

Technical Report

Ranger Class



Inuksuk High Schools

Volcon 626

Team North Robotics



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Team North Robotics



Team N.O.R.T.H Members:

(Top Row) Ben Westwell, Louis Lebel Wong, Duncan Mackay, Zachary Cousins, Aaron Frasier Eric Blair,

(Back Row) Steve Carter, Anthony Tucker, Elle Crawford, Jacklyn Eaton, Jessamyn Mallory, Alan Heath.

Mentors:

Steve Carter ((Bottom Left)

Figure 1: Team North Robotics Team Picture with New Jackets.



Team North Robotics



Abstract

The tech report is an outline of what occurred throughout the entire school year in order to make this process a success. The main aspects included ROV frame building, tool building and fundraising.

To build the necessary tools we had to scope each individual task. The tasks include 1) Resurrect HUGO by placing HUGO near the seismic activity and restore power 2) Collect a new sample of crustaceans 3) Sample a new vent site and record temperature, collect samples and 4) collect samples of a bacterial mat.

As the ROV was being constructed we had to get out in the community and fundraise enough money to accommodate 12 group members and two mentors. This year fundraising was a challenge. The large amount of money needed to take 14 members and the increase of fundraising in the area made it difficult to raise the required money. However, this was not the biggest challenge our team had to face. Having such a large group we decided to work in smaller groups with different tasks. When completed we all came together, only to find out we had some major gaps to fill. In the end it came together as we work as a team to complete the ROV.

Team North Robotics



1. BUDGET AND FINANCIAL STATEMENT

Table 1. Total cost of materials and travel to competition.

| Item | Donated | Cost to Team North |
|---|---------|---------------------------|
| <u>Robot supplies</u> | | |
| Motors X 6 @ 35 each | | \$210 |
| Sheets of Lexan | | \$400 |
| Tether with Ethernet connection (Leoni Elocab) | \$1200 | 0 |
| Subcon underwater connectors | | \$5000 |
| Cameras X 2 @ 1500 each | \$3000 | 0 |
| Underwater servos 5 @ 25 dollars each | | \$100 |
| PVC pipe (1/2," 2/4", 1", ect) | \$200 | 0 |
| Phidgits, sensors, SBM, ect | | \$1000 |
| Miscellaneous gripper, gear, and prototype supplies | | \$1000 |
| <u>Travel:</u> | | |
| Airfare from Iqaluit to Hawaii | | \$28,000 |
| Hotels in Hawaii | | \$5000 |
| Meals | | 5000 |
| Ground Transportation | | \$2500 |
| Activities in Hawaii | | \$2500 |
| Clothing | | \$3000 |
| Total | \$4400 | <u>53,710.00</u> |
| <u>Total Costs</u> | | <u>\$58,110.00</u> |

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Table 2: Total contributions to Team North Robotics Team

| | |
|--|------------------------|
| Raffle | \$11,000 |
| Support Dinner | \$2,000 |
| Student contribution (14 * 500) | \$7,000 |
| Toonie Draw | \$1,700 |
| Sponsorship iSPY Program | \$5,000 |
| Kakivak funding agency | \$9,700 |
| Saving from prior years | \$10,000 |
| Legion | \$2,500 |
| Donations | \$4,400 |
| Canteen Sales | \$1,000 |
| <u>Total</u> | <u>\$54,300</u> |

2. DESIGN RATIONALE

2.1 Structural Frame

2.1.1 Frame: In previous years our team has constructed the frame of our ROV out of 1.25 cm PVC pipe. Team NORTH used this material because it is readily available and can be easily cut into the shapes and sizes we needed for our designs. PVC is also strong, and easy to attach to other parts of the ROV. But PVC was limiting because it is heavy (requiring two screws to secure each connection) and created a significant amount of drag (which require stabilization wings to correct). In 2009 we adopted a new Lexan frame. It proved to be much lighter and streamlined then previous PVC frames. Our new Lexan frame is far superior to PVC frames of past years because it presents a virtually nonexistent forward profile. Lexan is lighter and with our bender we are able to manipulate it into almost any required shape (be it the frame, tools, or a mount for the camera). The shape of the frame is a square with a protruded tale. This provides a top heave frame and makes it hard to tilt from side to side. The bottom is connected by two supports cross joices providing rigidity. The

frame has many pieces removed to reduce weight. This also provides superior water flow in both top to bottom and left to right directions.

