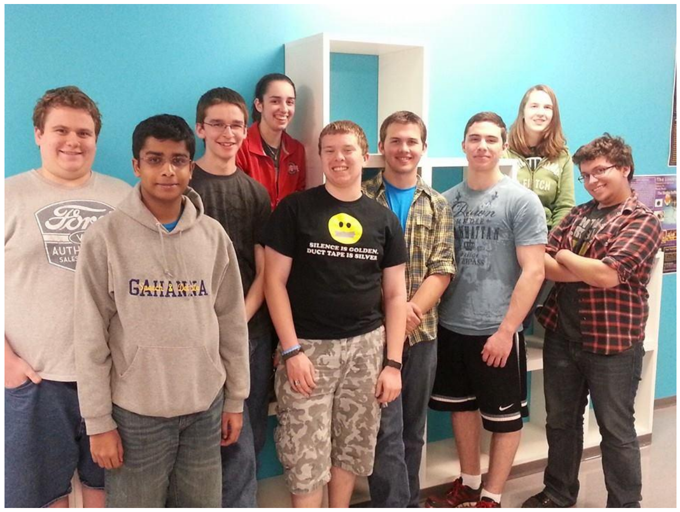
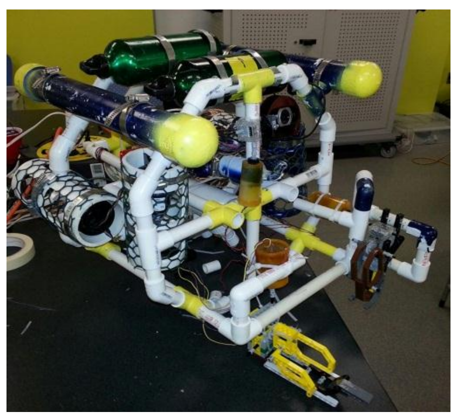
Gizmo



(Team photo, from left to right: Victor Moseley, Sibi Sengottuvel, Nathan Moon, Emily Merickel, Andrew Lewis, Daniel O'Grady, Andrew Shannon, Laura Stegner, Diego Quevedo)



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Ranger Division
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True intelligence isn't knowing the answer.
It's knowing what to do when you don't know the answer!

Abstract

The Lincoln Group, LLC from Gahanna Lincoln High School, has created a new product line in the Ranger Class for the 2014 Marine Advanced Technology Education (MATE) competition. This ROV and tool packages, based on NXT technology, is the first in a new line of Ranger class vehicles designed for shipwreck investigations, providing outstanding performance at a minimum cost to customers.

The new Gizmo ROV is based on a modular design approach, with a basic ROV frame and controller equipped with removable tool packages and tether. But unlike the competition, who uses expensive off-the-shelf connectors costing scores of dollars, the Lincoln Group design team has developed simple, cost-efficient connectors with PVC union joints, tested to over 3 atmospheres of pressure, thus considerably lowering the cost of adding tool packages. The flexibility attained by this modular approach allows much more testing and trouble-shooting during package development, and promises to help the Lincoln Group stay ahead of the competition.

Featuring 2 Lego-based grippers, generating several Newtons of force, and a microbe vacuum device powered by a simple bilge motor, Gizmo can remove bottles and trash, open doors, move canisters easily, and sample life without harming it. Combined with a rotatable camera, a nunchuck motor controller, and four inexpensive thrusters, this ROV can perform. Outfitted with a newly designed NXT-based sensor array, this bot can measure temperature and conductivity for sampling deep water wells. Combined with the Lincoln Group's design, manufacturing, and quality control based on Barckhoff's Principles, this new product demands consideration.

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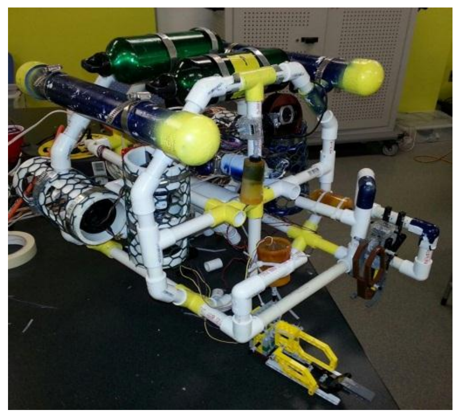
Design Rationale: ROV Component

When the Lincoln Group committed to developing both Explorer and Ranger class vehicles, they decided to plan the ROV designs around a set of principles that they believed would create the best possible ROV at a reasonable price. These principles included: 1) creating a basic ROV around a modular design, with removable tool packages for true flexibility; 2) using inexpensive parts, easily obtainable by most high schools; and 3) building a highly maneuverable robot with a simplified layout for ease of work and repair. After several days of brainstorming and viewing various ROVs on the Internet, the Gizmo ROV was designed *(See Photo 1)*.

Frame

The frame of our ROV was designed to be simple and light, yet strong enough to support all of the hardware and tool packages that we needed to complete our mission. The entire frame is constructed of half inch Schedule 40 PVC pipe, with a tool package "manifold" at the center made of 2 inch PVC and PVC unions. The ROV is 70 centimeters long, 48 centimeters wide, 53 centimeters tall, and weighs approximately 10 Kg out of the water. PVC pipe is a very cheap material, but it is durable and is easily cut to make sections as long as needed. The main hull of the frame is an octagonal shape and the manifold holds the connectors that supply power to the tool packages. The motors are also connected to the main hull, with two providing horizontal thrust and the other two providing vertical thrust. The "manifold" is a cylindrical tube that contains power from the tether that hooks into female ends of PVC unions. These ends contain female connectors from the CAT5 part of the tether with control signals from the surface which have been epoxied to waterproof them. Each modular tool package contains male connectors epoxied into a male PVC union, which can then be screwed onto the appropriate control female end in the manifold. The front of the ROV has a rectangular fitting that houses three separate tool packages: the microbial vacuum, the vertical gripper and the horizontal gripper. An X-axis rotatable camera allows us to easily view all three packages, as well as do sonar scans and check for life forms on boat hulls. All in all, our ROV is designed to be modular and interchangeable.



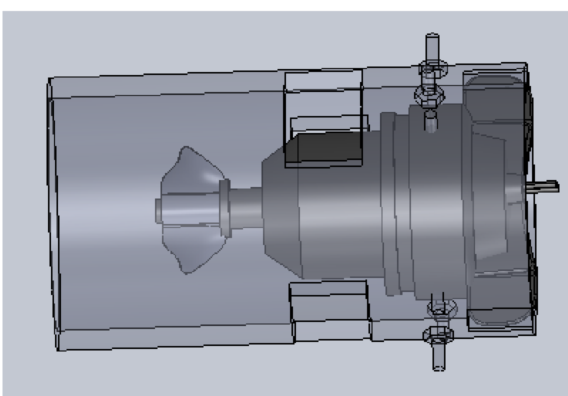
(Photo 1: The Gizmo ROV)

Propulsion

Engine Shrouds

In order to mount the thrusters, and to protect the tether from the propeller, we used an engine shroud designed by last year's Explorer team that does both. The engine shrouds are made of 3" PVC, plastic mesh, and two hose clamps. Two vertical cuts were positioned on opposite sides of one end of the shrouds. The fins on the sides of each thruster slide into these slots. From this point, a single hose clamp was used to pinch the top of the slots shut, effectively securing the thrusters into the shrouds. Six strategically placed "windows" were cut out of each shroud to allow proper water flow. A tube of mesh was formed to fit around the shroud. Finally, the thruster/engine shroud combo was attached to the frame using an additional hose clamp, which also helped keep the mesh in place.

