Technical Report

Ranger Class

Submitted by:

Team N.O.R.T.H

Inuksuk High School

Nanook

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

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Mentors: Kim Parsons, Joey Rhodes

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Abstract

The following technical report describes the Remotely Operated Vehicle (ROV), *Nanook,* which was designed and created by Team N.O.R.T.H from Inuksuk High School in Iqaluit, Nunavut, Canada. During the course of construction, the team worked together creatively and efficiently to produce an ROV that can complete the designated tasks of this year's International ROV Competition. Team N.O.R.T.H discovered ways to solve their problems, better their ROV, and learn through their mistakes.

Nanook was designed over a period of 9 months to complete the mission specifications of the 2007 Marine Advanced Technology Education (MATE) competition. The year 2007 has been designated as an International Polar Year to help raise awareness of many issues facing the polar regions of the Earth, including the worldwide effects of global warming and loss of the polar ice caps. MATE's 6th annual competition is being hosted by the Marine Institute in St. John's, NL, which is equipped with facilities to simulate polar conditions. There are three missions outlined for the Ranger class, each in their own challenging environment. *Nanook* was designed to perform, and complete this year's tasks with precision and flexibility.

This report includes: detailed descriptions and diagrams of the ROV and its components; challenges we faced and overcame along the way; lessons we learned and some we didn't; a list of things we would like to improve on next year; a first hand glimpse of the life at the North Pole, a detailed budget; reflections of the process and experiences of each team member, a list of all those individuals and groups who helped us get here.

Design Rational

Frame: The frame of *Nanook* was constructed out of 1.25 cm PVC pipe (Figure 1). Team N.O.R.T.H used this material because it is readily available and can be cut into the shapes and sizes we needed for our designs. PVC is also strong, lightweight and easy to attach to other parts of the ROV with connectors. Also, we did not melt the PVC so there were no safety concerns; instead we used a variety of elbows and T's to manipulate the shape.

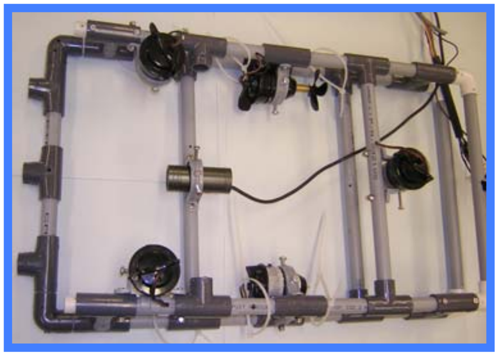


Figure 1

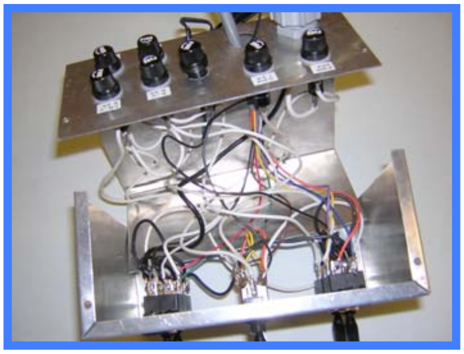


Figure 2

Control System: The control system we used is an electrical control box (Figure 2). We used this box at our first competition, and it worked very well for Team N.O.R.T.H. The box is relatively simple to construct and use. It consists of a rectangular box that houses wires and momentary switches. