Technical Report

Ranger Class

Submitted by:

Eric G. Lambert Robotics Team

Eric G. Lambert School

Churchill Falls, Newfoundland and Labrador

ROV

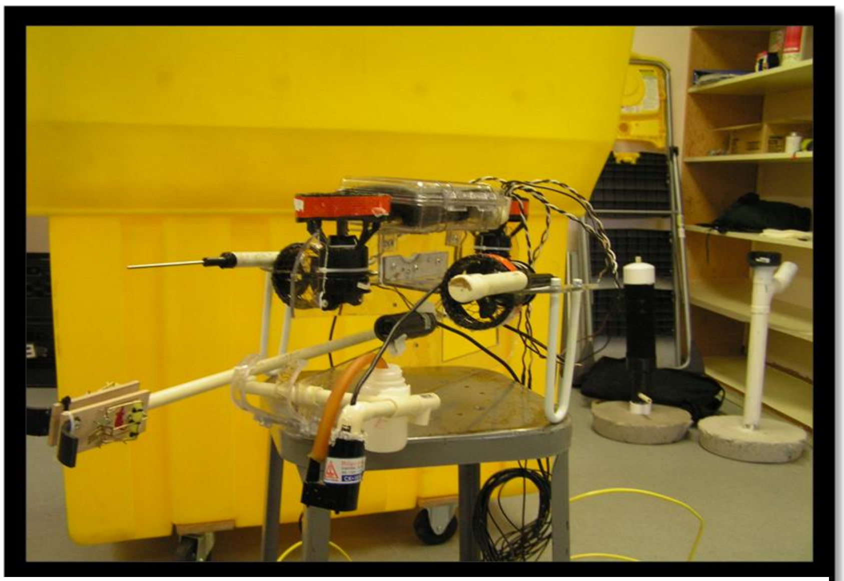


Figure 1: Completed Underdog ROV

Mentors:

Barry Noble	Instructor
Krista Collins	University Student
Spencer Collins	Electrical Engineer

Team Members:

Name	
Riley Edwards	Grade 11
Joshua Burt	Grade 11
Shane Collins	Grade 10
Andrew Loder	Grade 10
Chantelle Flynn	Grade 11
Emily Bonnell	Grade 10

Table of Contents

I. Abstract

This year the Eric G. Lambert Robotics Team is composed of all new members. We are a younger team and had no previous experience in building an underwater ROV. We wanted to construct an underwater robot that would be able to complete all the tasks at the 2010 Ranger class International ROV competition. This year, making our ROV lightweight was a specific goal for our team. We discussed many ideas for the frame and decided to use Lexan in the shape of a wing that would be able to support all our task specific devices. Lexan is lightweight, which is what our team was aiming for; a lightweight frame. The bar across the bottom, made out of ¾" piping, supports all our task specific devices. The devices are interchangeable with the pipe so that when we bring our ROV to the surface we can change the devices used. This makes our ROV lightweight because not all the task specific devices have to be on it at the one time. It also is convenient for travel. We live in Labrador and have a long way to go to get to Hawaii. As always, the team had help from others as well as from our mentor; we had an electrical engineer and a university student help us as well. In the following report you will read how we built and operate our ROV, challenges we encountered, the lessons we learned, troubleshooting techniques, improvements that we could make to our ROV in the future, the investigation of the Loihi Seamount, our budget, reflections from our experience, and pictures to go along with the report.

II. Design Rationale

a) Safety

Safety is an important aspect in completing any job and building this year's R.O.V is no different. Working in a lab can be dangerous, but wearing safety equipment and proper clothing takes away much of the risk. When working in the lab, especially when working with machinery our team wore safety glasses and gloves were a required piece of equipment when operating machines. Our team made sure they wore shoes with a closed toe in the lab and the girls on our team pinned back there hair. As well, the clothes that were worn in the lab were never baggy. We weren't the only ones being safe in the lab. Our robot's frame does not have sharp corners; we have cut the corners to be rounded. As well, our thrusters have orange tape that says danger on them. Our team wanted to make sure that we had the safest working environment possible along with a safe robot.