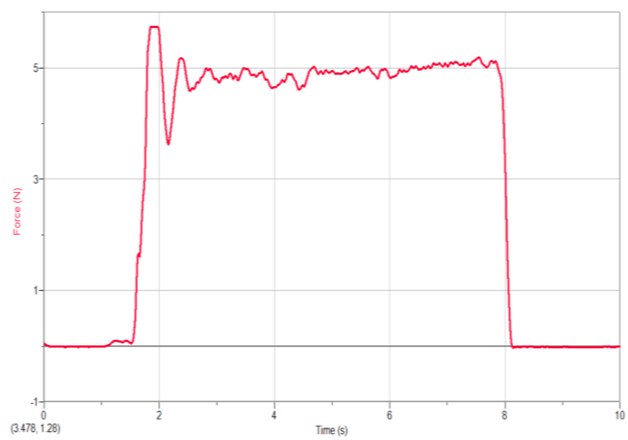
(Photo 2: Thruster in newly designed shroud)



(Photo 3: CAD of old style thruster shroud with less holes and unreliable screw attachments)

Thrusters

In keeping with our principle of using materials available to typical high school students, the team decided on using four Johnson 1250 GPH 12 Volt bilge cartridges, outfitted with an adapter and propeller blade. Bollard testing was performed on the thrusters. Aside from a slight spike at initial start-up of the motors (5.9 N and 2.68 Amps), the thrusters produced approximately 5 Newtons of force consistently at top speed and drew approximately 2.3 Amps. Even if all five motors are run at once, they would still draw less than 12 Amps, well under our safety fuse limit of 20 Amps.



(Photo 4: Bollard Test on Johnson 1250 GPH Thruster showing force in Newtons)

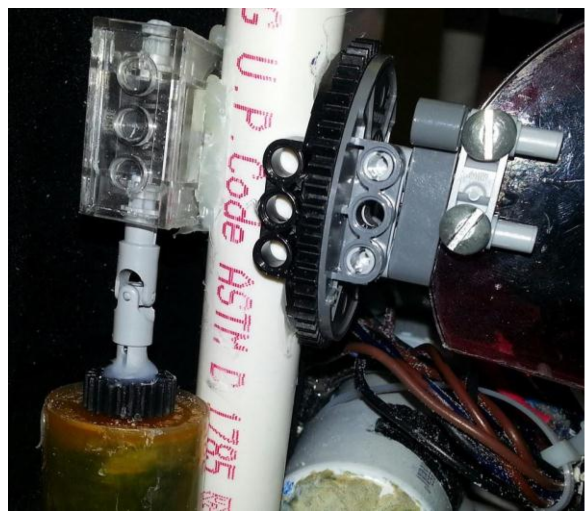
Camera

Gizmo possesses a newly designed Logitech Webcam that has been potted and is powered by USB repeaters and CAT5 cable. The camera was potted in in a deep petri dish with epoxy. The 100 foot CAT5 cable is flexible and was easily attached to the tether. The camera's USB connection by way of network cable makes it easy to record video on a computer and the webcam software provides a magnification package to zoom into interesting features. This is a much improved system over the previous version, which needed RCA plugs and a video recorder to record during missions. Another advantage of the cameras, their ability to image in color, allows objects to stand out better than black and white cameras, making missions easier to complete. The fact that images are digital also allows one to use software to enhance those images for certain details. Also, the webcam has the ability to snap pictures which can later be stitched together for panoramic views.

(Photo 5: Potted camera)

Camera Mount

The potted camera was mounted on a rotatable platform. This rotating platform is driven by a waterproofed hobby motor. Using a flexible U-joint, the hobby motor was run directly into a LEGO gear box, which increased the torque and decreased the rotational speed. Various gears were used to fix the platform perfectly around its PVC body. The final rotational ratio from hobby motor to camera is 188:1. When fixed to specific parts of the ROV frame, this rotatable camera platform gives the pilot the ability to see multiple tool packages in a matter of seconds.



(Photo 6: Potted hobby motor and rotating platform for camera)

Tether

The detachable tether is a unique tether design that our company has been utilizing since last year. The tether attaches to Gizmo through two segments of PVC sealed with an O-ring, with the re-sealable connection being anchored onto the bot itself. The wires within the connection are cut, and quick connects are crimped onto each end of the wire. On the side of the wire that runs up to the battery, female disconnects are used, while on the side of the wire that runs to motors, cameras, or other tool packages, male quick connections are used. The female disconnect is comparable to an electrical outlet; the male end is "plugged into" the female end. It is safest to have the female disconnects on the side that is receiving power because it significantly reduces the danger of accidentally coming into contact with a hot wire.

To create the O-ring connection, two pieces of PVC were capped on one end and on the other end, one half of an O-ring union connection was attached. Small holes were drilled in each end, and wires were strung through the PVC. Appropriate connectors were crimped onto each end, allowing the wires to be connected. The holes in the PVC were sealed off with hot glue and putty; then epoxy was poured into each half of the connector to make it waterproof. The finished product allows for the tether to be removed from the ROV with ease, which allows for simpler transportation and the ability to use the same tether for another company ROV should the situation ever necessitate such actions.

In addition to the main tether that connects to the motors, several smaller O-ring connectors were made to attach tool packages to the bot while allowing for quick repair or replacement of each tool package without needing to cut and re-solder wires. These unions have been tested down to 70 feet or approximately 3 atmospheres of pressure with no leakage, proving their worth.

Photo 7: Team-designed PVC union "quick connects" for tether connection (large) and tool packages (small)

The smaller unions, made from half inch unions and epoxied end caps, are used for connecting our tool packages. Each tool package is connected to the male side of the union. The female sides of the union were glued into place in a circular "manifold" in a "V" configuration and placed inside the ROV near the bottom. When installing or removing a tool package, one must simply flip Gizmo upside down, and they can easily unscrew the union of the old package and replace it with a new one. This truly makes Gizmo fully modular, which is one of the Lincoln Group's guiding principles.

(Photo 8 – Small PVC Union "quick connect")

(Photo 9 – Small PVC Union "quick connects" configured in the V shaped manifold)

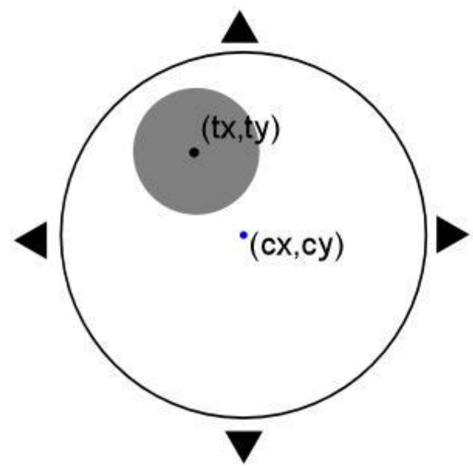
Controller, Electronics and **Software**

The ROV is controlled using an NXT-G program that is able to control the speed and direction of each motor, and is able to turn, and move in any direction. The ROV is controlled by using two NXT touch sensors, which serve as buttons that allows the ROV to ascend and descend, and also a Nintendo Nunchuck controller, which controls the speed of the ROV, and the direction of each horizontal motor, which allows for omni-directional control.

