Technical Report 2009

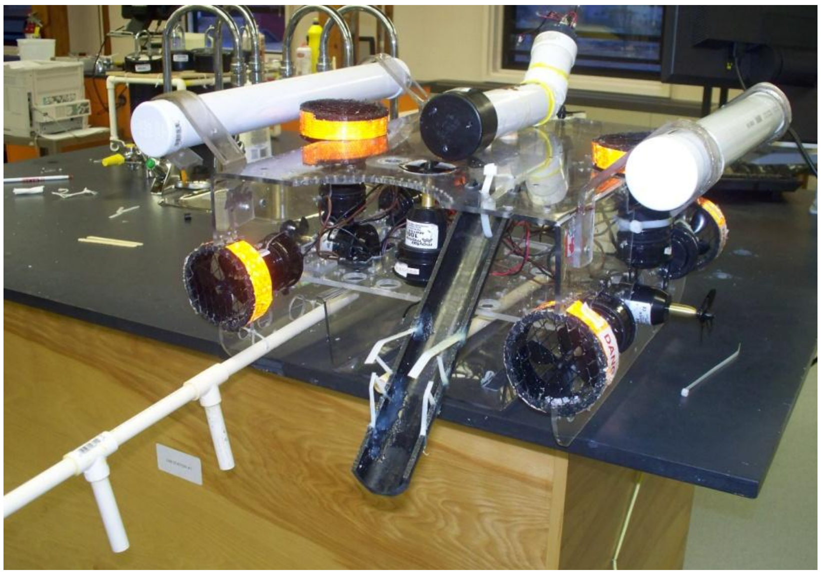
Ranger Class

Eric G. Lambert Robotics Team

Eric G. Lambert School

Churchill Falls, Newfoundland and Labrador

Poseidon ROV



Completed Poseidon ROV

Mentors:

Barry Noble	Instructor
Samantha Kent	University Student
Spencer Collins	Electrical Engineer
Jamie Curtis	Mechanical Engineer
Craig Rowsell	Mechanical Engineer

Team Members:

NAME	YEAR
Laura Bonnell	Grade 12
Krista Collins	Grade 12
Heidi Kent	Grade 12
Joshua Hawco	Grade 11
Sarah Power	Grade 11
Daniel Sutton	Grade 11

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ABSTRACT

This being Eric G. Lambert Robotics Team's third year competing at the MATE International competition, we began this year by assessing the previous year's design. We decided to reuse the main Lexan frame of last year's robot and our goal was to modify its components to successfully compete in the Ranger class at the 2009 MATE International ROV Competition. We maintained the rectangular prism shape because it provides us with the balance and space needed to mount our arms, motors, and other necessary payload tools. It will also be easier in determining the buoyancy of the robot and ensuring that it is neutrally buoyant. We wanted our robot, *Poseidon*, to glide through the water as much as possible, therefore we chose to reduce surface area and minimize resistance by not having a front, back, or bottom of Lexan. Also the water may flow through the ROV allowing it to move quicker. Through the use of various components, such as PVC pipe, ty wraps, and slotted Lexan, we have assembled *Poseidon* to successfully complete the necessary tasks. Our team has benefited from the assistance of local electrical and mechanical engineers, a previous team member and our coaches. The following technical report includes a description and photos of the ROV, challenges we encountered and overcame, lessons we learned, possible future improvements, a description of an organization involved with submarine rescue, our budget, and reflections on our experience this year.

Eric G. Lambert Robotics Team 2009

NATO'S SUBMARINE RESCUE SYSTEM

An organization involved with submarine rescue

The North Atlantic Treaty Organization is an alliance between countries of North America and Europe and is committed to fulfilling the goals of the North Atlantic Treaty. Security for all its members is just one of the many things NATO looks after and so it is natural for them to have developed a Submarine Rescue System. The NATO Submarine Rescue System (NSRS) is a multinational project and its main goal is to develop an international rescue system that can be deployed anywhere in the world. NSRS is jointly owned by France, Norway, and the UK. It consists of two sub-systems that can mobilize independently of one another.

Intervention is the smaller sub-system which is focussed around the Intervention Remotely Operated Vehicle (IROV) and can be quickly mobilized to a distressed submarine to prepare the site for the much larger Rescue System and provide life support. This system performs tasks that are most like those that *Poseidon ROV* is designed to complete. IROV surveys the site and assesses the damage, which our ROV is also capable of doing. It also provides Emergency Life Saving Stores (ELSS), which contain food, water, atmosphere control equipment, and medical supplies, to the distressed submarine. As outlined by the second task in our mission, *Poseidon ROV* can transfer ELSS pods to a submarine.

The second sub system, the Rescue System, consists of a free swimming manned submersible, a Portable Launch and Recovery System (PLARS), a Transfer Under Pressure (TUP) decompression system, and other necessary support equipment. It is used to recover the crew from the submarine by mating with it. Once the pressure has been equalized, up to 15 people can be rescued and transferred to the rescue vehicle including patients on stretchers. This is a much larger scale version of what our mating skirt is designed for.