2.1.2 Buoyancy: The material we used for buoyancy is high-density Styrofoam insulation. We cut the Styrofoam into pontoons located in the upper section on either side of the main structure. This location serves to keep the ROV stable and is important in precision driving. The Buoyancy also serves as a safety measure to further shroud the vertical thrusters. Lastly, the location allows for maximum viewing for the cameras by keeping the buoyancy out of the camera's way. All tools are place inside of the cube design while the buoyancy is place on the outside thus maximizing the viewing of the tools.

2.2 Propulsion:

For propulsion, our ROV uses 6 4.2A Johnson 1250 GPH bilge pump thrusters. 2 mounted vertically inside of the pontoons, and 4 mounted horizontally. We discovered, while installing our horizontal thrusters that the propulsion in each direction (forward/backward) was not equal. To deal with this issue, we mounted each set of horizontal motors facing each other but on different levels to prevent backwash from interfering with the other thruster. With this new design, there is equal propulsion in each direction allowing our ROV to navigate at a constant velocity in both the forward and reverse directions. All of our thrusters are mounted on the exterior of our ROV. This gives us all of the interior space for tools. Our thrusters were placed in such am manner to allow us to fit directly over the agar sample.

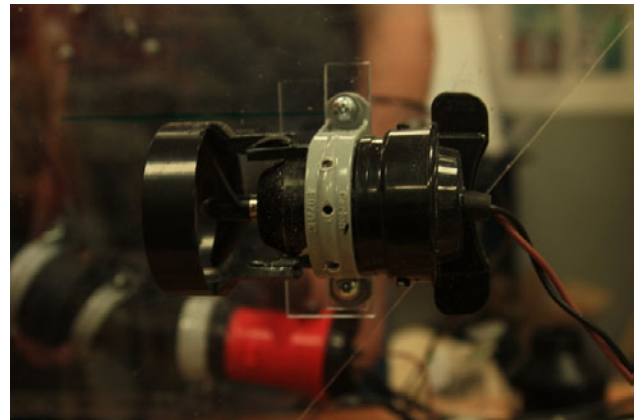


Figure 2: 1250 GPU thrusters with shroud

Our reasoning for incorporating more horizontal thrusters into our design is simple; we believe that horizontal motion takes priority over vertical motion. Installing 2 vertical thrusters allowed us to save money, and redirect power to utilize a second *Inuktun crystal cam* camera making the completion of our tasks more efficient.

2.3 Camera:

We used two high quality, low-light Crystal Cam cameras donated by Inuktun. They are .635cm color CCD cameras. These cameras have a 3.6mm lens that give a horizontal field of view of 41°. These cameras have 12 high intensity LED's to provide lighting. They are qualified for use up to a 300m depth.

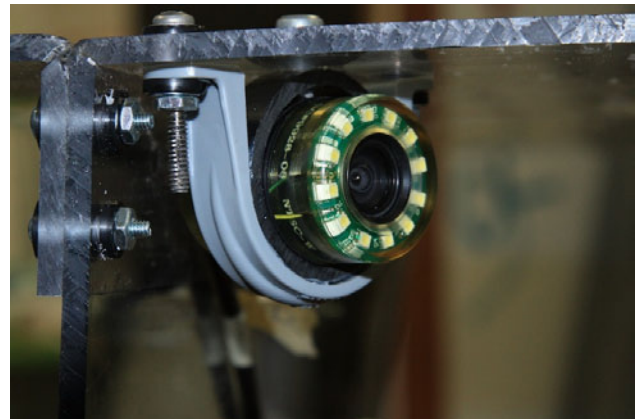


Figure 3: Inuktun Crystal Cam mounted to ROV.