(Photo 10: The Dexter nunchuck interface)

The two touch sensors control the ascent and descent of the ROV by turning the vertical motors on and off, and in a certain direction depending on the sensor pressed. Pressing any button makes a looping if-statement true, which turns the motor on in the proper direction. When the button is released, the if-statement becomes false, which has the motor stop.

The direction and turning of the ROV is done using the joystick of the Nintendo Nunchuck. The joystick returns data as two integers in the form of Cartesian coordinates. The first integer provides the x-axis, while the second provides the y-axis. The base of the Nunchuck has eight corners, so the program allows for eight different directional inputs. In order to do this, the program uses eight different methods, one for each direction. A ninth method is used to make the robot stop when there is no joystick movement. Each method also uses if-statements under an infinite loop in order to check for joystick position. Because the joystick returns data as two integer variables, each method requires two if-statements that check for the proper position of the joystick. The methods each have a certain range at which the x and y values much be in order to be used. For example, if the forward movement method were to be used, the first if-statement must find that the x value is near, or at 0, while the y value is at its maximum. This means the joystick is pointed forward. By giving each method a range in a similar fashion, the position of the joystick is accurately represented. Each method also tells the motors to move in a different way. The forward and backward positions tell both motors to move in the same, corresponding directions. This allows the ROV to move straight forward or backward. The horizontal left and right positions allow the ROV to make sharp turns by moving one motor backward and the other forward. Each diagonal position of the joystick only tells one motor to move. For example, if the joystick is pointing to the top right, just the left motor will move forward. This allows for a more gradual, and accurate turning.



(Photo 11: Nunchuck joystick control)

Finally the speed is controlled by using the two buttons on the Nintendo Nunchuck. The speed can be controlled from a range of 0% to 100%. The entire program uses a single variable to control the speed of each motor. Initially, this variable is set to 50% power. Each time the top button is pressed, this variable increases, and each time the bottom button is pressed, the variable decreases, which allows for fluid speed control while driving the ROV. This is done by using if statements, that increase and decrease the variable based on which button is pressed.

These three components together allow for a fluid, simple, and accurate way to control all aspects of the ROV's motion.

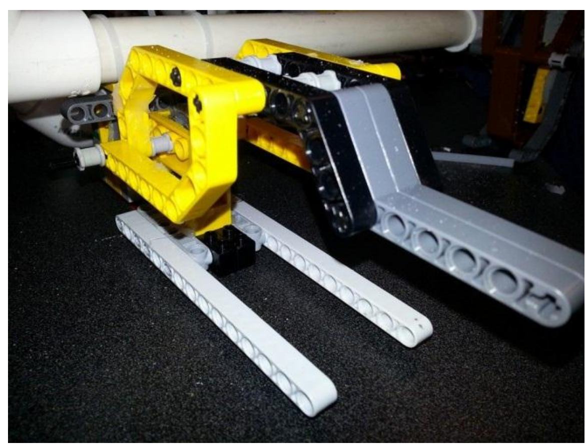
Design Rationale: Tool Packages

Because of Gizmo's modular design, and its focus on simplicity, this product is capable of doing serious shipwreck investigation.

Grippers

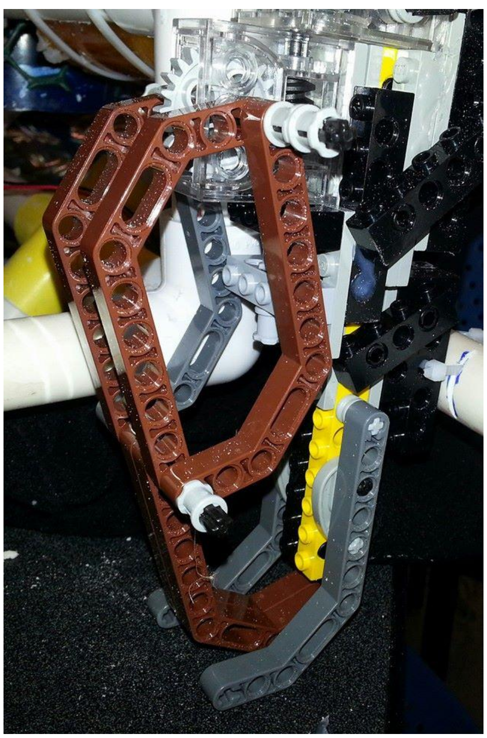
Several concepts had to be implemented for the grippers in Gizmo to properly work. The grippers were being constructed out of Legos, and due to this, the material could bend, and even break, if put under enough stress. The motors responsible for opening and closing both grippers can produce enough torque to break lego pieces, so a gear system was put into place to prevent any damage to our gripper during the mission. The gear system involves a smaller gear rotating a larger gear, effectively slowing the rate of rotation for the actual cost while also increasing torque. Both grippers have a gear ratio of 728:1, meaning that to fully open or close the gripper, the motor must spin 728 times. We found this solution to be more desirable over a 1:1 ratio, because the gripper would become too fast and uncontrollable without our gear system.

The grippers themselves have been specialized for their tasks; one gripper clamps vertically, like an alligator mouth, and the other grabs from left to right. The vertical gripper, nicknamed "plate claw" has been designed with the goal of picking up the ceramic plate with little difficulty. The gripper has a nub on the underside of the fingers that allows it to hook the lip of the plate and keep it from leaving the gripper. The bottom 'lip' of the gripper is stationary and straight, and sits on the bottom of our bot, so that we can wedge it under the bottom of the gripper, and then close the top lip with the nub so as to trap the plate. The gripping surfaces of this gripper have been covered with high friction surfaces to increase the grip underwater.



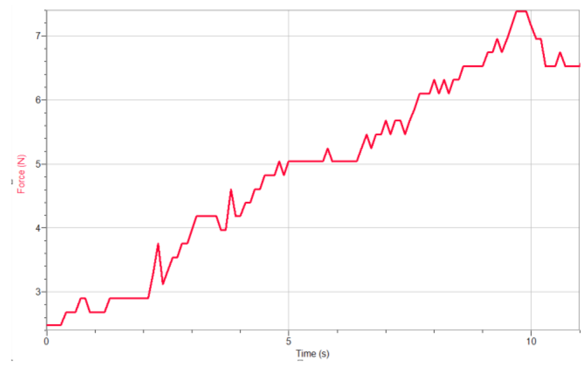
(Photo 12: Front view of plate gripper)

The side to side gripper, nicknamed the "crab", is designed to open doors, grip handles, and pick up bottles off the sea floor. We initially had it grip side to side in a horizontal plane (much as a human hand would if your hand is at shoulder level), but altered the design so that it grips in a vertical plane (As a human hand would if it is at waist level). The design change came after the realization that the horizontal gripper would prohibit us from picking up debris off the floor, and thus hinder our mission. The gripper itself has slanted fingers on both the thumb and finger, designed to hook objects and pull them into the gripper. Like our "alligator" gripper, the thumb is stationary, and our fingers close with the assistance of the gearing system. With this gearing system on both grippers, they are extremely controllable, and the orientation of the gripper allows for optimized ease of access.