Figure 1 Submarine Rescue System

Figure 2 Intervention System onboard ARGONAUTE

SOURCES:

http://www.armedforces.co.uk/projects/raq3f6dac45ad605

http://www.ismerlo.org/assets/NSRS/NSRS%20Factsheet%20Issue%204%201%20lo-res1%20_2_.pdf

DESIGN RATIONALE

FRAME

The frame of *Poseidon ROV* was revised and added to the main frame from last year and is constructed from Lexan. We chose this material because it is durable, lightweight, and sturdy. Living in a small isolated community creates challenges in acquiring Lexan, therefore it needed to be used sparingly. Since it is very difficult to cut Lexan once it has been scored and bent into a rectangle, we decided it would be best to do a cardboard mockup of the ROV with precise measurements and motor cut-outs so that it could be used as a template for cutting the Lexan. To accommodate for this year's missions we attached a piece of Lexan to the bottom of the ROV with slots to fit over the carousel assembly. There is a shelf of Lexan attached inside the outside frame that allowed us to place motors for lateral movement and to mount one of our cameras. Also Lexan makes it very easy to mount other components, such as arms made out of PVC pipe.

Figure 3 Lexan frame prior to mounting components.

CONTROL SYSTEM

We modified a tool box to accommodate our controls. Initially we placed holes in the sides, one for the tether to enter and connect to all of our switches, a second to connect with the power supply, and another to mount the main switch. Another piece of Lexan was cut to fit inside the toolbox, so that the switches could be mounted on top of it with the wires running underneath. The control box contains four variable resistors that control the speed of the ROV and four double pole single throw (DPST) switches for forward, reverse, up, down, left, and right motion of the thrusters. There is also a push button switch to control the motor that is connected to the pipe, which turns and allows the release of the ELSS transfer pods. We also wired in a voltmeter as a troubleshooting mechanism.

Figure 4 Open and close view of control box

CAMERAS

Figure 5 Camera

Poseidon ROV has two underwater digital cameras to provide the ROV operators with a clear colored image. One camera is mounted to a Lexan shelf inside the main frame of the ROV and points downwards so the operators can clearly see the slotted Lexan that is used to pick up the ELSS transfer pods. The second camera is mounted on top of the ROV. With this camera the operators can see both arms, one which is used for the airline and the other for opening and closing hatches. Both cameras will be used to locate damage points and will help the operators to see where they are headed.

THRUSTERS

Seven 1000 GPH and three 750 GPH motors are used so that *Poseidon* may efficiently glide through the water. Four motors, two 1000 GPH and two 750 GPH, are used for both forward and reverse movement, with two mounted on each side of the robot. Due to the fact that the motors are not as efficient in reverse, we decided to mount them backwards to one another. They are wired accordingly, so that when one motor is in forward it is complemented by the one opposite of it, which is in reverse. This ensures that when the robot is moving forward, it produces the same amount of push as when it is in reverse motion. Two other motors are mounted; one on the middle of each side near the bottom of the robot, which are used for lateral movement. Four more motors are mounted on top of the ROV for upwards and downwards movement. In previous years only two motors were used for up and down and we found that this was too slow. To be faster in descending and ascending and to increase life, we added two extra motors. Each motor has a four blade plastic propeller, which was selected because during our Bollard test the brass props gave a thrust of 1-1 ½ N while the plastic props produced thrust of about 8N. For safety reasons, each motor is housed inside an ABS shroud with wire mesh stitched and epoxyed to the outside. There is also highly reflective tape and danger signs on the shrouds.

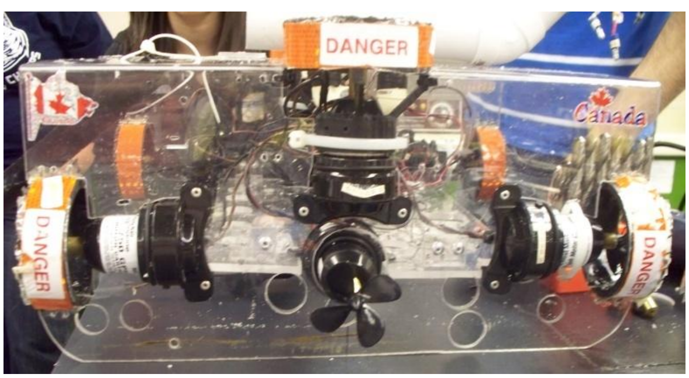


Figure 6 Side view of thrusters

TETHER

Figure 7 PVC pipe connects tether to ROV

The tether used for our ROV is being reused from last year. It is 14m long and originally contained ten 18-gauge wires. In order to accommodate for our cameras, there are two cables attached to the outside of the tether with electrical tape. We added 2.5 meters of extra wire to the tether on the end that will not enter the water in order to be sure that it would be long enough. The tether now meets all of our electrical requirements and is flexible enough so that it does not interfere with the motion of the ROV. The wires of the ROV are housed inside a piece of 2" PVC pipe and the tether is connected to the end of this pipe using a compression fitting that contains an O-ring to ensure that it is water tight and will allow us to disconnect the tether from the ROV. The disconnect will be very beneficial because in our first competition we experienced many problems with the size of our ROV during travel, because we couldn't disconnect its parts. In travelling long distances it is essential that the ROV can be disconnected from the tether to make it much easier for packaging and transporting.