b) Frame

We designed the frame of our ROV to be small and lightweight, yet have all the task-specific devices attached to our frame (Figure 2). Once again, the Eric G. Lambert School R.O.V team designed the frame out of Lexan. Lexan is lightweight and sturdy, which is why we chose to use it. Because Lexan is not easily accessible in Labrador and once you cut it, it can't be changed, we made a mock-up of the frame using tape and an uncut piece of Lexan (Figure 3). Next, we removed the taped-on thrusters and mock task devices and measured where we would cut the Lexan to fit in the underwater camera and thrusters. Two of the thrusters were cut out from last years robot's design in rectangle pieces and are mounted on the sides. The other two thrusters have been cut to fit into the top of the Lexan. The camera is placed in the centre of the main frame where it can see all of the task-specific devices and it's weight could be easily buoyed up. The main float is above the centre of mass of the robot. This allows the Centre of Buoyancy (COB) to be high and the centre of mass to be low and below the COB. Small amounts of rigid foam and some weights were used to level out any unevenness in flotation. Finally, with this arrangement, we were able to achieve neutral buoyancy for our robot. This arrangement

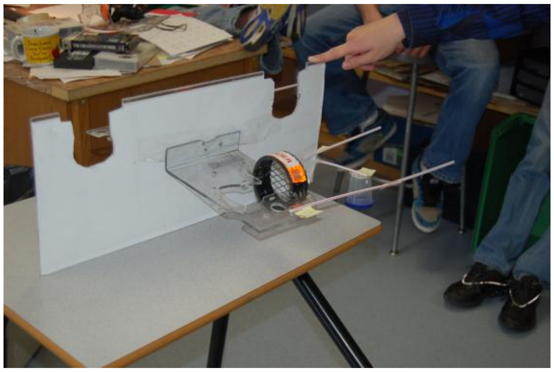


Figure 2: Mock-up side view.

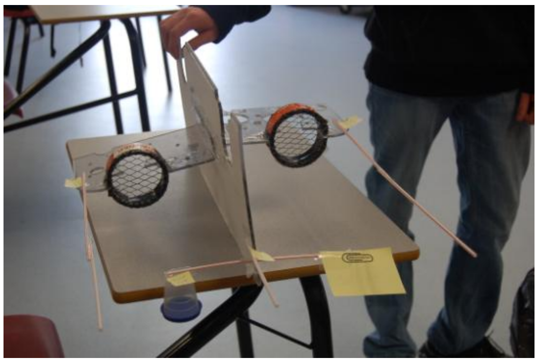


Figure 3: Front view of mock-up shows where all the task specific devices will go.

gives our little *Underdog* great agility under water. The task-specific devices are on each side of the frame, in order to keep balance. Another feature of our robot is that the middle of the Lexan is cut out. This makes our robot lighter, and easier to move in the water.

c) Control System

Instead of the hard wire control system used in the past years, our ROV team decided to use a five channel Remote Control (RC) system. Four channels are used to control the movement of our robot through two dual channel motor controllers. The fifth channel is used to control a relay switch, which in turn, controls our bacteria bilge pump. We chose to do this so there will be fewer wires contained in our tether, therefore making the design lighter. Since the radio control system (Figure 4) does not work well under water or at the air to water interface we have found a method that will allow our system to work while underwater. The system was originally designed to work through the air. The receiver picks up the commands from the remote control . These commands travel from the receiver to the Sabertooth 2x10 Motor Controllers (Figure 5) located in the watertight box (Figure 6). But, since our robot is an underwater robot, we had to make some further adaptations. Instead of the signal travelling through the air and water, it travels via a solid conductor in the tether down to the robot. There, it is transmitted to the receiver (Figure 7), which, in turn, controls our robot through our RC motor controllers. The wire then goes from the tether to the receiver. The receiver is in a watertight box (Figure 8) on the top of our robot. The cable connecting the receiver to the Sabertooth 2x10 motor controllers gives the commands to the thrusters (Figure 9). The Sabertooth 2X10 is able to operate under various modes of input information.

Sabertooth 2x10 specs

Input voltage: 6V-24V

Output current: 10A with a Peak Output current:15A

Operating modes: Analog, R/C, Serial

The input of 12volts is suitable for our needs; also, the output current per channel is suitable since our bilge pump motors only require 6.0 amps each. Finally, our operating mode must be selected. It must be set to the correct operating mode before use. This is accomplished through a series of dip switch settings located on the board. Figure 8 indicates the correct dip switch settings for our system.

The R.F radio transmitter then controls the robot's movements. There are two joy-sticks that direct the movements on the controller. When the joy-sticks are up *Underdog* moves forward; when they are pointed back, the robot moves backward. When both joy-sticks are pointing to the left the robot moves up and when both joy-sticks are pointed to the right, *Underdog* moves down. When one joy-stick is forward and the other joy-stick is back, the robot turns.