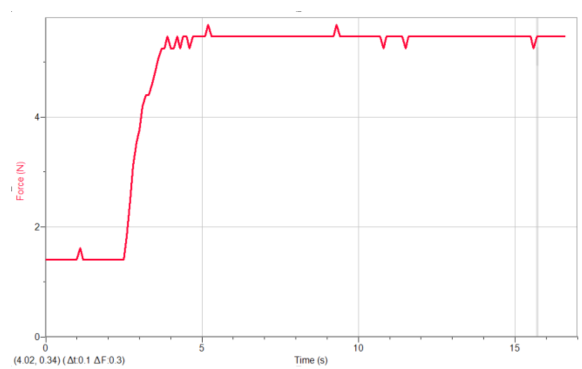


(Photo 13: The crab gripper)

The ROV grippers were tested with a Vernier force sensor to show their strengths. The diagrams below show the results over a ten second test period for the "alligator" and the "crab" respectively.



(Photo 14: Force generated by "alligator")



(Photo 15: Force generated by "crab")

Conductivity

One of the tasks that often is important during shipwreck investigation is to locate and study sinkholes in the area. Because these holes release groundwater in to the surrounding ocean/lake, those areas contain increased concentrations of ground salts, which can be detected by measuring the water's increased conductivity.

Gizmo is outfitted with a conductivity probe produced using a divided circuit that comes standard in the Lego NXT module.

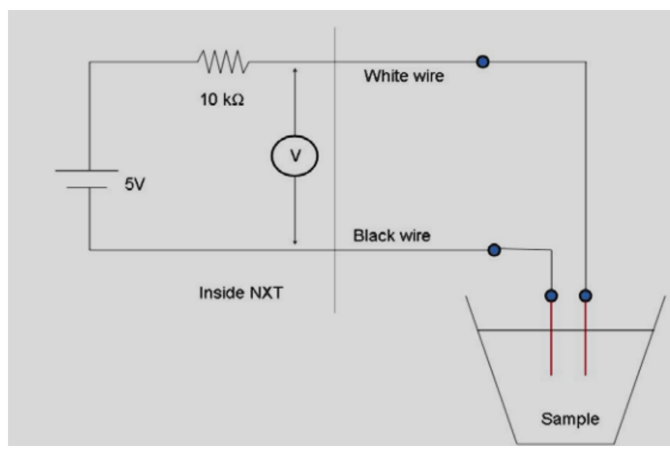
Ports 1 through 4 on the NXT each contain an analog-to-digital converter, built into each port as part of a divided circuit that also contains a 5 V power supply, which acts like a battery, and a 10 kΩ resistor. The black and white wires are two of the wires in the 6-wire NXT connector that plugs into these ports. The device can read voltages between 0 and 5 volts, with zero sending 0 to the NXT, and five sending the number 1023. If it reads a number between zero and five volts, the number is sends to the computer will be proportional to the voltage that it reads, according to the following equation:

$$x/5 = n/1023$$
or
$$x = 5 * n/1023$$

where x is the voltage and n is the number sent to the computer. Once constructed, the conductivity meter was calibrated using various concentrations of salt and running regression analysis for a best fit line/equation that could return appropriate salt concentrations tested.

Construction of the conductivity device was relatively simple. Two 10 gauge solid wires were soldered and waterproofed with silicone and shrink wrap to the wires coming from the male end of a PVC union joint from the tool package manifold. This hooked to a pair of CAT5 twisted pairs in the tether that ended in the female side of the PVC union. The solid wires were then connected to the outside of a half inch PVC pipe that then was connected to an ROV tee and placed so that it could penetrate the simulated sink holes with solutions.

(Photo 16: First prototype conductivity probe)



(Photo 17: Divided circuit used in probe/NXT)

Microbial Vacuum

Microbes are microorganisms consisting of both single and multicellular organisms. Many larger organisms have infant stages of life where they exist as microorganisms, and many types of bacteria, fungi, and algae exist as microorganisms their entire lives. Because the oceans on Earth are so vast, there are places around the world that have yet to be explored, and scientists believe that there are hundreds, if not thousands or millions, of species of microorganisms to be discovered that live in remote oceanic habitats. If collected by ROVs, these creatures could give scientists invaluable information about the life that exists on or around sites that are impossible to be explored by human divers.

The microbe vacuum on Gizmo was constructed from a 12 volt motor, a PVC motor shroud, and a lidless, round-edged aluminum can. To make the shroud, the motor was fit into a PVC tube and attached so that only the back of the motor fins were showing. Holes were drilled into the PVC before the motor was attached so that water could travel in and out of the shroud. Small holes were also drilled into the bottom of the aluminum can, to allow for filtered water to travel through the entirety of the structure. The bottom of the aluminum can was then attached to the other side of the motor shroud using hot glue and larger PVC tubing to overlap the connection. After its construction, the vacuum was secured onto Gizmo using a metal clamp. When placed on top of the bacterial mat, the pilot turns on the bilge moter and at the same time rotates Gizmo back and forth slightly, allowing the edges of the open tin can to cut through the agar. The suction developed from the bilge motor helps pull the can to the bottom of the container of agar, and then continues to hold it in place in the can. At this point, the pilot can rise and return to the surface with the sample.

(Photo 18: Microbial Vacuum)

Safety

As with any company, the Lincoln Group makes safety a priority. Below is the company's basic protocol when setting up the ROV in a new area for the first time:

- Bot is unpacked, and components are prepared to be powered up.
- Hands-Free check is called, before powering up the Control system, cameras, and monitors.
- All of the above components are checked for functionality.

- A second Hands-Free check is called, before powering up the bot.
- Wait 5 seconds before starting NXT program to ensure all circuits not overheating.
- Hands-Free is called once again and controller is activated to individually test thrusters.
- Bot is lowered into the water and rolled to ensure that all air has left the frame
- Last Hands-Free is called on the rover, before the controller is picked up, and the mission proceeds.

Safety is extremely important when working with Robotics. The Lincoln Group kept safety in mind during all parts of design, construction, and operation of Gizmo. We designed motor shrouds that prevent loose debris and any unwanted appendages from coming near the propeller during operation. During construction, we were sure to use proper gear, like goggles, when using equipment, in order to prevent injuries.

