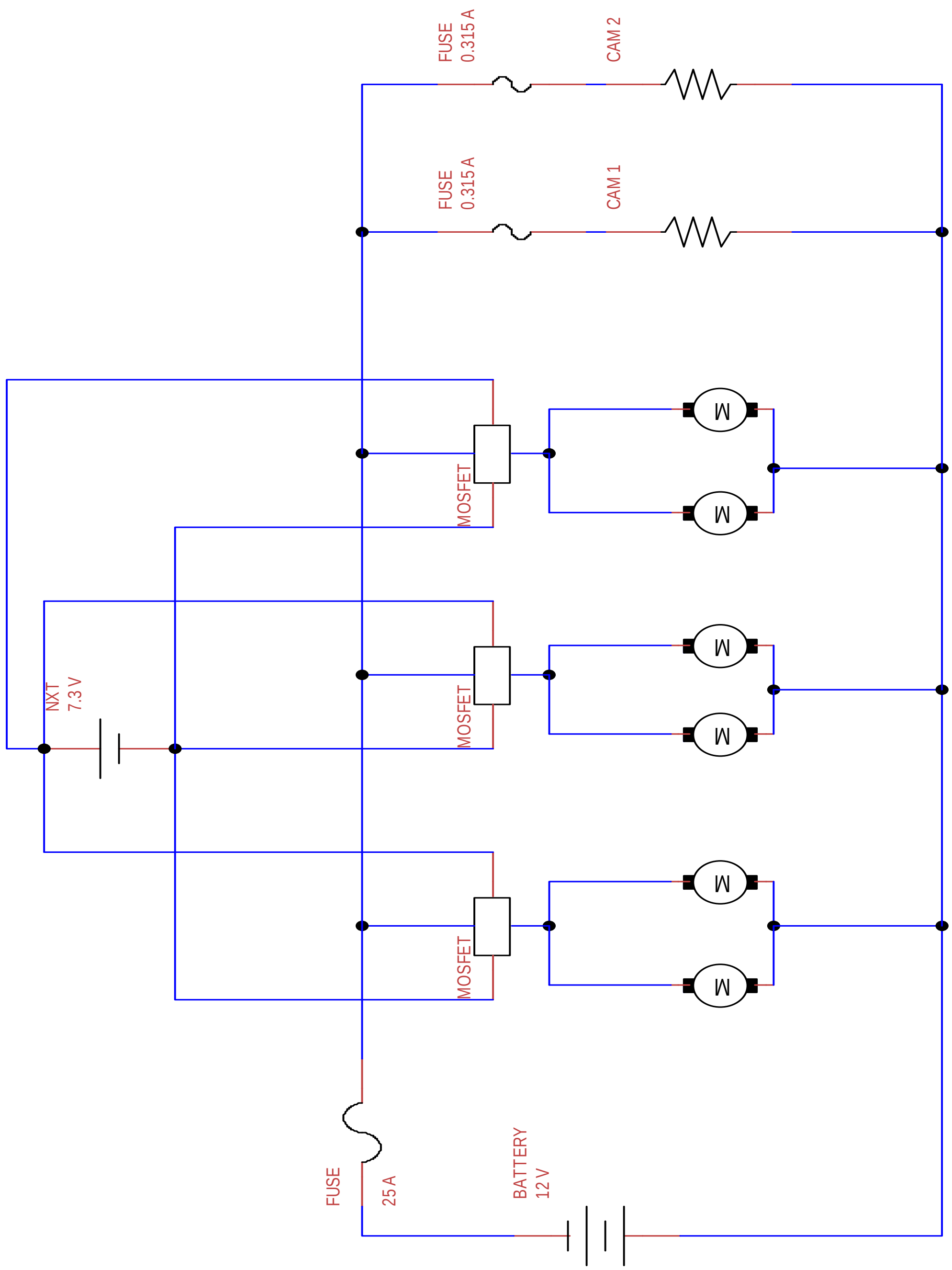

FUSE
0.315 A
CAM 2
FUSE
0.315 A
CAM 1
MOSFET
MOSFET
MOSFET
NXT
7.3 V
M
FUSE
25 A
BATTERY
12 V

Figure 9

Cameras

The cameras are the X10 Anaconda cameras, chosen for their ease of installation, focus, and color. They have a built-in 60 foot cable. One reason why these cameras are used was because they were already used in our previous year's ROV, and so we have experience with them. They were also chosen because the ROV may be used in other applications in our community, such as an underwater robotics summer camp and our Ecology classes. Since they have an RCA video jack, they can be easily linked to video cameras to record images during exploration. Although not particularly useful for our sub rescue mission, this function is extremely important when studying ecosystems in a pond or stream.

Potting the cameras was easy. The cameras and the circuit boards were removed from the housings and then they were potted in transparent epoxy to waterproof them (See Figure 10). Two cameras are used to see all areas that need to be seen to complete the missions. The red camera is placed near the middle of the ROV, on a hinge that tilts in the forward-backward axis. The camera's standard position places it parallel with the xy-axis of the ROV, so it sees the frontal instruments and other objects in front of the ROV. The green camera is positioned at the middle of the back of the ROV, and it is angled down so it sees the bottom of the ROV and any objects underneath it.

Figure 10

Tool Packages

The Air Hose