Figure 4: Remote Control System

Figure 5: Remote Control Receiver

Figure 6: Water tight box

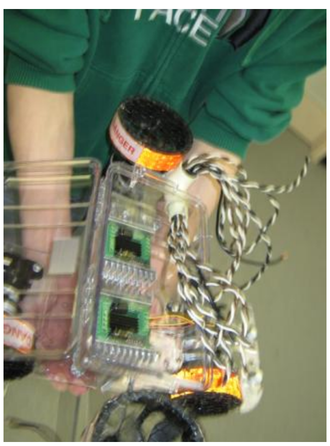


Figure 7: Watertight box with motor controller

Figure 8: Sabertooth 2x10 *motor controllers*

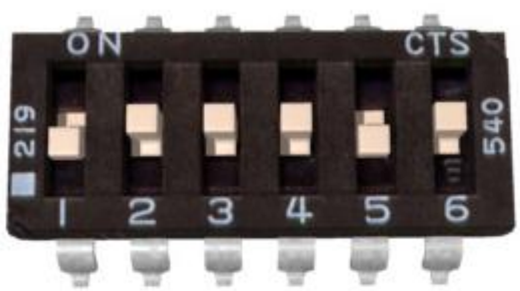
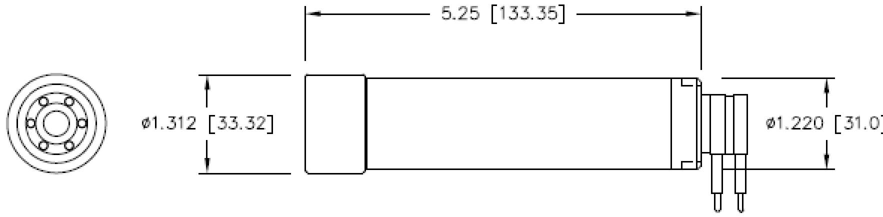


Figure 9: Radio control, dip settings

d) Camera

This year our R.O.V team decided it was not necessary to use two cameras. In order to aid us in building a small, efficient ROV for the task challenges. We used one underwater digital camera (Figure 9). It is a high quality, compact color video camera with integrated lights for underwater and dimly lit environments. This was the perfect choice for our cave task. It is placed in the middle of our frame for stability purposes, which also let the camera see all the task specific devices. The camera provides a clear view for the operator so he can see what he is doing and where he is going.

Figure 9: Camera used in robot.



e) Thrusters

Four 1000 GPH bilge pump motors enable *Underdog* to move quickly and efficiently. Two of the motors are mounted on top of the robot for up and down movement. The motors on either side are used for back and forth or turning motions. The thrusters are mounted on the top to give it balance (Figure 10). The thrusters on the top are also needed for power when lifting the robot. On either side of the wing design, there are thrusters that give *Underdog* the ability to turn (Figure 11). Fewer of thrusters have been used in order to make the robot more lightweight. Still, with four thrusters it can complete all the challenges. Safety is always thought about while working; the thrusters are no exception. Bright-orange tape that reads “danger” have been placed on the thrusters. As well there is wire mesh that has been epoxyed to the outside of the thrusters (Figure 12). The propeller selected is a 4 –blade, 70mm diameter, -35mm pitch plastic prop with a 5mm brass adaptor for coupling to the bilge pump shaft.

Figure 10: Thrusters on top.

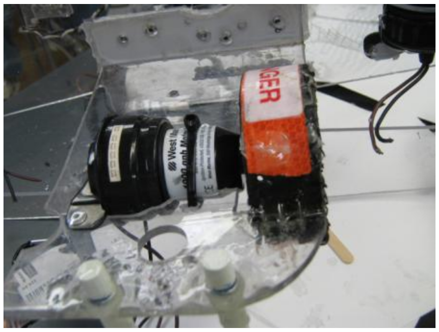


Figure 11: Thrusters on side.

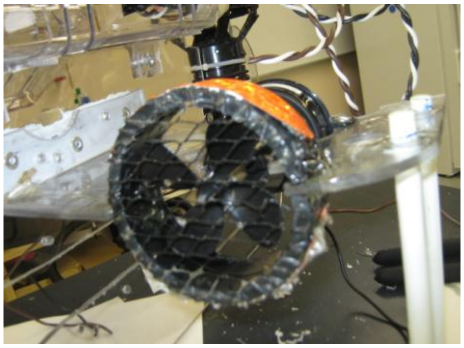


Figure 12: The epoxyed, mesh on the outside of the thrusters. 4-blade prop shown

<u>f)</u> **Tether**

Once again this year, with a new team came up with a different idea for the tether. We designed a new lighter weight tether (Figure 13). The power source has 6 cables connecting the tether to our ROV. The cables do five jobs; one cable for the underwater video camera, another cable for the temperature probe, two for power for our ROV to move, another cable for our control system and a final cable for our hydrophone.