When designing the electrical systems tool package connectors, the female plug was always placed on the power side of the circuit, to reduce the chance of accidental shock. In house outlets, the female connection is on the wall, which prevents people from accidently touching a live wire and getting shocked. The male end is on the tool package, which is not always hooked to the power. Can you imagine how many home accidents we would have if we had prongs sticking out of the walls that are live? One has to purposely put something into the female end in order to get shocked. If this safety is demanded in our homes, then certainly it should be in the work place. The Lincoln Group, by following this and other important safety principles in placing fuses and using proper grounding procedures, is setting the pace for Ranger Class vehicles.

Budget

ROV Expenses			
Quantity	Item	Unit Cost	Total
10	1/2" PVC Elbow-Joint	$0.46	$4.60
8	1/2" PVC T-Joint	$0.28	$2.24
9	1/2" PVC Cross-Joint	$1.26	$11.34
2	1/2" PVC Side-Outlet Elbow-Joint	$1.18	$2.36
6.3	1/2" PVC Pipe (per ft.)	$0.15	$0.95
16	1/2" PVC End Cap	$0.36	$5.76
1	2.0" PVC Pipe (per ft.)	$0.55	$0.55
2	1.5" PVC End Cap	$0.66	$1.32
2.5	3.0" PVC Pipe (per ft.)	$1.25	$3.13
2.5	1.5" PVC Pipe (per ft.)	$0.45	$1.13
18	1/2" PVC 45-Degree Joint	$0.67	$12.06
4	Propeller & Adapter	$8.95	$35.80
5	Johnson 1250 GPH Ultimate Bilge Pump	$29.95	$149.75
50	Zip Ties	$0.02	$1.00
100	CAT5E Wire for Tether (per ft.)	$0.21	$21.00
200	16-Guage Wire for Tether (per ft.)	$0.22	$44.00
5	1/2" PVC Union	$2.89	$14.45
1	Camera	$59.99	$59.99
1	Conductivity Probe Parts (wire/solder)	$ 2.00	$2.00
3	Hobby Motor	$2.97	$8.91
1	1.0" PVC Union	$2.50	$2.50
1	Legos for Tool Packages	$5.00	$5.00
12	4.0" Steel Hose Clamps	$1.85	$22.20
1	Epoxy/Shrink Wrap/Silicone	$53.95	$53.95
Total		**$465.98**	

Control and Interface Expenses			
Quantity	**Item**	**Unit Cost**	**Total**
2	NXT Controller Module	$149.95	$299.90
4	MOSFET Board and Components	$14.75	$59.00
1	Dexter Nunchuck Adaptor	$21.00	$21.00
1	Nunchuck	$16.00	$16.00
2	NXT Touch Sensor	$20.00	$40.00
Total		**$435.90**	

Total ROV	**$901.88**

Travel/Meals/Lodging Expenses			
Quantity	**Item**	**Unit Cost**	**Total**
3	Vehicle Rental/Gas (5 days)	$550.00	$1,650.00
12	Lodging (bed/brkfst/student/4 days)	$120.00	$1,440.00
12	Meals including travel ($6/meal)	$60.00	$720.00
12	Possible tour/boat ride	$30.00	$360.00
	Total		**$4,170.00**

Income			
Quantity	**Item**	**Unit Cost**	**Total**
4	Donation	$200.00	$800.00
10	Student Payments	$410.00	$4,100.00
	Total		**$4,900.00**

Barckhoff's Principles

The Lincoln Group applied real-world methods into the design and manufacturing of our ROV. We chose to follow the quality assurance methods developed by J.R. Barckhoff, author of ***Total Welding Management***. Mr. Barckhoff has spent 40 years in the welding industry, and his vast knowledge helped him to create an evaluation system that works to improve production while decreasing costs, called the "Barckhoff Welding Management System." This system takes the main areas of production, such as the Design, Manufacturing, and Quality Control phases, and asks the question: what can/could be done to reduce the different costs in this area? His company looks at ways to reduce scraps, reduce the time it took to produce products, reduce the time to move materials from one workstation to the next, and many other cost factors to improve production capabilities. His methods were so successful that many other companies across America have adopted his principles into their quality assurance methods.

Reduce Materials/Cost:

We used mainly inexpensive materials to construct Gizmo, including PVC, zip ties, and hot glue. With our detachable tether connection, we built our own connectors each with a PCV union O-ring and epoxy.

Our tool packages can be easily interchanged with other tool packages, meaning that the same port on the ROV can be utilized for several different tool packages without rewiring the entire ROV due to our modular design. Similarly, any type of divided circuit probe will easily attach to the CAT5 tether/NXT currently in place.

Reduce Time:

Each tool package, probe, and motor can be quickly removed or attached because of the specialized detachable tether we designed for this specific purpose.

Reduce Scrap:

With our design, we incorporated recycled PVC parts from past ROV designs that are still perfectly functional instead of trashing all of those parts and using only new materials. While trouble-shooting and testing claw designs, we found that some designs did not always work the best and were in need of tweaking. Instead of building an entirely new claw design, we would start with the same basic parts and make adjustments as needed.

Reduce Work Effort:

For larger tasks, the work effort was reduced by allocating all of our team members to work on that one task until it was completed, as not to hinder the steps that would come after. When the tasks were of less magnitude, they would be divided among workers to eliminate the hassle of having too many people trying to work on the same components at once.

Reduce Motion/Delay Time:

For the most part, our workspace was compact, which reduced the amount of travel time between locations. Also, for the majority of our working, we were able to work at the same table on similar projects, so that all parts and people working together could communicate and pass on information/materials very easily.

Challenges and Troubleshooting

The biggest issue that has been stymieing the progress of making the bot has been being able to get everyone together at one time. As high school students with other scholarly, social, and work responsibilities, a single meeting time every week has been difficult to organize for everyone. With a sizeable team, there are many ideas contributed by each person. If that person isn't present to implement their idea, then the team is left in confusion. Confusion when only a few core people can't show up has been stifling us as well. There was one point when the design for the bot was memorized by only a single primary person and when the frame all fell apart, 30 minutes had to be taken just to get it back together. Overcoming that challenge has been difficult, and to some degree it still hasn't. There are still a few core team members that can't show up every week, but very soon in the manufacturing of the bot we were all on the same page.

Future Improvements

Gizmo is just the first in what is hoped will be several products for the Ranger Class ROVs. The first expected improvement will be changing the current vertical motors into a pair that are separately controlled so we can vector them, allowing us to be able to drift from side to side without actually turning. This will allow for much more precise control of the robot, and may be very helpful when facing underwater currents. A second area under consideration is developing a controller fixed in a helmet, so that the driver could just turn his head, and the bot would turn. Some experimentation has already been done in this area for a helmet driven wheel chair for quadriplegics, so we believe it is possible. A third area that our division is considering exploring is to mount a simple fish finder sonar device on an ROV, so that it could find possible shipwrecks or other structure on the bottom in murky water, which is often faced while exploring here in the Midwestern lakes. Once structures were found, we could then send our webcam ROVs down to the precise location and find it much more quickly. Finally, we are looking at ways to possibly make our thrusters rotatable, so that if we need extra lift, we can take our horizontal ones and make them vertical during the lifting process.