At first we thought we could just lower our air hose into the pipe by driving the TBSII diagonally and just have it hanging on two pipes (Figure 11). It was discovered that it was nearly impossible to place the air hose in the sub when it was hanging straight down. To fix this problem, a U-shaped bracket was designed so that the air hose would hang at an angle (Figure 12). This made it easier to place in the sub.

Figure 11

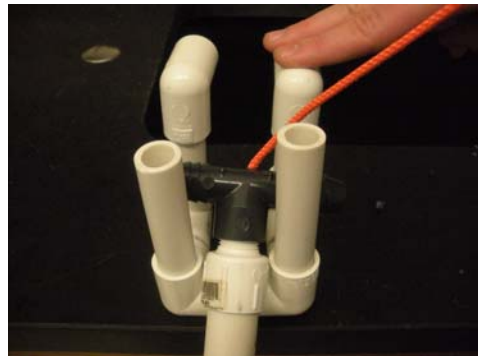


Figure 12

The Multi-Tool

This tool is used for multiple tasks during our mission. It is made up of two PVC pipes that extend out of the front of the rover (Figure 13). We originally designed this tool to pick up the ELSS Pods (submarine supplies), but discovered that the tool could be used for other tasks as well. It can open the hatch by going under it and lifting it up. After it is unlocked and opened, it can grab the pods and drop them inside the sub by picking them up by the loop and using the side of the crate to scrape them off. It can then be used to close the hatch. It also will open and close the door to the air pump, and pull the lever to turn the flow of air on and off by going under it and flipping it over. Although simple, this tool is quite effective with an accomplished pilot.

Figure 13

The Spinner Tool

Opening the hatch on the sub is simply a matter of twisting the handle correctly and then lifting the hatch open. Rather than making a gear or arm to twist the handle, we decided to put a package on the bottom of TBSII so that the ROV could just land on the handle and spin the whole ROV rather than manipulate it with a tool. The two-pronged yoke-like tool (Figure 14) is on the bottom of our red camera PVC pipe (Figure 15), and easily fits into the hatch handle and then spins with the ROV. Once loose, the ROV can be maneuvered to use the multi-tool to lift the hatch open.