Figure 8 O-ring compression fitting

The PVC pipe that houses all the wires on the ROV has a second purpose. It is placed in the center on top of the ROV to provide buoyancy. Having read the "What Works What Won't" section of *Build Your Own Underwater Robot* we know that the weight always ends up below the floats. Since the majority of the weight of our ROV is on bottom we made sure the pipe was centrally located above everything else. This year we decided it would be more beneficial if the tether was angled upwards away from the robot, therefore we used a 45˚ elbow on the end where the tether connects ensuring that the tether will not interfere with the motion of the ROV.

BOUYANCY

Figure 9 PVC pipe for flotation

Buoyancy is defined as the difference between upward and downward forces acting on the bottom and the top of an object, respectively. Archimedes Principle states that the buoyant force on a submerged object is equal to the weight of the fluid that is displaced by the object. When dealing with heavy motors and cameras underwater it is very important to have a good understanding of these concepts. It is very important for *Poseidon ROV* the right amounts of floatation in the right places. To provide overall buoyancy to the robot we have attached two pieces of PVC pipe, one on each side on top of the robot. For fine tuning to achieve neutral buoyancy we will be using high density foam and small pill bottles with iron washers inside.

Figure 10 Fine tuning for floatation

PAYLOAD TOOLS BY TASK

Task 1: Survey and inspect the submarine for damage.

To accomplish the first task we will use both of our cameras to locate the damage points. Our motors allow for a variety of different movements, including forward, reverse, and lateral motion to either side, which will greatly help us in maneuvering around the submarine.

Task 2: Pod Posting.

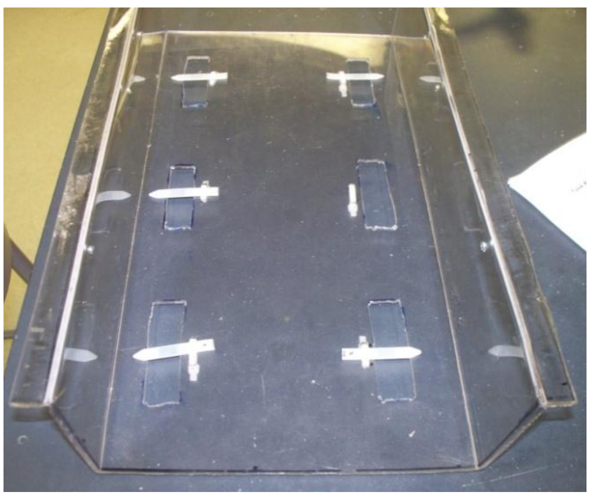


Figure 11 Lexan attachment for ELSS pods.

To complete this task we have bent a piece of Lexan so that it has only three sides and extends beneath the ROV. As with the main frame of the ROV we first used cardboard to make this attachment and then used it as a template to cut the Lexan. We cut six slots in the bottom side of the Lexan, spaced apart so that we can pick up all five ELSS transfer pods at once. Across the slots are pieces of large ty wraps that keep the pods from falling out as the ROV is maneuvered to the submarine. To release the pods, which is done two at a time, the ty wraps are attached to strings of varying lengths that is tied around a PVC pipe. With the push of a button by the operators at the surface a windshield wiper motor slowly spins the stick allowing the pods to drop two at a time. The varying lengths of string ensure that they don't all drop at the same time and it allows time for the motor to stop so the ROV can be repositioned to drop the next set of pods.

To turn the hand wheel and open the hatch of the submarine's escape tower we have attached an arm made of five pieces of ½" PVC pipe and three T-joints. Three pieces of pipe form the length of the arm are connected with the T-joints and one at the end, while two more pieces of pipe extend downward perpendicularly. These two perpendicular pieces are used to turn the hand wheel, by simply descending on top of it, ensuring the pieces are in the hand wheel, and then turning the ROV 180˚. We discussed using an electronic arm or claw in opening the hatch, but discovered that when the end of our PVC pipe arm is inserted sideways underneath the hand wheel and the ROV is propelled upwards the hatch comes open easily.

This PVC pipe arm also worked well for closing and locking the hatch. This method proved to be much simpler and less time-consuming.

Task 3: Ventilation

We, Eric G. Lambert Robotics Team, designed an arm specifically to transport the airline to and from the submarine. A (insert length) piece of 1.5" PVC pipe was cut in half and four slots were cut on either side. After experimenting with different lengths and varying strengths of ty wraps, we decided on four smaller ty wraps at the front part of the pipe to carry the airline down. The ty wraps are bent so that once the airline is inserted we can propel the ROV downwards to release it. Larger ty wraps worked best in retrieving the airline and the smaller ones in the front guide it nicely right into the grasp of the large ty wraps and ensure it won't be lost on the way to the surface.

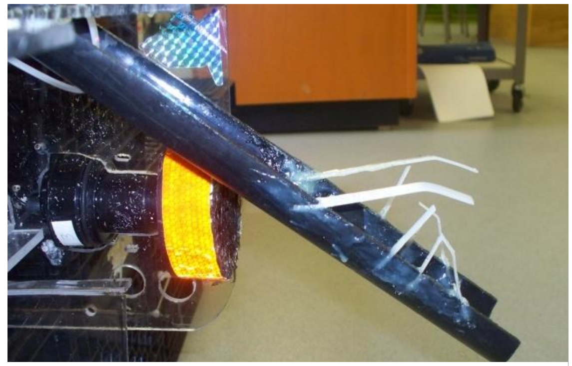


Figure 12 Arm for airline

To open the hatch we once again use our arm made of ½" PVC pipe. The T-joint on the end makes it easier to open and close the valve. We found that initially trying to flip straight pipe with straight pipe didn't work well, however the T-joint corrects this and hooks the valve making it easy to close.