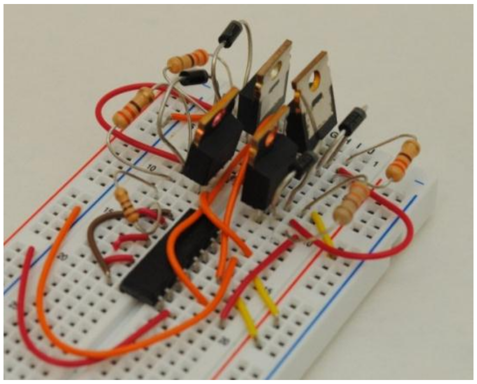
Skills Gained

Beyond the previously mentioned technical skills The Lincoln Group gained in building its ROV, it has acquired many interpersonal skills. The team learned how to compromise on ideas. If disagreements arose, team members would try both approaches to a problem if possible, and if not, they would vote on which design they liked the most. This approach prevented most bickering about the ROV's design. Unlike previous years, everyone had a voice, and thus, everyone felt as if they could contribute to team decisions.

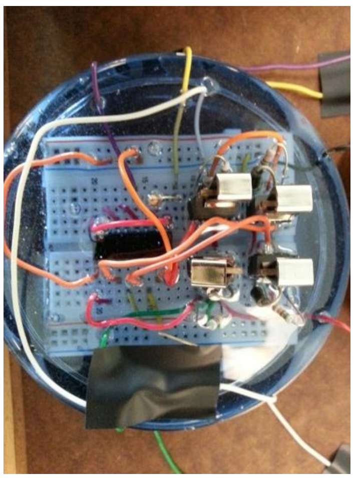
Also, building our bipolar MOSFET amplifiers was quite a challenge. In the process of overloading a few of them, we learned how to use the diode feature of our multimeters to test components, which put a very practical spin on noting the differences between n and p channel MOSFETs.

Gizmo only has three signal cables coming from the NXT, but they are controlling four motors. The up and down thrusters do not need to run in different directions at any point, and therefore operate like a paired system at every given moment they are on. In previous years, teams tried to use this system by using a single MOSFET board for running both motors, but it was clear then that the MOSFET board couldn't handle the amperage of running both motors, so previous teams limited themselves to one lifting thruster. Learning from previous experience, we instead have a MOSFET board for each motor now and control the vertical ones in parallel, meaning that they both receive the same commands originating from one NXT cable. They then send that command to their own individual motor via pulse width modulation. This lessens the chance of a MOSFET overheating during the mission.

Also, we found that bread-boarding our MOSFETs was fun and very educational, and we really did not want to have to then design and buy circuit boards to replace them. In order to make them more permanent, we took our boards and potted them approximately half way in epoxy, like our webcam. Our first prototypes have worked well, and although not totally waterproof, they certainly are less likely to short out due to water. They also are able to release any buildup of heat in the actual MOSFETs.

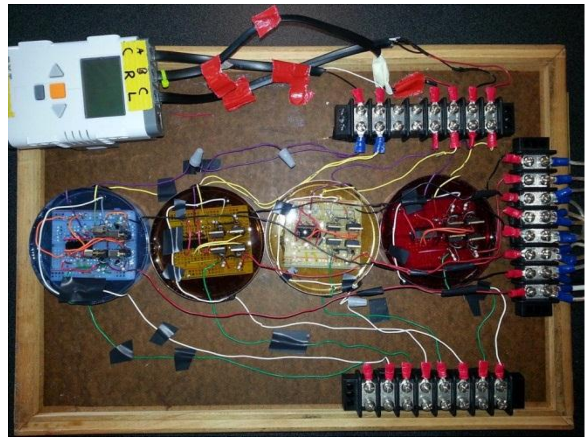


(Photo 18: Prototype bipolar MOSFET amplifier)



(Photo 19: MOSFET board potted with epoxy)

We are considering potting them completely next year so they will be completely waterproof, and mounting them on board directly in the water, allowing its high specific heat to cool the components. This may actually be an advantage over placing them in O-ring sealed containers as is done on most Explorer vehicles.



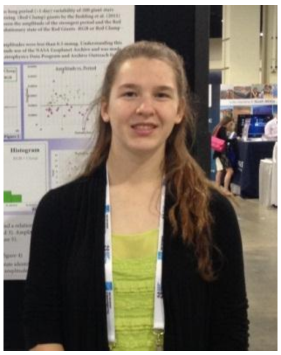
(Photo 20: Electronics layout with NXT controller and 4 potted bipolar MOSFET amplifiers)

Mission: Exploring Wreckage

As time passes and transoceanic travel becomes ever more popular, shipwreck exploration becomes all the more necessary. Because exploring shipwrecks under several miles of water is not always feasible or possible by other methods, remotely operated vehicles have and still continue to play a huge role in this endeavor. Often ROVs are sent down to depths where the water pressure is too great for human divers. By exploring both new wreckage and older vessels, precious artifacts can be recovered and other valuable information (such as the cause of the wreck) can be gathered. Deep sea missions can also provide scientists with a chance to collect microorganisms and sediment from marine habitats hundreds or thousands of feet below the surface to provide information about environments that otherwise would be left unexplored. Microorganisms gathered by ROVs offer scientists an opportunity to learn more about environments that they cannot physically visit.

Reflections/Bios

Laura Stegner
CEO, Communications



I am a senior at Gahanna Lincoln High School, and this is my second year participating in the MATE ROV competition. Last year, my team had a slight lack of senior leadership, which caused the juniors on my team to have to learn virtually everything about underwater ROVs before we could get started. This year, my team voted me as CEO, and I was determined to provide the leadership they sought. I think that this year was more organized, thanks to the schedule that I made to keep people on track, and also I think that we communicated much more effectively. These communication and organizational skills have definitely helped prepare me for college, where I will most definitely have to collaborate on various projects. Next year, I plan to study materials engineering at the University of Cincinnati. I am so thankful to have been part of this Ranger team, and look forward to seeing all we can accomplish!

Emily Merickel
Engineer, Communications

I am a senior at GLHS, and this is my second year on the underwater robotics team. Throughout all of my first year on the team, I worked on learning the basics of building, wiring, and waterproofing the ROV, as well as functioning within a company. This year, I was able to take part in the design process (especially in implementing Barckhoff's Principles) and take charge of the public relations sub team. As a result, I feel that I learned much more about running parts of a company and designing a product that is both efficient and effective.

Diego Quevedo
Electronics, Engineer

I am in the 11th grade at GLHS, and this is my first year on the team. I am responsible for the care and creation of all of the above ground electronics under my control. By taking control of the MOSFETs I have effectively become the person to come to for making them in my class away from the club team. The model of MOSFETs we use is so embedded in my head that I have memorized where all the loads and power wires go on it, and I can do most of it in my head by now. So I'm basically the electrical engineer for Gizmo, and this project has really opened my eye to going into electrical engineering for my future career.

Andrew Lewis
Engineer, Tether

I am a junior this year at Gahanna Lincoln High School and this is my first year in the Lincoln Division. Before I started in the club, I did not know any electronics, how to drill or just about anything involved with building a robot, let alone an underwater one. Over the course of the year I learned how to solder, how to waterproof hobby motors, how to use a Dremel, how to write basic programs and how to pot cameras, as a few examples. This team also taught me how to work with other people, my peers, under intense pressure. I learned how to figure out solutions to seemingly unsolvable problems. Most importantly, I learned how to improvise under pressure, and to learn from my mistakes.

Acknowledgements

The Lincoln Group, LLC. would like to thank the Mate Center for giving us the opportunity to participate in an engineering and robotics competition. The lessons and skills that we have gained through this project (both educational and social) are invaluable, and would not have been gained without the hands on experience we have had throughout the development and testing of our ROV. We would also like to thank the Gahanna Jefferson Education Foundation and Mr. Jack Barckoff for their financial support with this project and their overall support of the Science Academy at Gahanna Lincoln. In addition to his financial support, we would also like to thank Mr. Barckoff for his systems engineering advice. Finally, we would like to thank our advisors, Mr. Fred Donelson and Mr. Tyler Bruns, for their endless support, guidance, and time throughout the course of our work, as well as our families and parents, who consistently encouraged us in our endeavors.

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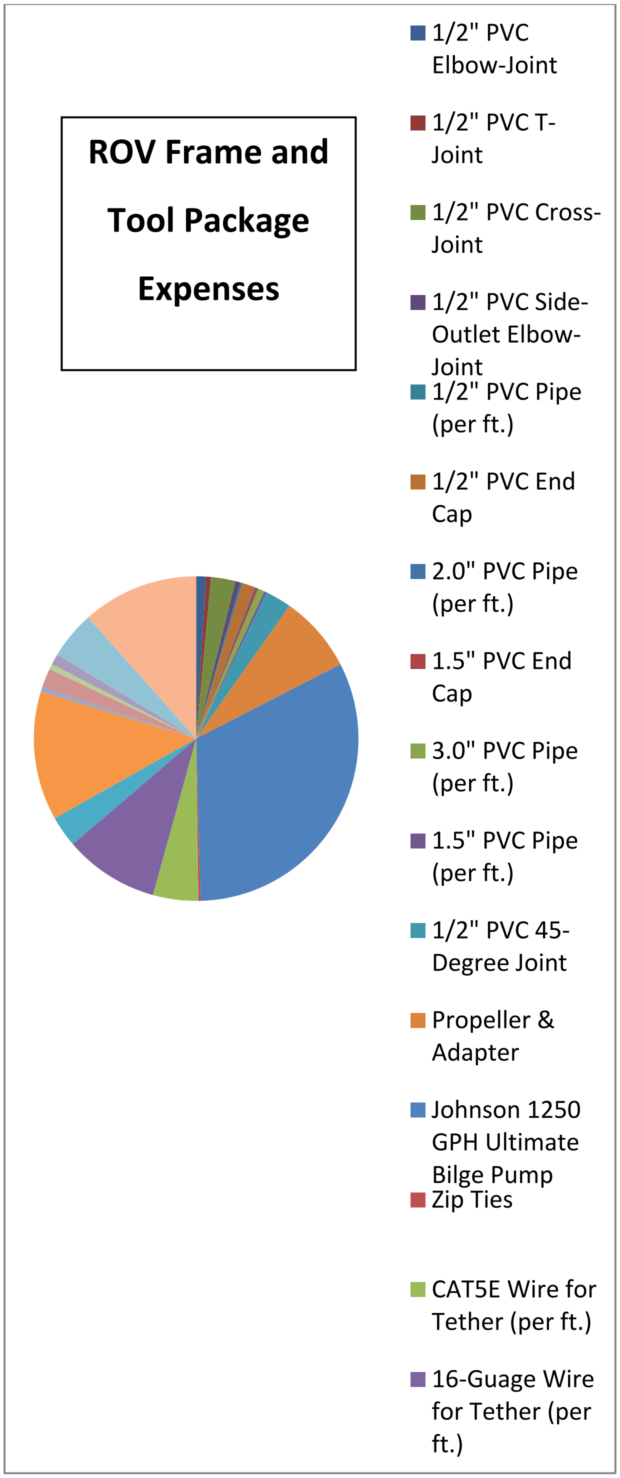