We have two cameras mounted on our ROV, one is a fixed view of our robotic arm and the other is a swivel camera for the overall viewing and driving of the ROV. A “C” shaped piece of lexan was cut and joined with a second “C” shaped piece of lexan via a common axle. A Trexxas servo was attached to the shaft giving us control and movement of the bottom half. This enabled us to create a vertical moving camera. This has an advantage of seeing a 180-degree vertical view. The swivel-cam is mounted in front of the control box to give an optimum view of the whole ROV. For our connections we have tried something new this year. We have moved our control box so that it is actually attached to our ROV underwater. This enables us to use an underwater connector so we can detach the ROV from the tether to allow for easier travel. The power for the camera is run through the generic power feed and split inside the underwater

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control box. The power for these cameras is rated at 15 volts, which posed a problem given our power supply of 12 volts. To overcome this issue we obtained a voltage increaser that was able to increase the voltage output from 14 volts to 16 volts for this specific purpose. The original plan for video was to stream through the Phidget SMB via an Ethernet cable. After much thought we decided to run a small phone wire that has eight 22 gauge wires along side of our new slim tether. This phone cable carries the dual video signal to the topside control box. This system is more complex then previous years but this dual camera system and higher quality video is worth the extra time and effort in making this system work.

2.4 Tether:

The tether is a shielded Ethernet cable, with two conducting wires. One end of the tether is crimped for a connection to a router. The other end of this tether is connected to the male version of a sixteen pin underwater connector. The tether is covered in a polyurethane coating; this coating causes the tether to become neutrally buoyant in fresh water. We changed our tether from last year because we had multiple problems. The tether was extremely stiff, limited our movement and caused a lot of resistance in the water. The new tether is much more flexible but because it is an Ethernet cable it cannot support video. We solved this problem by attaching a generic phone cable to the outside and running the video connections through this.

3. Control Systems:

The control system for our ROV this year, *Vulcan 626*, is very different compared to past ROV's. *Sedna*, our first ROV from the 2005 competition in Texas was controlled by a series of momentary switches. In 2008 we began programming our ROV, *Tectonitron*, with ESC's and Servo controllers. This gave us a great deal of precision that was extremely important in such tasks as measuring the temperature from the thermal heat vent and gathering vent rock sample. Last year, we used the same control system but with a new neutrally buoyant tether. This tether

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was not very effective due to the fact it was thick and stiff, thereby limiting the movement of our ROV. This year, we obtained another neutrally buoyant tether but it is much thinner and flexible. It consists of an Ethernet cable and two conductors. Because we have decided to change our tether, we had to change the entire control system for our ROV. This control system consists of a Single Board Computer (SBC) and two high DC voltage motor controllers. The SBC contains 4 USB ports, which allow us to connect the motor controllers, the Servo Controller and Temperature Sensor. These boards are all contained within a waterproof Lexan box control box, and is attached to the tail of our ROV. We have three sets of WetConnects on the control box; a 16-pin bulkhead for the tether, A 24 pin bulkhead with 12 two-wire sections for the thrusters, vacuum tool and thermal

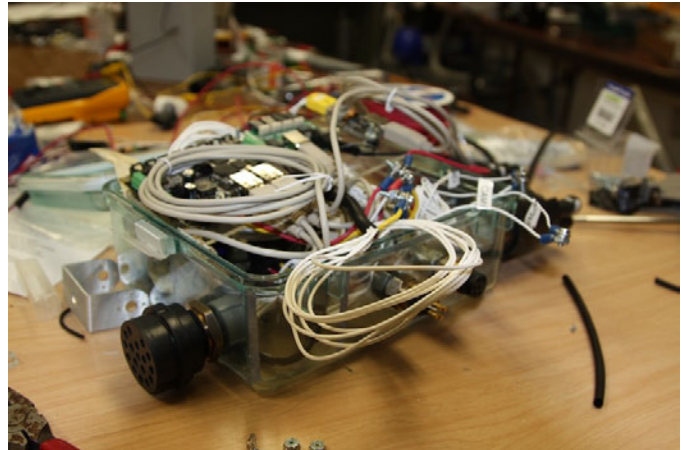


Figure 4: Underwater Control box

couple. Then we have a final WetConnect with 24-pin bulkhead with six 4-pin plugs for the servos. At the deck of our control system we have a smaller box where the power distribution and a 25 amp fuse is located. Power comes in from the batteries provided and powers the ROV. A Router and Laptop connects to the small topside control box, which communicate with the SBC, and the two conductors from the tether. We also have two video feed coming in from the tether via a small telephone line to provide dual video.