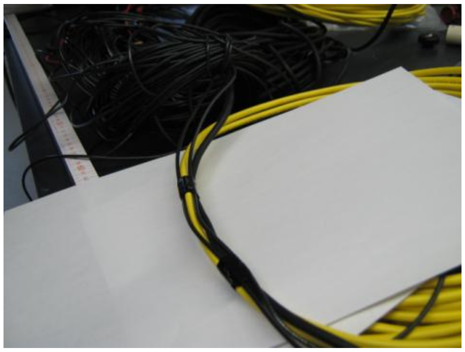


Figure 13: The tether.

<u>g)</u> **Mission Oriented Devices**

<u>Task 1: Resurrect HUGO</u>

To complete the challenges more efficiently in a shorter time we decided to identify which site the rumbling sound comes from first. We used, an electric microphone and a canister made of 3/4" piping with an end cap filled with mineral oil to make our standard microphone a hydrophone (Figure 14). To ensure, that it was waterproof, we used epoxy and heat shrink to seal the caps. Then, with the use of the claw made out of Lexan installed at the bottom of our R.O.V (Figure 15), we pull the pin to release the HRH from the elevator. Still using our claw, we pick up the HRH and then place it at the site where the rumbling comes from. We remove the cap from the HUGO junction box, and retrieve the HRH power/ connector from its holder with the claw, bring it over and insert it at the HUGO junction box. At this point, task one is complete.

Figure 14: The hydrophone.

Figure 15: The claw designed out of Lexan.

Figure 14b: Hydrophone with venier.

Task 2: Collect Samples of a New Species of Crustacean

The Scoop attached to the front of *Underdog* (Figure 16) is designed to pick up the crustaceans. The ROV enters the cave proceeds to the back wall and manoeuvres the scoop along the wall to collect three or more crustaceans. Then the ROV backs out of the cave, with the crustaceans safely in the mesh, and returns the crustaceans to the surface. Task 2 is now complete.

Figure 16: The scoop used to pick up crustaceans.

Figure 17: venier and temperature probe.

Task 3: Sample a New Vent Site

First we used a stainless steel temperature probe waterproofed with heat-shrink material (Figure 17)

This probe allowed us to measure the temperature of the venting fluids at three different heights. The temperature probe is connected to the vernier Labpro interface, data collecting system. The Labpro is capable of monitoring six channels (Figure 18) that can collect data simultaneously.

Figure 19: six input channels

Four analog channels are available for over 50 different sensors including temperature and sound. Two digital channels are dedicated to motion detectors, photogates, radiation monitors, rotary motion sensors and drop counters. Two analog channels are used to monitor temperature and sound. The software package used to interpret the data was Logger *Pro* from vernier labs. The software is capable of integrating real-time graphing, with a continuous real time display of incoming data.

This device takes the information from the temperature probe and creates it into a graph on our computer for the judges to view. **(**Figure 20)