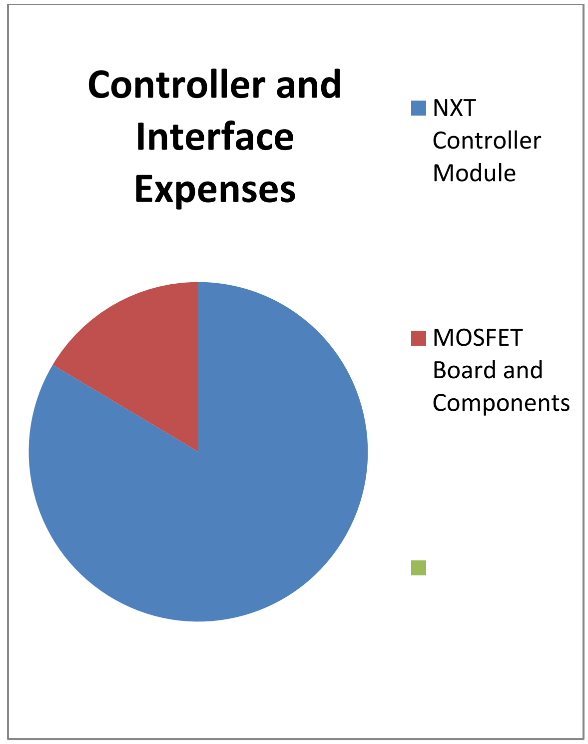

Appendix

Figure 1

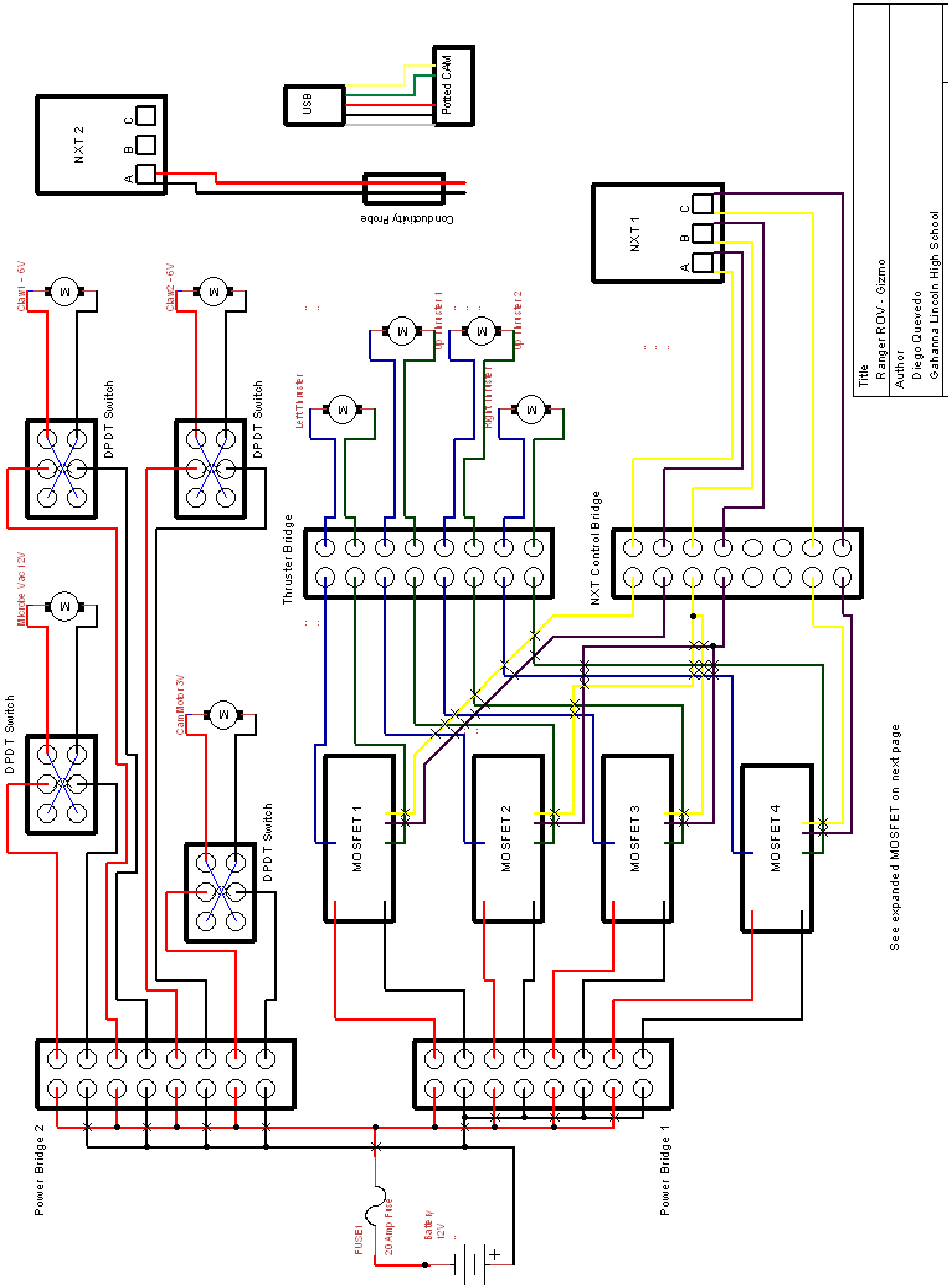
NXT 2
A
B
C
USB
Potted CAM
Conductivity Probe
NXT 1
Title
Ranger ROV - Gizmo
Author
Diego Quevedo
Gahanna Lincoln High School
Claw1 - 6V
Claw2 - 6V
DPDT Switch
DPDT Switch
Microbe Vac 12V
DPDT Switch
CamMotor 3V
DPDT Switch
Left Thruster
Up Thruster 1
Up Thruster 2
Right Thruster
Thruster Bridge
NXT Control Bridge
MOSFET 1
MOSFET 2
MOSFET 3
MOSFET 4
See expanded MOSFET on next page
Power Bridge 2
Power Bridge 1
FUSE1
20 Amp Fuse
Battery
12V

Figure 2

BIPOLAR MOSFET AMPLIFIER DETAILS

From
Extreme NXT: Extending the LEGO MINDSTORMS NXT to the Next Level, Second Edition

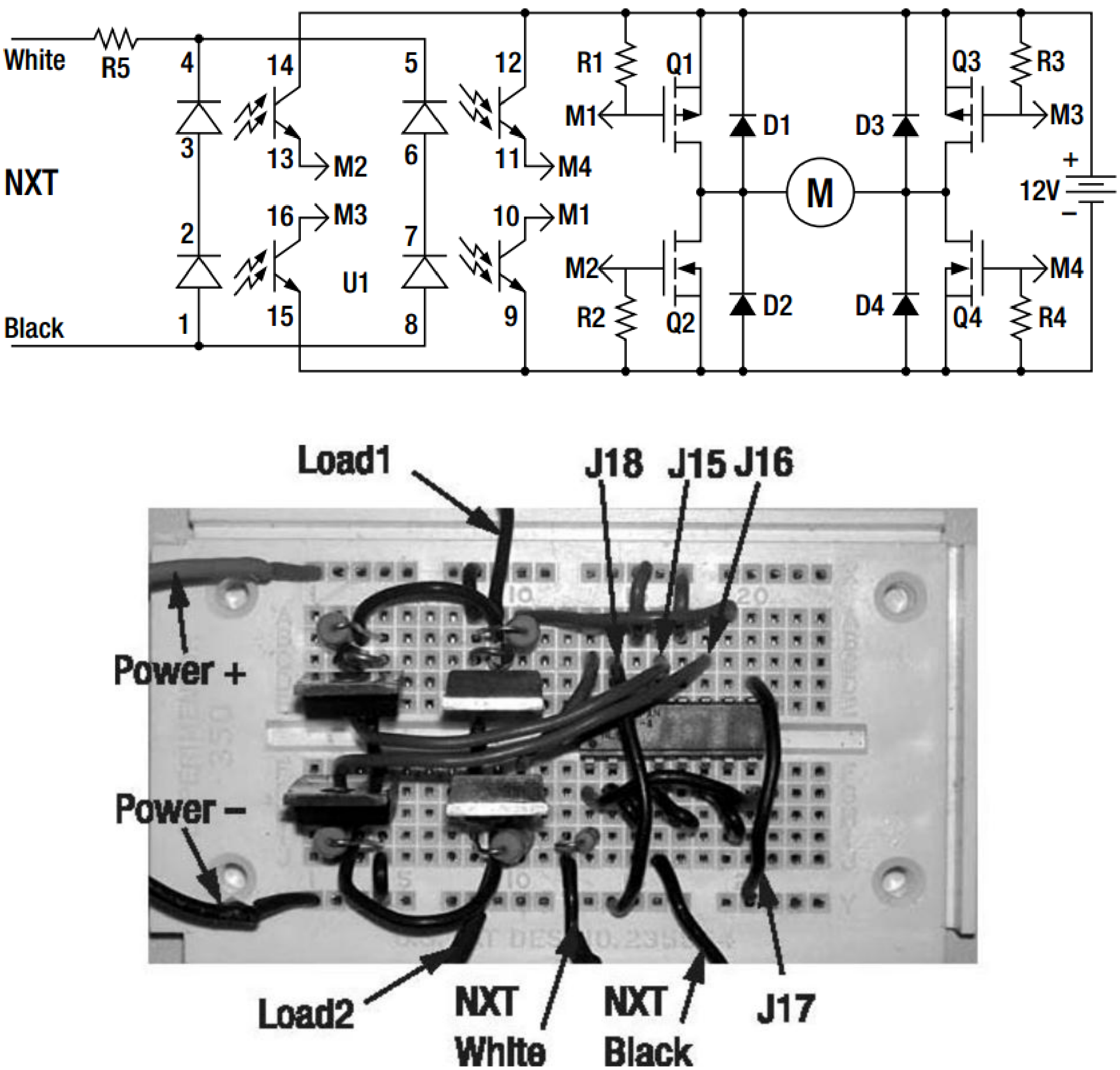

Figure 3