4. Programming:

The 2010 programming is built off the framework of the mast two ROV. The basic



Figure 5: Underwater Wet Connects

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control of the ROV has remained constant. We use a USB joystick to collect inputs and then the visual basic program directs each of the motor control. This year we incorporated new high capacity servo controllers to manipulate the bilge pumps. This was an easy transition and had little to no problems with this transition. Our ROV frame is relatively light lighter so we can afford to add more thrusters. In 2009 we had a total of eighth thrusters. This year we have seven, with three underwater servos. Besides these motors we have a thermal sensor, and a sound sensor.

Within our program the basic control of the bilge pumps (thrusters) are basic on/off with pulse with modulation power. This enables us to control the intensity of the output power. Our robotics Nunaarm is control by three servos. The program has six separate buttons to direct the control of the servo. Each button is paired up to cover both rotational directions. This gives the operator precise control for any situation.

The temperature from the thermal couple displays in a text box on the user interface for the co-pilot to record the temperature and the high of the column. The sound sensor is place in a analog sensor and the increasing single is represented on screen with a meter. When the meter reaches a given level, we are near the required location.

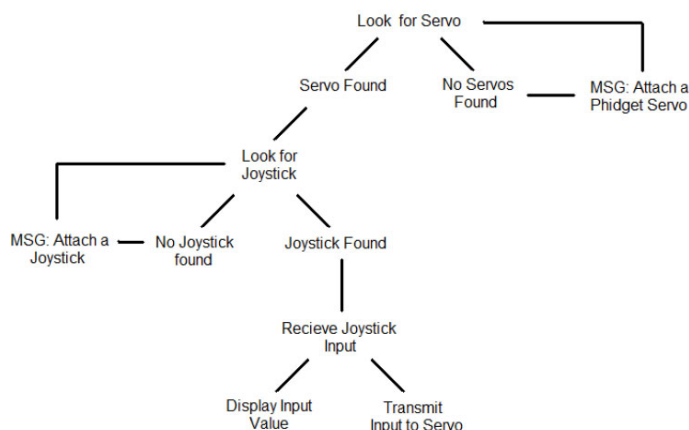


Figure 6: Flow
char of program

5. PAYLOAD TOOLS

5.1 Task #1: Resurrecting HUGO

The purpose of this task is to simulate the rescue of HUGO and make it operational again. To do this it must be relocated to the seismic activity and the power supply must also be restored. The main steps in this task are:

- Removing one pin from the platform to release the HRH
- Removing the HRH
- Identify where the seismic activity is originating from
- Restoring the power back to the HRH

To complete this task a variety of tools were constructed. To remove the pin we designed and built a gripper arm that has 3 degrees of

Figure 6: Flow chart of program

freedom. The power supply will be gripped by the gripper and then moved to HRH. In addition this arm is also used to grasp the HRH and relocate it to the area that produces seismic activity (sound). In order to detect this sound we have constructed a

hydrophone. This hydrophone is constructed out of a basic microphone located at the bottom of the ROV. We tested many designs but the most reliable was a plane microphone with a balloon tied around the receiving end. The signal end is plugged directly into the analog signal port of our Phidget SBC.

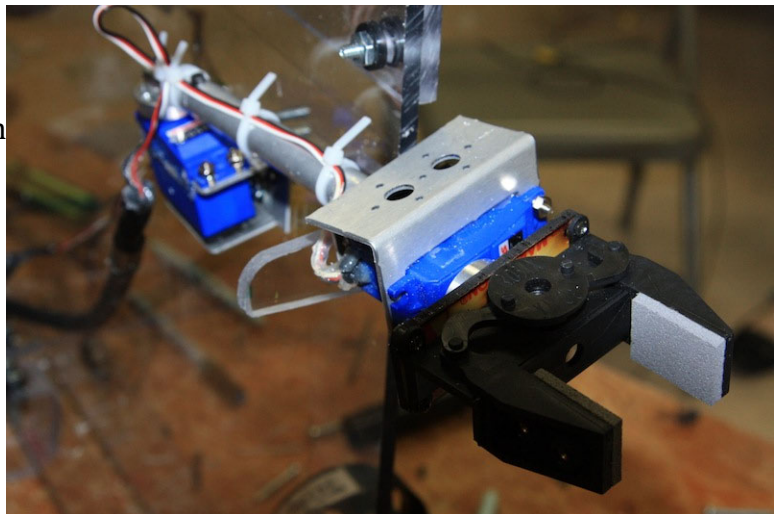


Figure 7: Nunaarm used to grip items.