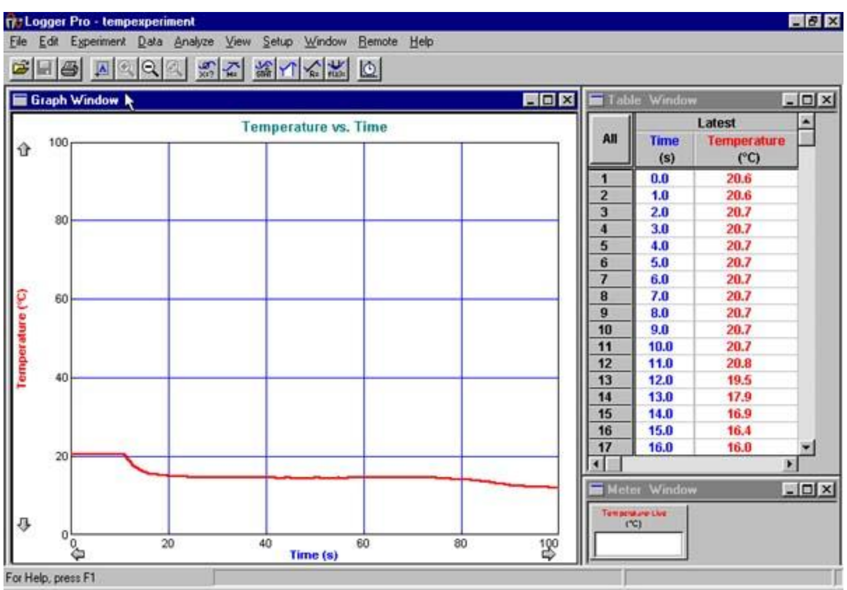


Figure 20
Temperature window

For the second part of this task, we have designed a simple device to sample the vent spire. It was made with two mouse traps that are designed collapse over the spire and hold it for retrieval (Figure 21). The Device snaps shut on the vent spire and pieces of a foam slow the motion of the trap's spring and help to secure the column in place. Two traps were constructed so we would have a backup if the first attempt failed.

Figure 21: Task Specific device to pick up the PVC pipe, top view.

Task 4: Sample a Microbial Mat

For this task we used a bilge pump activated by a remote double pole switch relay (Figure 22) housed in a waterproof container. A tube is connected to the pump which leads into a cup that is epoxyed shut to collect the bacteria sample (Figure 23). The bilge pump transfers the agar into the tube and fills the cup to the specific level. Then the cup is returned to the surface. Task 4 is now complete.

Figure 22: Dimension Engineering DoubleSwitch Radio Controlled Relay

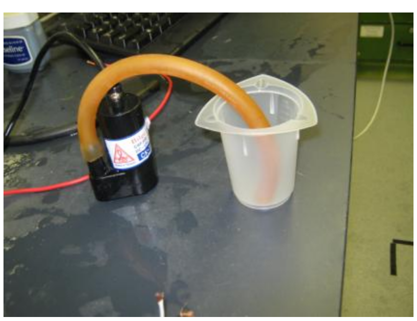


Figure 23: bilge pump connected to cap.

III. Overcoming Challenges

Working with more than one person on a task is always difficult; different thoughts and opinions may cause disagreements. Our group this year did not let the different personalities affect the group's work. We all managed to put our ideas together and come up with a robot idea and task-specific devices to complete all the challenges given to us.

Along with our different personalities, we all have different and busy schedules to work around. Finding the time to invent and construct our ROV was not easy. The group found some afternoons that worked for everyone. Also, some nights we needed to be down at the lab. Everyone realized the responsibility needed to build *Underdog* and had to make some sacrifices with their own schedules in order to complete this R.O.V.

Living in a remote part of Labrador caused challenges in getting the materials needed to construct Underdog. We needed to figure out everything that was required to construct our robot. If we didn't plan in advance, we might not get the materials needed in time to build our robot. Whenever a team member went out of town, they brought something back that would help us build our robot. Many things were ordered in advance as well. If a part didn't come in, we'd have to find new ways to adapt something else to perform the same function. Some of the materials were reused, but had to be tested in advance to make sure that they still worked.

Waterproofing our ROV proved to be a problem, just as it has been in past years. Our watertight box on the top, which contains our saber-tooth motor controls, was not 100% waterproof the first few times that we tested it. We decided to epoxy it shut to keep water out.

Finding an effective way to pick up the agar was another challenge. Our team made the agar solution and tested various ways we thought would work. The method that we found worked the best was the bilge pump connected to a tube connected to a cup.

Whatever the challenge was, our team overcame it with support from our mentors and each other. We always found a solution.

.

IV. Troubleshooting Techniques

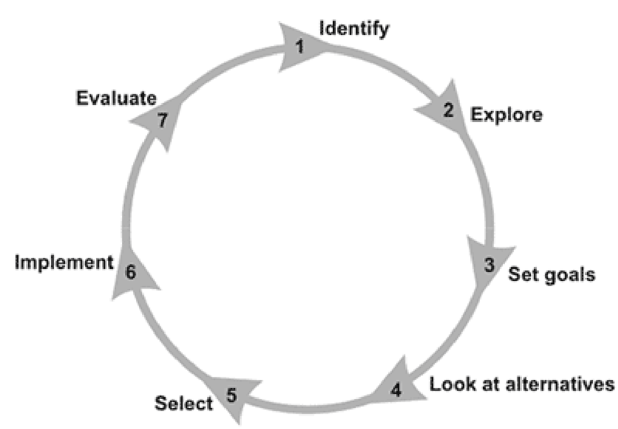


Figure 16: Problem solving diagram

In constructing *Underdog,* our team took all the necessary precautions to ensure that things would run smoothly. For example, we tested all the motors to see which ones worked best with which props and to ensure that output was the same for ones that had to work together. Since our robot was already small and light, there wasn't much need for disassembling it for travel. As well we tested to make sure our underwater video camera was in working order and the screens with it worked properly. We tested all of our task-specific devices to make sure they are able to complete the task given. This included testing the microphone used to make the hydrophone to make sure it could detect sound and testing the temperature probe, as well as the mousetraps used to collect the pipe samples. Everything had to be tested or we would not know if something was not working properly.