Figure 14

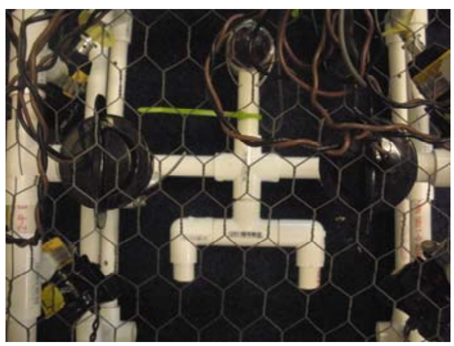


Figure 15

Challenges, Improvements and Reflections

Future Improvements

Several improvements have been considered for next year's ROV design. First, TBSII currently uses pool toy floats or air-filled PVC sealed pipes to make itself buoyant. Although this system allows the ROV to be easily adjusted to differing salinity and density levels in the water, it often requires meticulous manual adjustments, such as cutting and adding new floats, or unsealing and resealing pipes to accommodate such changes in the water. TBSII's team is considering adding a floatation system that uses a central air and/or water tank, using pneumatics or hydraulics to provide adjustable floatation for the ROV and use pool floats only as auxiliary or emergency flotation devices.

Second, TBSII hopes to become even smaller. Though the ROV is already fairly compact, the TBSII team believes that small but powerful ROVs are the wave of the future. Small ROVs can be used in many situations in which larger ROVs cannot be used such as exploring small crevasses and cracks. Furthermore, they tend to be more maneuverable.

Finally, we want to improve on the multi-tasking functions of both driving the ROV in real time and also using the NXT to control the ROV autonomously for scientific research. One area of interest would be to use GPS rather than magnetic fields as feedback control for the autonomous missions, so that mapping of data can be super imposed onto GIS maps in a more direct way.

Lessons Learned

The most challenging part of this year was realizing that it was going to be different than last year. Losing three of our original members and adding new folks really changed the dynamics of the system. We had to befriend our new team members, make them feel welcome and get to know their strengths and weaknesses. They needed to learn about soldering, neutral buoyancy, and how to run a dremel and drill. We also needed to teach them about the MATE website, how to use ProE, and research skills.

But they also brought some great characteristics to the table. Everyone was excited about helping build things and we finished constructing the practice sub in about two sessions! Everyone pitched in and volunteered for at least one job, and many helped out on several things. Students came in extra hours, and those in sports arranged other times to help out. Just like last year, we made new memories, from listening to good tunes while we worked to shooting PVC dart guns! We aren't just like last year … and that's a good thing. Each year becomes a unique experience, and we are trying to enjoy this year to the fullest.

As far as "content" learning is concerned, our biggest challenge was learning how MOSFET amplifiers worked with the NXT and pulse width modulation and how to make a bipolar MOSFET that used H-Bridge principles to run our thrusters in both directions. Collin took the lead in this area and did his own research as well, actually working on the compass sensor for feedback. And of course, we learned that submarines have skirts and pods, something we thought only teens had!

Finally, we learned a great lesson in the KISS Principle (Keep It Simple Stupid). When we first put together our bipolar MOSFET board, it wouldn't turn the motors on. We checked diode directions, soldered joints, placement of resistors and n & p MOSFETs … all of the things we could think of. Since we weren't experts in using these, we went to some mentors, who also checked similar things. Finally, four mentors later, someone checked to make sure we had the correct parts. We had checked that for all the parts we had mail-ordered from Digi-Key, but had picked up one set of resistors at the local Radio Shack. We had asked for a 100 ohm resistor, but the sales clerk had inadvertently given us a 100 K ohm resistor instead! We just assumed he had given us the correct resistor, and with that assumption lost about 4 weeks of practice time, simply because we didn't check the obvious simple things first … the striped code on the resistors! What is amazing is that not only our team, but our teacher and several mentors made the same mistake. Now we take nothing for granted, and check every little detail. It just goes to show that many times the simplest things are where we make mistakes.

Reflections

TBSII has undergone so many changes in the last year. A new control system was added to the ROV to make it easier to operate. A new way to position the motors made the rover more maneuverable. New tools were incorporated to overcome new challenges.

But, the real change in TBSII has been in the team itself. It has added many new members and lost many old ones. People change; things change. The team has changed and its members adapt. Sometimes leaving the familiar for the new can be daunting.