5.2 Task #2: Collect a samples of a new species of crustacean

For this task, we have to manoeuvre our ROV into a 80cm by 80cm cave and retrieve samples of a new species of crustacean. The main steps in this task are:

- Enter the ROV into the cave
- Maneuver to the back of the cave
- Retrieve 3 crustacean samples
- Maneuver out the cave
- Return to the surface with samples

One of the first ideas we had was basically a big comb with sharp points to scoop up the crustaceans, but we changed it because it would be safer to the crustaceans and environment.

After determining that the initial tool was dangerous to the pool and the crustaceans, we developed an underwater vacuum to collect the samples in a safe and effective way. The Crustacean Vacuum is constructed of a Johnson 12 volt, 3.5 amp, 500 GPH bilge pump. The Bilge pump casing has a 1.5-inch pipe attached to the draw end. At one end there is an expander joint from 2.0 to 2.5 inches. At this location there is a netted filter to collect the crustaceans and prevent them from entering the bilge motor. At the other end is another extender to maximize the surface area at the suction point. This part funnels into the



Figure 8: Nunavacuum used to collect crustaceans



tunnel bringing it to the netted compartment. Upon completion of the task we can remove the netted compartment and safely extract the crustaceans. The Crustacean Vacuum is located on the lower right side of the ROV and the suction point is protruding 1.5 inches out the chassis and is 3 inches above the surface.

5.3 Task #3: Sample a new vent site

Task Three involves descending to the bottom of ocean and sampling an underwater vent while returning with spires for research. The main steps in this task are:

1. Measure the temperature of the venting fluid at three different locations along the height of the chimney
2. Create a graph of the temperature data versus chimney height
3. Collect a sample of a vent spire
4. Return the sample to the surface

To complete this task we plan to use two main tools: 1) A temperature Sensor tool, which measures the temperature while our ROV maintains a steady balance 2) A claw to collect the spire and transport it to the surface. Our temperature sensor consists of a thermo couple that connects directly into the underwater control box. This tool is combined for space reasons with the hydrophone and will be mounted on the inside front right of our ROV's chassis. Secondly the co-pilot will read data displayed on the user interface and graph it against the height of the tube. Following this, we will maneuver our ROV to the bottom of the pool, at which point we will use our servo run claw to collect a vent spire. Our claw consists of three underwater Trexxas high torc servo motors. These motors provide three degrees of freedom to the gripper. The main servo is attached to the body of the ROV and provides horizontal swing, the second and third servos are attached to the claw itself allowing it to both rotate and close. Upon retrieving each spire, the arm will rotate inward and drop the spire into a collection area.



The gripper can open a maximum of two inches, thus able to collect any of the different size spires.

5.4 Task 4: Sample a bacterial mat

For this task we are asked to collect a sample of agar from a plastic container on the bottom of the pool. Our original design was a pair of agar scoops that would be used together to mimic cupped hands. These scoops were composed of 2 inch PVC caps screwed to pieces of Lexan. We originally planned to attach both scoops to a servo motor so that we could easily rotate, open, and close the scoops.

Unfortunately we had to abandon development on this tool. We were forced to end this project early because we realized that the PVC caps required too much force to pierce the surface of the agar, let alone collect a sample. We turned our thinking to a much simpler tool. We have now decided to use a pill bottle with the end cut off and a hole screwed in the top. This bottle holds a maximum of 135 ml. This new tool is not only a lot simpler, but it took nearly no time to create, is more efficient, and takes up less space on the robot. This tool relies on the robots movements to operate and does not require a motor of its own which means less wires going through the tether. We have mounted the bottle to the bottom of our ROV's chassis. This allows the tool to be in plain sight of our pan-camera system and also allows us to use the ROV's propulsion system to apply pressure to the tool onto the agar sample. The tool is also placed strategically so that when the bottle hits the bottom of the agar container the ROV's chassis will be resting on the pool floor. This adds stability and makes it easier to position the tool over the agar. We have attached all of our propulsion motors to the outside of the ROV. This allows the tool to be used without any obstruction.