Figure 16 shows the problem solving method we used. First, we came up with the idea. Then we had to test the idea to see if it worked properly, set a goal for when we want the task completed, and explore additional options, so that we would always have a plan b. We had to choose which way will work best for our task, complete all the work within our chosen goal, and finally, evaluate whether it was the best decision to make and whether there could be improvements. The ROV team this year used this wheel of thought for nearly every task we completed.

V. Lessons Learned

The Eric G. Lambert Robotics Team has learned many lessons and gained various skills over this year as we designed, constructed, and operated our ROV. First of all, we educated ourselves on these missions, Loihi Seamount, and underwater robots by conducting a large amount of research. Through the internet we looked at different designs to get an idea of which ones are more common, seem to work best, or tend not to work well.

The team also learned that it is very important not to act on impulse. Important decisions need to be discussed by the whole team to ensure that materials and, most importantly, time was not wasted. We learned to discuss problems and let everyone have a say instead of wasting precious time arguing.

With regards to the actual building of the ROV, we gained much experience with the various tools used for cutting and assembling, electrical set-ups and soldering. Some of our team members didn't even know what a number of the tools we used were at the beginning of the year. Now we have all become skilled at drilling holes, using epoxy, and how to solder wires together and seal them with heat shrink. Above all, we've learned that it is extremely important to work together as a team. Altogether, this ROV has been a rewarding experience for all team members.

VI. Future Improvements

Even though *Underdog* may be able to complete all the necessary tasks, that does not mean it is perfect. One improvement that can be made is the overall appearance of our robot. Due to time constraints we were not concerned about aesthetics this year. To make the robot more appealing, we would need to be tidier when gluing or epoxying. Most of the frame was built new, although the wings where the left/right motors are attached were re-used from last year.

More cameras would not go to waste, as they would assist the operators with depth perception. We currently have one camera angled so that we have a view of all the task-specific devices, allowing us to see what we are doing during the missions. Since this camera does not provide different angles of the same piece of equipment, the operators must look at things in 2-D and use trial and error to complete the tasks. At least one more camera would be beneficial and two more would be ideal. With three-four or 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 a R.F. Radio Control. By inserting a chip we would be able to operate our robot using a computer through these technologies. This microchip could also detect temperatures and sound. We would first need to learn how to use the software, possibly by bringing in someone to teach it to us. That would make it a reality in the future.

VII. Reflections from the Team

Emily Bonnell: Joining the ROV. team this year has taught me time management skills, responsibility, how to work with other people, and how to construct a robot. I came to the group knowing nothing about the construction of a robot and have learned a lot. I've gotten a taste of working with electrical systems, solving challenges, designing new devices, and the construction of a ROV. I've enjoyed this learning experience.

Chantelle Flynn: When I first joined ROV, I had very little knowledge about all the teamwork, time, patience, and organization skills it took to build a robot. I have always had some interest in careers that involves working with my hands, and now know that I do want to pursue a career in hands-on field. The time put into building this robot and into solving challenges was definitely worth the experience. I think the skills I've learned will be useful later in life.

Andrew Loder: During the process of building the robot, I learned how it is important to come up with a design and know how to wire it. I enjoyed building the robot the best and that may be my career choice in the future.

Joshua Burt: Throughout this year working with the ROV team, I learned a lot about teamwork skills. If everyone does his or her part, everything goes smooth. A lot of patience and hard work is needed to complete a task like this. Personally, I think it was an excellent experience and I had a lot of fun working on the robot and working with my teammates

Riley Edwards: Throughout the year, I have learned so much about the engineering, and fabrication of remotely operated vehicles. Also, this project has taught me many important teamwork skills that can be used in every aspect of life.

Shane Collins: During this experience I have learned many new ways of doing things. We have had to overcome many problems as a team, which has lead to us being able to work together better. Under water robotics has always interested me and I hope to use what I have learned in post secondary education.