Figure 13 1/2" PVC pipe arm

Task 4: RORV (Remotely Operated Rescue Vehicle) mating

To complete this task we designed our transfer skirt with the dimensions as outlined by the competition. We decided to attach the transfer skirt to the back of the ROV because we have other components attached to the front and we wanted to be sure it would not interfere. For a clear view of the transfer skirt the camera placed inside the frame will be angled downwards and towards the back.

Figure 14 Transfer skirt

OVERCOMING CHALLENGES

Building a functioning ROV to complete certain tasks is no small feat. When working with a group of people, regardless of the project, there are sure to be challenges to face and overcome. For Eric G. Lambert Robotics Team one of our biggest issues is always materials. In a small isolated community where you cannot purchase the materials needed at a moment's notice means careful planning and always buying a little extra. We started off the year by taking apart last year's robot and identifying what parts, if any could be salvaged. Fortunately we were able to reuse the main Lexan frame and all of our motors. Since more Lexan was needed for another component, our coach brought it back when he went out of town, along with other necessary parts.

One of our biggest technical problems this year was our cameras and camera cords. After last year's competition we knew there was a slight problem with one of the camera's cutting in and out. When we set it up this year we found that one of our monitors was not working properly and one of the connectors from the camera was broken. Our next problem was that one camera still cut in and out. After trying many combinations of cords we discovered that one of the wires was broke off inside and so it had to be taken apart and re-attached. Finally both cameras worked. Through trouble shooting the problems we managed to get everything working.

A final challenge faced by our team was coordinating our busy schedules with the equally busy schedules of our coach and mentors. We each had to take time on our own to familiarize ourselves with the tasks so that time would not be wasted at meetings and we could work more efficiently. It soon became clear that while only half the team might be able to meet after school on one day, the other half would meet the next, and on weekends we would all make a special effort to make it to the meetings. Slowly but surely the ROV has come together thanks to everyone's hard work and determination.

TROUBLESHOOTING TECHNIQUES

While constructing *Poseidon ROV*, Eric G. Lambert Robotics Team took all the necessary precautions to prevent problems and ensure things would run smoothly. First we tested all our motors that were still on the frame to see if any needed to be replaced. We also tested new motors before putting them on the ROV to avoid the unnecessary work of removing them. Also, by having a fuse panel with four fuses and four switches in our control box, we made it very easy to detect which set of motors has failed in the event of an individual control system failure, such as forward/reverse movement, up/down movement, or left/right movement. This saves us much

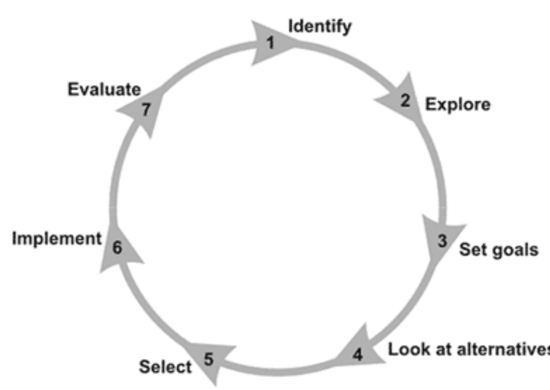


Figure 15 Problem solving diagram

needed time otherwise spent searching for the cause of the problem. Also in our control box we have a voltmeter to detect any power failures. For safer transportation of our ROV and to avoid any crises upon arriving at the competition, we designed *Poseidon ROV* so that it may be disassembled to a degree and condensed for travel. By labeling all the corresponding wires it makes for quick reassembling once we have arrived at the competition. The tether, perhaps the bulkiest part of the ROV, can be disconnected from both the robot and the control box, which is very convenient.

LESSONS LEARNED and SKILLS GAINED

The Eric G. Lambert Robotics Team has learned many lessons and gained various skills over the course of this year as we designed, constructed, and operated our ROV, *Poseidon ROV*. First of all we familiarized ourselves with the four tasks outlined by MATE International and educated ourselves about submarine rescue missions and ROV. Those team members who had been involved in previous years helped the new members get a better understanding of the project through discussions about what works and what doesn't when it comes to underwater robotics.

All of the teammates agree that two important skills gained through ROV are teamwork and time management. In order to tackle such a large project it is necessary for the team to function as whole with everyone fully informed of the task at hand, what needs to be completed and in what order. When cooperating and working together things always ran smoother and were accomplished faster.

In constructing the ROV everyone received practice working with tools, from wire cutters and strippers to electric drills and jigsaws. We all became very familiar with epoxy and ty wraps. We've learned that above all else it is extremely important to work together as a team. Altogether ROV has been a rewarding experience for all team members.

FUTURE IMPROVEMENTS

Poseidon ROV can complete all the necessary tasks; however that does not mean that there isn't room for improvement. One improvement that could be made to our ROV in the future is to have a more flexible tether that would not restrict the motion of the ROV. This would mean a tether that is smaller in diameter and made of a more flexible material. A lighter tether would also be beneficial as we would not have to use as much flotation in making sure that it did not drag down the ROV.