6.Challenges

Facing the different challenges and obstacles, our team was able to co-operate together and challenge each other to stay optimistic during the hard times. We were able to brainstorm together different ways of overcoming each

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challenge and becoming stronger in learning from each one. Raising the funds was difficult, considering we had to raise over \$50,000. Travel expenses accounted for two-thirds of the cost. Raising this money was difficult and the team recognized that we would have to come up with fresh ideas to make money, as well as relying on previous fundraising ideas such as raffle tickets and approaching businesses. Team NORTH's geographical location was once again problematic this year. Many materials we used need to be ordered and shipped from the "South", and the time for shipping materials is lengthy. We have learned to store things, always plan ahead and try to anticipate materials that will likely be needed for the upcoming tasks. However, the ROV's advancement frequently depended on a piece of material we didn't have, and the team would have to make due until it arrived.

7. Troubleshooting Techniques

Living in Iqaluit, Nunavut can have its difficulties when it comes to designing and building a ROV. Being in a remote area has helped us learn how to think quickly and work with what we have. For example, we had ordered waterproof servos online, and when they arrived they were not waterproof. Considering we can not just head to the store for items such as servos we had to make a compromise, and find a solution using the things that were easily available to us. We decided to seal the servos with epoxy. One of the servos was not meant to be waterproof at all, so we opened it up, filled it with Vaseline, and resealed it with epoxy. Another problem that we had was our tether. We ordered a tether, and are very happy with it, but it did not have the number of wires we required to run our camera through it. To fix this problem we ran an extra phone cable up the side of the tether, fastening it with shrink-wrap. When ever a problem came up our team would put our heads together, and solve it with the resources and tools that were available to us.

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8. Future Improvements:

One of the main things that our team knows we must improve on is our time management. Many hours have been wasted as nothing was being done. With that being said, it is often hard to stay focused when we are waiting for parts in the mail, and when not everyone can make it to meetings due to scheduling conflicts. Our team has however improved on a few of the things that we had mentioned last year such as getting a room in the school strictly for the robotics team, and ordering the supplies we know we will need at the beginning of the year. Another thing we have improved on is that instead of cancelling out ideas before they have been tested, we build any tools that people think of, and try them out, modify them, and try them again, before we discard the idea. Next year, and hopefully in years to come our Robotics team will learn how to arrange our time better so that the ROV and mission props are built faster, allowing us to get more practice time in the pool, and make sure everything is perfect before the big competition.

9. Lessons learned/Skills Gained

Everyone on Team North has learned one lesson or another throughout the entire year. Whether it may be mounting a camera on to the ROV or learning how to wire a motor. We have learned that we need more technology attached to our ROV. In the past we have used simple methods to complete the required tasks. For example; we built a Lexan gripper to pick the specified prop. The major problem with this is the prop easily fell out of the gripper. Some lesson we have learned that the simplest way is not the most practical way. Our access to new technology is limited by our location and how we have to fly in anything that is needed. We have learned that our location is a setback but we are able to pull through with our determination. Since we do not have an easy access to new technology we have to deal with our limits. Our time management skill is not the

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best but every year we try to push ourselves to new levels and heights to achieve our goal to be better. Time is not on our side with everything from having to fly up parts, focusing on tasks and being able to finish projects. Depending how large the project it is it may take more time than others, and being able to only do this after school and on holidays is a challenge. We try to balance everything out between school, social time, and robotics. Everyone here on Team North has grown with knowledge both mental and practical.

10. Reflections:

Zachary Cousins

“This is was my last year part of Team NORTH Underwater Robotics Team and I really enjoyed my experience. This past three years being part of this team has taught a lot of skills that can be used in my future careers and life.”