VIII. Investigating The Loihi Seamount

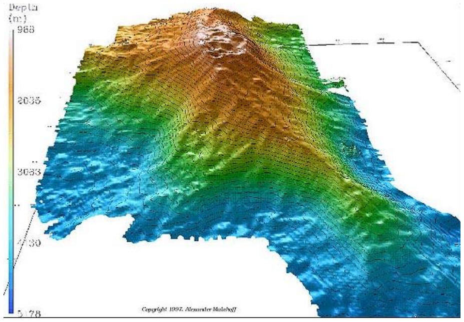


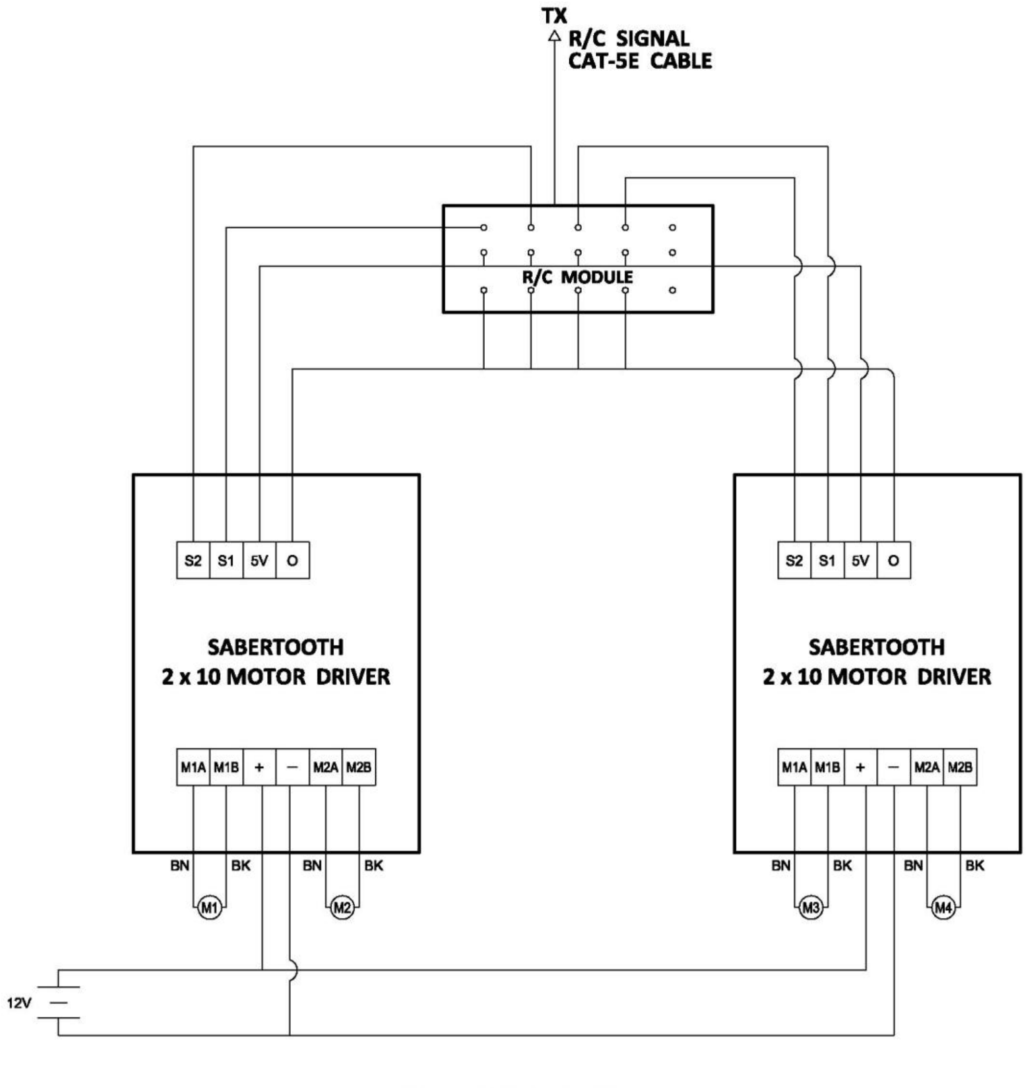
Figure 17: Loihi seamount

Loihi seamount today is an active volcano (Figure 17). Before the 1970s it was not seen as an active volcano. It was thought to be just another seamount like the numerous ones near Hawaii. These ideas quickly changed with an expedition for sampling purposes was done in 1978 to the Loihi seamount that revealed Loihi was actually an active volcano. In 1996, the volcano erupted making this the first eruption recorded from the seamount.
October of 1997 the University of Hawaii deployed HUGO (Figure18), an underwater submarine that would record the information of any changes at Loihi.