Yet, change is not always bad. When one meets a new person, it is not a disaster but a chance to make a new friend. When one says goodbye to an old friend, he does not lose them forever but keeps his friend in his memory forever. As old members leave, TBSII still remembers. We remember all the time Collin spent building, testing, and redesigning his H-bridge and MOSFETs. We remember the times Joe spent dremelling each PVC piece. We still laugh about the time Robert hit the light reflector with a meter stick, permanently denting it and the time Aaron started shooting darts out of a PVC pipe. These memories are permanently ingrained in our collective TBSII memories and will always be remembered.

Next year, TBSII will still look to the past to fix future problems.

"So we beat on, boats against the current, borne back ceaselessly into the past."
The Great Gatsby, F. Scott Fitzgerald

Submarine Rescues

On April 10, 1963, a pipe broke on the USS Thresher as it conducted a deep sea dive during a sea trial. This small action led to a series of events that shut down the submarine's nuclear power reactor. Without power, the *Thresher* slowly sunk below crush depth killing 129 service men. The loss of the *Thresher* shocked the United States. The U.S. Navy immediately started the most comprehensive submarine safety programs to date, SUBSAFE. Since the SUBSAFE program began, only one U.S. submarine has been lost. This disaster also began a movement around the United States and the world to develop submarine rescue systems. One of these systems is the Australian Submarine Rescue Vehicle *Remora.*

The Australian Submarine Rescue Vehicle *Remora* (ASRV *Remora*), which was built and designed by OceanWorks International, has been run by the Australian Navy since 1995. This remotely operated rescue vehicle (RORV) revolutionized the submarine rescue industry; it did not follow the U.S. Navy concept of a free-swimming submersible.

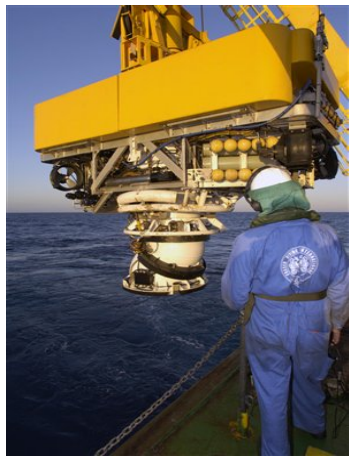
The RORV concept of submarine rescue was adopted by the Australian Navy to increase the rescue system's affordability. Simply put, it is less expensive to train ROV pilots than it is to train submersible pilots. Our own ROV design team for The Blind Squirrel II, while it did not decide between a submersible system and an RORV system, did make decisions to lower costs. Many of the materials that were used by TBSII were chosen to provide the best results for the money.

Like the TBSII, most of the parts (with the exception of an underwater telephone) on the *Remora*'s suite were made from commercially sourced parts. This practice ensures that all the skills used in industry are compatible with those used to operate the *Remora*. Therefore, training in specific skills used to operate the *Remora* is only needed twice a year. Ease of use and versatility are two of the main priorities of TBSII. Our decision to use a controller similar to a Play Station controller was for a similar reason. Students who use a Play Station system regularly will need less training since they are used to the commercially available controller.

Another comparison between the *Remora* and TBSII is their portability. The *Remora* is the only air-portable submarine rescue system. No single component is bigger than can be carried by a C-130 Hercules aircraft. Though not nearly as massive, TBSII was designed to be able to be broken apart and packed in a suitcase for easy transport.

As with TBSII, the *Remora* has a transfer skirt. This skirt allows the vehicle to connect with a submarine at various angles to allow for transference of personnel from and supplies to a submarine. It also contains 12 ELSS pods, enabling it to supply a stranded crew for several days while working on contingency rescue plans. Our mission task of moving the ELSS pods into the open hatch of the sub simulates the real experience provided by the *Remora.*

The *Remora* demonstrates that a submarine rescue system can be maintained by a single navy and that ROVs can be used in submarine rescues. The *Remora's* success has inspired other countries, such as the United States with its SRC-RCS.