Eric Blair

“Throughout my three years as a member of Team NORTH I have learned many things. Chiefly among the lessons learned is that nothing works as well in practice as it seems on paper. But more importantly, it can be hard to work as a team but the end result is worth it. Being a part of Team NORTH has brought me closer to friends, allows me to travel and has been an awesome experience from start to finish.”

Aaron Frasier

“This is my first year being a part of the Team North robotics team at my school, and I was eager to join this year to gain the experience of how to use the technical tools and the techniques of building a ROV. The acceptance and help I got from my team mates made this an incredible and unforgettable year on the team, and I am excited for what next year will bring.”



11. Loihi Seamount

Rising to almost 3000 m from the sea floor, the Loihi seamount is an active volcano situated 30 km from the shore of Hawaii (<http://www.soest.hawaii.edu/GG/HCV/loihi.html>). The youngest volcano in its region, it is estimated to be 400,000 years old and is still undergoing massive structural changes.

During three weeks in 1996 scientists recorded close to 4,000 earthquakes causing a new crater to form on the summit of Loihi. Named Pele's Pit, this crater is one of the hypothetical locations designated for exploration by our Remotely Operated Vehicle (ROV). The pit takes its name from the volcano goddess of the Hawaiian people, whose myths credit her with saving them from numerous eruptions over the course of their cultural history (book ref). This large collapse created many hydrothermal vents that began to release fluids of temperatures measured as high as 77°C (<http://www.soest.hawaii.edu/GG/HCV/loihi-summary.html>).

The shape of the seamount forms from sporadic movement of a tectonic plate allowing the release of magma into the ocean floor. Growth is most obvious along the rift zones traveling from North to South, and the volcano's anatomy is skewed by the wasting, or deterioration, of its Western slope (<http://www.agu.org/pubs/crossref/1988/88JB03559.shtml>).

The volcano is in a "transitional growth phase" which provides an opportunity for researchers to study the evolutionary process of its structure as well as the sea life dependent upon the gases it releases. Carbon dioxide is the principal gas expelled. (<http://www.soest.hawaii.edu/GG/HCV/loihivents.html>). The areas surrounding the vents are a prime location for colonies of microorganisms. These colonies are largely composed of iron-oxidizing bacteria studied by organizations such as the National Science Foundation, who funded an expedition to gather samples in 1999, and the Fe-Oxidizing Microbial Observatory (FeMo). The microbial mats created by these colonies thickly coat Loihi's rocks, influencing their eventual shape, and the oxidized iron from the bacteria has the ability to affect other planetary processes (<http://earthref.org/FEMO/>). Many institutions are studying the seamount as well, including the University of Hawaii who in 1997 placed the Hawaii Undersea Geological Observatory (HUGO) on Loihi's summit to gather data on temperatures, seismic activity, chemical concentrations and to take images of the volcano. Collected data is relayed to the shore via a 47 km fiber optic cable, which additionally provides power to HUGO. The seamount is under constant observation for educational reasons and as a precautionary measure against potential catastrophe from both eruptions and tsunamis (http://www.soest.hawaii.edu/HUGO/about_hugo.html).

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Each task in the 2010 International MATE competition relates to a different area of research being conducted on the Loihi seamount. The technologies used in our ROV are directly linked to the needs of scientists from a range of scientific fields such as geophysics, oceanography, microbiology and volcanology.

12. Acknowledgements

Would like to thank the following supporters of the 2009 – 2010 school year. All of the following have donated or supported our team in some form. Team North Robotics Thanks You!

Inuksuk High School (space and Money)

Baffin Regional Chambers of Commerce (Clothing and Donations)

Northmart (Donations for Raffle)

Arctic Ventures (Donations For Raffle)

Studio 2628 (Donations For Raffle)

First Air (Donations for Raffle, discounts on airfare)

Skills Canada (Donations)

Kakivak Association (support for beneficiaries)

I-SPY program (purchase of Wet Connects)

Inuktun (Donation of cameras)

Leoni Elocab (custom-built tether)

MATE (for providing this opportunity)

Appendix A – Electrical Diagram

Figure 9: Electrical diagram fro Valcon 626