This relates to what our group is challenged to do. We built an underwater ROV that has to collect data and give the data to our computer above the water. Just as the University is taking the data that HUGO gives through fiber optic cables and delivers the information above the surface of water. We, as well, use underwater cables that deliver the information we need.

Figure 18: HUGO *Underwater submarine*

IX. Electrical Schematic



M1 - RIGHT SIDE MOTOR

M2 - LEFT SIDE MOTOR

M3 - FRONT UP / DOWN MOTOR

M4 - BACK UP / DOWN MOTOR

X. Budget

Item Description	Quantity	Unit	Cost/Unit (tax incl 13%)	Total Cost	Reused	Given
Temperature Probe	1	EA	$38.00	$38.00		
Microphone	1	EA	$51.00	$51.00		
3/4” 90-Joint	2	EA	$0.70	$1.40		
Coat hanger	1	EA	$1.00	$1.00		
Water Tight Container	1	EA	$26.00	$26.00		
½” PVC pipe	N/A	EA	$20.00	$20.00	√	
Heat Shrink (pkg)	1	EA	$6.77	$6.77		
1000 GPH motor	4	EA	$25.98	$103.92	√	
Lexan 3/16” Clear	1	EA	$56.00	$56.00	√	
Camera	1	EA	$259.00	$259.00	√	
Plastic prop	4	EA	$14.00	$56.00		
PVC ½” joiner	1	EA	$4.44	$4.44		
Monitor	1	EA	$170.00	$170.00	√	
4000 GPH Pumps	4	EA	$35.00	$35.00		
Tether	1	EA	Donated	Donated		√
R.F. Radio Control	1	EA	$150	$50		
Sabertooth 2x10 Motor Control	3	EA	$80.00	$240.00		
Ty Wraps (pkg)	1	EA	$10.00	$10.00		
Epoxy 37ml	6	EA	$6.19	$37.14		
Slilicone	2	EA	$7.85	$15.70		
Coax power jack	1	EA	$4.51	$4.51		
Connector (male)	1pkg	EA	$10.16	$10.16		
Connector (female)	4pkg	EA	$2.81	$11.24		
Sealant tape	1pkg	EA	$6.20	$6.20		
RCA fitting	2	EA	$6.77	$13.54		
2” central vacuum PVC	1	EA	$5.64	$5.64		
R.F. Two-way switch	1	EA	$50	$50.00		
				$1,283.66	**$608.92**	**N/A**
Subtract Reused and Donated				**$608.92**		
Total ROV Build Cost				**$674.74**		

Trip:

	Travel	Accommodations	Food	Other
Churchill Falls to Wabush	$250			
Wabush to Montreal (7 Plane tickets)	$8,386			
Montreal to Hawaii (7 Plane tickets)	$8,400			
Hotels - 3 for 4 nights (KOA/Hawaii/Honolulu)		$2,160		
UH HILO		$800		
Van Rental (Hawaii/Honolulu)	$1,400			
10 Days of meals for 7 people $80/day			$5,600	
Total:			**$26,996**	

Revenue:

Marine Institute: $10, 000
Nalcore: Hydro Company $9,910.64
School $9,910.64
Parents & Students $7,760

Total $27,670.64

XI. Acknowledgements

The Eric G. Lambert Robotics Team has many people to thank. First we would like to thank Nalcore for donating some of our materials to build *Underdog* as well as helping pay for the travel expenses to Hilo, Hawaii, and well the Marine Institute, Eric G. Lambert School, and our parents were sponsors to make this trip possible. Also, thank you to Nalcore for allowing us to use the pool for practices, and, of course, the pool staff for allowing this. Thank you to Eric G. Lambert School for allowing us to use their science lab. Acknowledgements go to the University of Hawaii at Hilo for hosting the 2010 MATE International ROV Competition and giving us all the information needed to complete this ROV. As always thanks to our mentors for all their time, support and guidance. As can be seen we owe many thanks to everyone who made this trip possible.

XI. References

- http://www.soest.hawaii.edu/HUGO/about_hugo.html
- http://www.soest.hawaii.edu/GG/HCV/loihi.html
- http://www.tos.org/oceanography/issues/issue_archive/issue_pdfs/23_1/23-1_staudigel5.pdf
- http://www.drgeorgepc.com/volcLoihiSeamount.jpg
- Investigating Loihi