The Remora being lowered into the sea. (From aviationweek.com)

Figure 16

References for Submarine Rescues

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GLHS Underwater Robotics Team
Trouble Shooting Guide

Computer problems

1. If the computer freezes, wait a minute to see if computer will continue operations.
2. If computer does not continue operations pull up the task list by pressing **CTRL+ALT+DELETE** and see if the program is operational.
3. If the program is not responding, click the end task button, then reopen the program.
4. If the task list cannot be pulled up, the whole computer is probably frozen, so reboot the whole computer.
5. If the problem happens again, try a computer with the program with more RAM.
6. If the computer crashes try a different computer with the same program.

Electrical problems

1. If the motors won't start, make sure the connections are secured to the battery.
2. Make sure the leads are touching the metal and correct terminals of the battery.
3. Make sure the wires are connected to motors or other electrical components.
4. Check the wires for any openings or cuts in the wire and check for continuity with a voltmeter.
5. Make sure the wires are well soldered and waterproof.
6. If any wires are in the water, they may have shorted out, waterproof the wires again and wait for them to dry.

Mechanical problems

1. Carry spares of items on the ROV most likely to break.
2. Check each part to make sure it is in good condition
3. If not in good condition, replace with spare part.
4. When replacing a part, re-check the buoyancy of the ROV when finished

Breadboard

1. Check to makes sure main power into the board is hooked up
2. Make sure any diodes are going in the correct direction.
3. Make sure the leads on the components are not touching and cause a short.
4. Always check resistor codes and other component parts to be sure correct parts are being used.

Budget

ROV Expense

Quantity	Item	Unit Cost	Total Cost
19	1/2" PVC Elbow	$0.26	$4.94
11	1/2" PVC T	$0.29	$3.19
504	PVC pipe (per cm)	$0.06	$30.24
9	1/2" Crosses	$1.30	$11.70
4	3 Joint PVC	$1.42	$5.68
4	bilge motor 600 gph	$12.99	$51.96
2	bilge motor 1000 gph	$19.99	$39.98
2	camera	$40.00	$80.00
104	zip ties	$0.03	$3.12
52	16 gauge wire for tether (per meter)	$1.00	$52
1	34cm X 39cm Chicken wire	$0.50	$0.50
1	LEGO NXT	$145.00	$145.00
1	PSP wireless controller interface	$59.95	$59.95
3	breadboard	$4.99	$14.97
3	n,p MOSFETS, Diodes, Resistors, O-coupler for H Bridge	$38.95	$116.85
	Total		**$620.08**

Accessories

9	milk cartons	$11.00	$99.00
3	hatch hinges	$3.00	$9.00
305.5	PVC (per cm)	$0.06	$18.33
0.708	4" PVC (foot)	$3.99	$2.82
1	3" PVC(foot)	$2.99	$2.99
26	screws	$0.02	$0.52
13	zip ties	$0.03	$0.39
12	1/2" PVC Elbow	$0.26	$3.12
9	1/2" PVC T	$0.29	$2.61
1	1/2" Crosses	$1.30	$1.30
1	3 Joint PVC	$1.42	$1.42
14	45 degree joints	$0.26	$3.64
12	couplers	$0.26	$3.12
1	12 volt car battery	$39.99	$39.99
	Total		**$188.25**

Travel/Meals/Lodging

9	Airline Tickets	$267.00	$2,403.00
5	Rooms (Double Occ) x 4 nights	$80.00	$400.00
9	Meals (estimated total)	$50.00	$450.00
9	Shuttle from Airport to Buzzards Bay & R	$120.00	$1,080.00
	Total		**$4,333.00**

Income

1	IHG Productions	$400.00	$400.00
1	Schweitzer Engineering Laboratories, Inc.	$100.00	$100.00
1	Gahanna Jefferson Education Foundation Grant	$300.00	$300.00
1	Toshiba America Foundation Grant	$300.00	$300.00
9	Student/Teacher payments for trip	$450.00	$4,050.00
	Total Income		**$5,150.00**
	Total Expenses		**$5,141.33**
	Excess Funds		**$8.67**