The overall appearance of our robot could be greatly improved. Due to time constraints we were not concerned about aesthetics this year. To make the ROV more appealing we would need to be tidier when gluing or epoxying, and more precise when drilling holes. Perhaps starting with a totally new frame next year would allow for a nicer looking ROV because it would not have all the holes from previous years.

More cameras would not go to waste as they would assist the operators with depth perception. We currently have two cameras angled so that we may have two different views, allowing us to see what we are doing during the missions. Since these cameras do not provide different angles of the same piece of equipment, the operators must deal with looking at things in 2-D and using trial and error to complete the tasks. At least one more camera would be beneficial and two more would be ideal. With three or four cameras in total a splitter would be used to ensure that the images from all the cameras could be seen on one screen, allowing the operator to navigate more efficiently.

Our ultimate goal for next year is to be able to work with software, such as Visual Basics and Gadget Master, instead of constructing a homemade control box. By using these technologies we would be able to operate our ROV using a computer, which would be much easier than our current layout of a variety of switches. We would be able to use a joystick to control the movement of the ROV and the cameras could easily be worked into the Gadget Master. To make this a reality we would first need to learn how to use the software and then how to program the joystick. We have discussed the possibility of bringing in someone to teach us how to use the necessary software and would therefore use this in the future.

REFLECTIONS FROM THE TEAM

Laura Bonnell: Once again I have taken part in my school's robotics team and it still amazes me the knowledge I gain from this experience. I've learned how to use tools I never even knew existed. I've gained a new more creative way of problem solving, improved my teamwork skills, and become more aware of all that is available in the field of robotics. My mechanical and electrical skills have improved immensely as I have taken a more involved role in constructing this robot. Every year the MATE ROV competition allows me to improve many invaluable life skills.

Krista Collins: Having learned so much from last year's competition, I joined the ROV team again this year. I have thoroughly enjoyed being more involved with designing and constructing the robot and have learned how to use many tools. I have certainly improved my teamwork skills, problem solving abilities, and time management skills. Being a part of ROV provides me with a great sense of accomplishment because after many hours of hard work you finally have a fully functioning finished product.

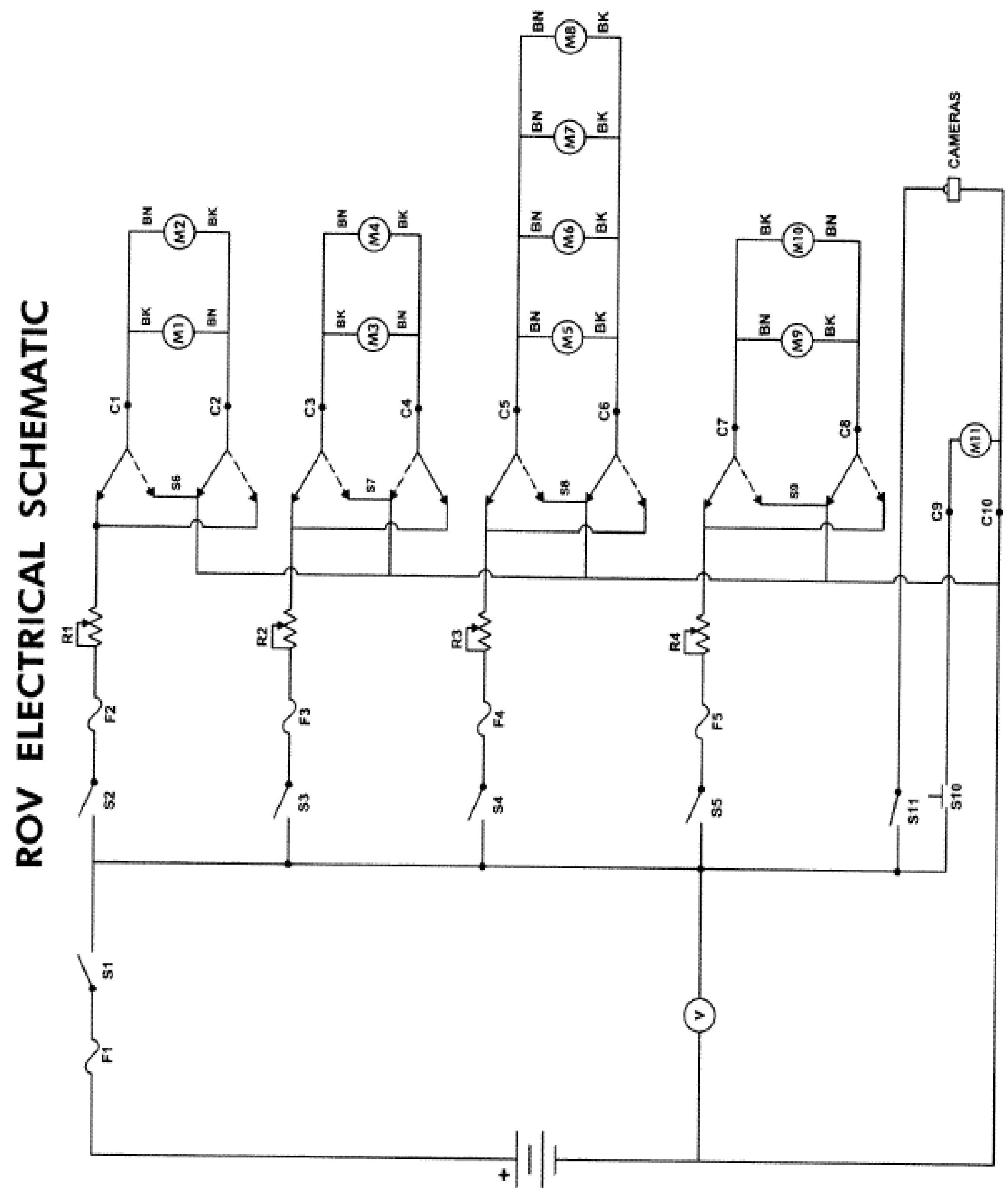
Heidi Kent: Through participation in this year's ROV project I have learned, above all, the importance of teamwork and time management. Together we have developed good time management skills which were required for such a large scale project. A lot of time and effort was put into the construction of our ROV and to finally be finished leaves me with a great sense of accomplishment.

Joshua Hawco: This is the first year of my involvement in ROV. Since joining ROV I have gained a new appreciation for the time and effort needed to make something like this. It shows that by working as a team, you are capable of accomplishing more than as an individual. ROV also offers a chance to experience new things, such as learning about the different structures involved, or using different tools to fabricate these things. It is not every day that you are able to incorporate modern science and engineering in order to accomplish tasks. Overall, ROV has instilled me with a great sense of pride and accomplishment because of the hard work we have put in.

Sarah Power: My first year being involved in the ROV team has been a great one. I've learned a lot about working with people and about robotics in general. I enjoyed brainstorming and trying different ways to do the different tasks. I hope to go to the competition this year and come out with a lot of experience and knowledge and to use it next year to make our team even better.

Daniel Sutton: Being a new member of the ROV team, I have learned a great deal. Working as a team has been a good experience and improved my skills in leadership, teamwork, designing and problem solving. Also working on such a time consuming project has showed me the value of time management.

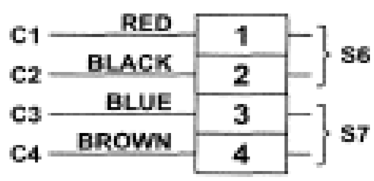
ELECTRICAL SCHEMATIC



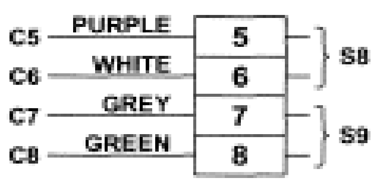
Electrical Schematic - Legend

LEGEND

M1, M2 - LEFT SIDE MOTORS
M3, M4 - RIGHT SIDE MOTORS
M5, M6, M7, M8 - UP / DOWN MOTORS
S1 - MAIN SWITCH
S2, S3, S4, S5 - SPST SWITCH WITH LIGHT
S6, S7, S8, S9 - DPST SWITCH
R1, R2, R3, R4 - VARIABLE RESISTORS
F1 - FUSE, 25 AMP
F2, F3, F4, F5 - FUSE, 15 AMP
M9, M10 RIGHT, LEFT MOVEMENT MOTORS
M11 - RELEASING MOTOR
S10 - PUSH BUTTON SWITCH
S11 - SPST SWITCH
V - VOLT METER



RIGHT SIDE
TERMINAL BLOCK



LEFT SIDE
TERMINAL BLOCK

C9 - LIGHT YELLOW
C10 - YELLOW

BUDGET

Item Description	Quantity	Unit	Cost/Unit	Total Cost (tax incl 13%)	Reused	Given
1/2” T-joint	3	EA	$0.87	$2.95	√	
3/4" 90-joint	2	EA	$0.60	$1.36	√	
Baskets	2	EA	$1.13	$2.26		
Large woggle	1	EA	$5.00	$5.00		
Small woggle	2	EA	$1.13	$2.26		
Lexan 3/16” clear	1	EA	$56.00	$56.00	√	
Wiring 25’	1	EA	$7.90	$7.90		
Heat shrink (pkg)	1	EA	$6.77	$6.77		
Flotation foam	1	EA	$1.13	$1.13		
1000 GPH motor	7	EA	$25.98	$205.50		
750 GPH pumps	3	EA	$22.59	$76.58		
Ty wraps (pkg)	1	EA	$10.00	$10.00		√
Epoxy 37mL	6	EA	$6.19	$37.14		
Camera	2	EA	$259.00	$518.00	√	
Tool box	1	EA	$14.68	$14.68	√	
One way switch	1	EA	$5.07	$5.07	√	
Variable potentiometer	4	EA	$5.59	$22.36		
DPST switch	4	EA	$5.59	$22.36		√
Green Switch	1	EA	$5.59	$5.59	√	
4 Fuse Panel	1	EA	$45.19	$45.19		
Plastic prop	10	EA	$14.00	$158.20	√	
Silicone	2	EA	$7.85	$15.70		
Monitor	1	EA	$170.00	$170.00		
Fitting Compression	1	EA	$1.62	$1.62		
PVC 3/4” joiner	3	EA	$4.44	$13.32	√	
Connector (male)	1pkg	EA	$10.16	$10.16		
Connector (female)	4pkgs	EA	$2.81	$11.24		
Sealant tape	1pkg	EA	$6.20	$6.20		
Tether 45’	1	EA	$450	$450	√	
RCA fitting	2	EA	$6.77	$13.54		
2” central vacuum PVC	1	EA	$5.64	$5.64	√	
2” end cap	6	EA	$1.80	$3.60		
3/4" PVC pipe	N/A	EA	$20.00	$20.00	√	
2” ABS piping 22cm	N/A	EA	$3.00	$3.00	√	
Screws	35	EA	$0.17	$6.00		√
Poster board	1	EA	$11.30	$11.30		√
Camera mount	1	EA	$45.14	$45.14	√	
2” PVC 45-Joint	1	EA	$1.12	$1.12		
TOTALS:				$2275.96	$1478.95	$49.66
TOTAL expense:				$645.19		