Acknowledgements

We would like to thank Schweitzer Engineering Laboratories, HIS Productions, The Toshiba America Foundation and The Gahanna Jefferson Education Foundation for their generous donations to help with equipment and upkeep of our practice pool. Many 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 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 appreciate all the time Jeff Carran and his dad spent helping us troubleshoot our MOSFET boards. Of course, we want to thank our teacher/advisor Mr. Donelson for the many evenings he spent mentoring and instructing us. It is hard to believe that those of us who are seniors won't be spending Wednesday evenings with him after this competition!

Finally, thanks to the MATE team who year after year provides a great venue to learn electronic, robotic, hydraulic and pneumatic principles without charging thousands of dollars to do so.

Appendix

I. On-Land Test Program for Compass Sensor in RoboLab

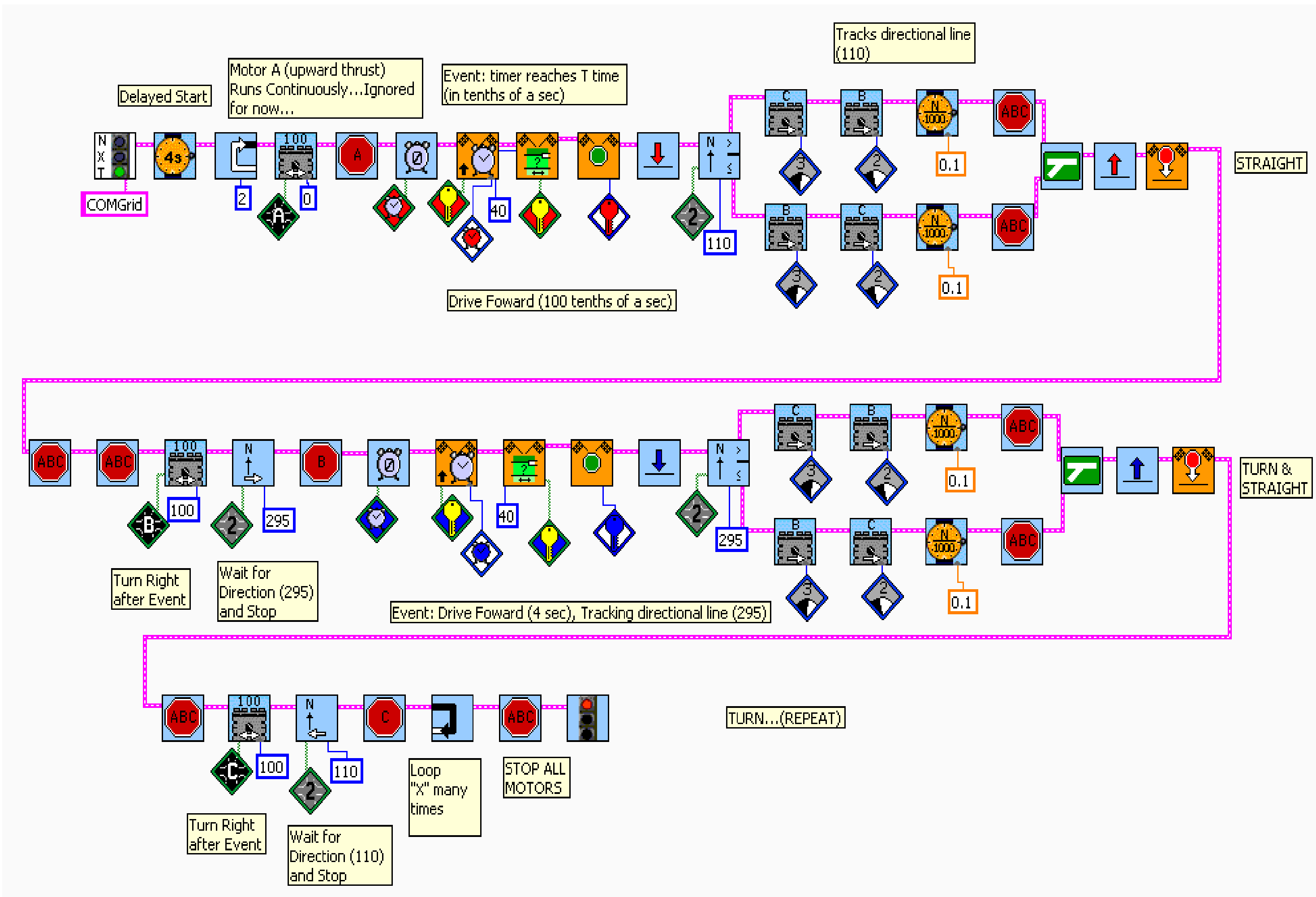

Figure 17

II. One Member's Personal Reflection on This Year's Challenges ...

This year's mission has presented two types of challenges to the TBSII team. First, the team's new members and structure has changed many of last year's team dynamics. These changes have led to changes in how the team operates. Second, this year's mission has led to different problems in the construction of the ROV.

Because this is only the second year that our TBSII team has competed in the MATE competition, the team's structure is still being worked out. Looking back at last year's problems with staying on task and getting members to meet on a regular basis as a guide, TBSII took on a slightly more formal structure this year. A president was elected at the beginning of the year. Deadlines were set. The meeting date was set to be every Wednesday.

Yet in time, TBSII discovered that this approach, while being theoretically efficient, did not match reality. Many of the deadlines could not be practically met because ideas with the ROV had to be redesigned. Many team members could not make Wednesday meetings for large parts of the year because of sports such as track and lacrosse. Sometimes, multiple students would be absent from meetings. Because of these problems, TBSII began to use *Flexible Scheduling*. Club activities were held right after school for people not involved in sports and later on for people in them. Some weekend dates were also made available to those who could spend extra time working on the ROV. Although deadlines were still imposed, they were not strictly followed. In fact, each part of the project was scheduled to be finished two weeks before it was actually due, allowing extra time for unexpected problems. This allowed TBSII to retain more members and helped stop older members from micro-managing the project.

This year team dynamics was a new problem for TBSII. Since last year was TBSII's virgin year, most of the group felt like it was a family. This year brought new members who were not immediately accepted by the group as a whole. To combat this problem and to help new members learn more about ROV's, every task that had to be completed to make the ROV was delegated to both a new member and an old member so that they would both bond and learn from each other.

Another challenge was building a suitable controller for the ROV. Last year's team members found that the double pull double throw switches which controlled the ROV's motors last year were cumbersome and required two people to operate. A serious effort was made to use an NXT, an NXT controller (which resembles a PS2 controller) and several H-bridges to make a better controller. Though several team members worked for weeks on the project, the H-bridges still had issues. However, rather than waste time, our team installed the double pull double throw controller from last year to explore and test our tool designs, counting on being able to get the MOSFET H-bridges done in time to use during the competition.

Like last year, TBSII started out by using pool noodles to make the ROV buoyant. Although this system worked fairly well, problems with having the ROV tilted in the water or losing a noodle plagued last year's design. To limit such problems, TBSII decided to redesign its floatation system so that a majority of its floatation comes from air filled PVC pipes, and noodles are only used to make slight adjustments in the tilt of the ROV depending on a particular pool's density.

III. Key Reference Document

The following book was extremely helpful in learning about MOSFET amplifiers (both single and bipolar), and provided schematics and directions for construction for our controller boards and how they interfaced with our NXT.

Gasperi, M. and Hurbain, P. ***Extreme NXT: Extending the LEGO MINDSTORMS NXT to the Next Level.*** Berkeley: Technology in Action Press, 2007.