	Travel	Accommodations	Food	Other
Churchill Falls to Goose Bay	$250			
Goose Bay to Halifax	$1400 x 8 = $11200			
MMA Dorms in Buzzard's Bay		$500		
Hotel in Boston		$400		
Van Rental Boston	$1000			
7 Days of Meals			$250 x 8 = $2000	
Total:				$15350

Revenue:

Marine Institute: $4500
School: $7000
Parents & Students: $4495.19

Total $15 995.19

Expense Total:

ROV and components $645.19
Travel costs $15350

Total $15995.19

REFERENCES

"*Build Your Own Underwater Robot and Other Wet Projects*"
by Harry Bohm and Vickie Jensen

ACKNOWLEDGEMENTS

Eric G. Lambert Robotics Team has many people to thank, all of which contributed to *Poseidon ROV* and our participation in the MATE International competition once again this year. First of all a big thank you to CFL(co) for sponsoring us on our trip to Massachusetts and providing us with many of the necessary materials for building the submarine and our ROV. Also we would like to thank the Marine Institute and our school for sponsoring us. A special thank you to the electrical and mechanical engineers, who were our mentors, for supervising, helping us with wiring, and the construction of the ROV.

APPENDIX A : SKETCHES OF *POSEIDON ROV*

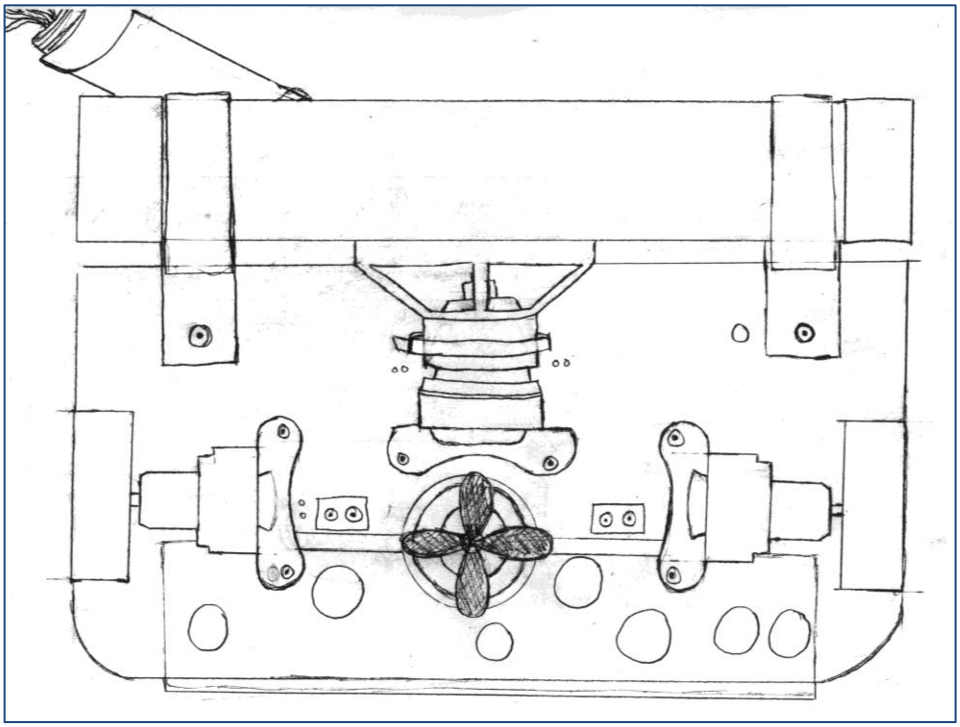


Figure 15 Side view sketch of ROV

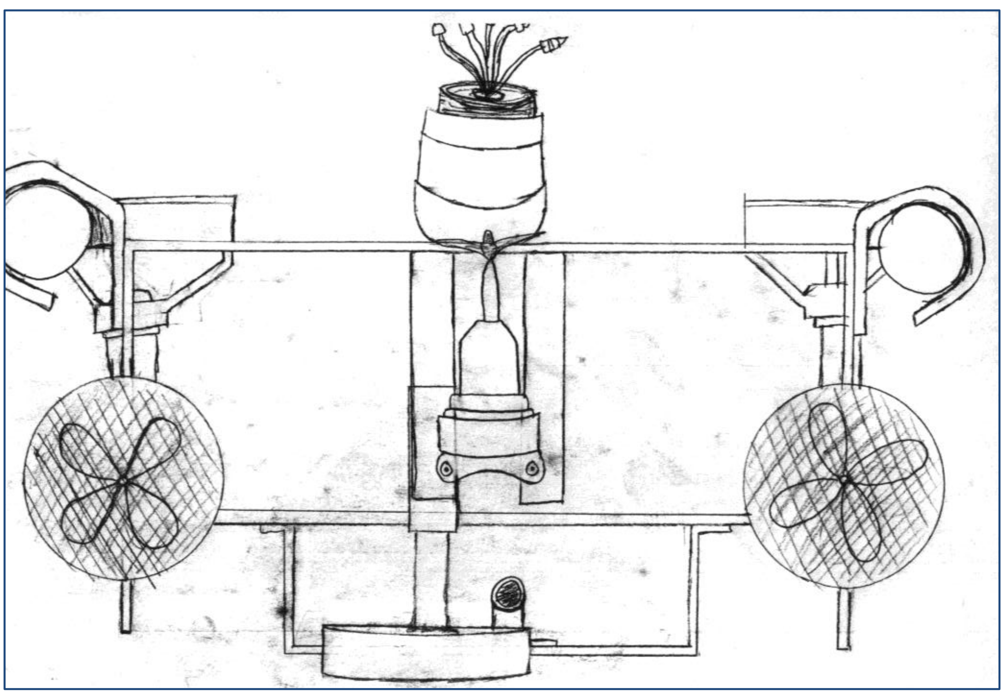


Figure 16 Front View of ROV

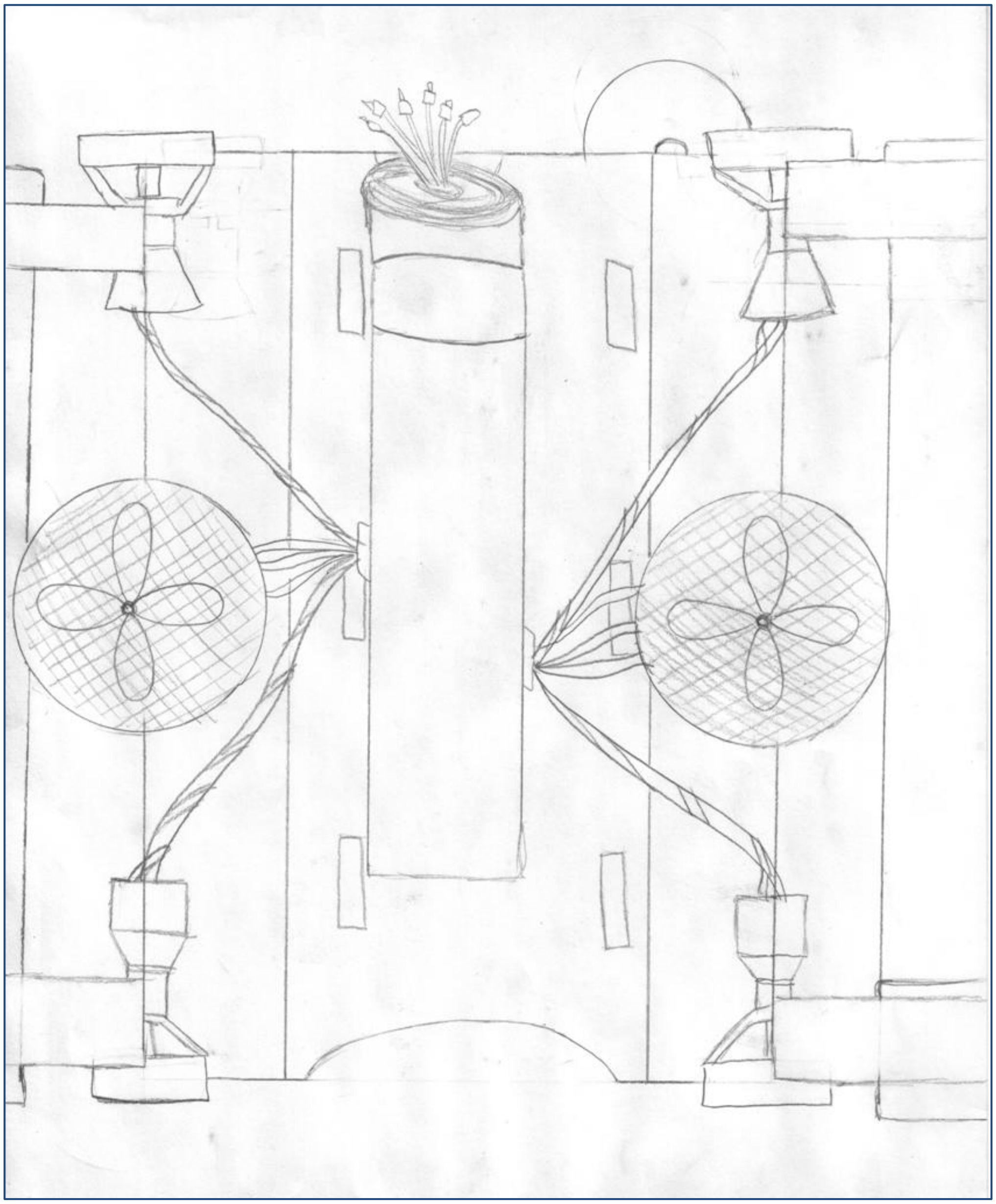


Figure 17 Top view of ROV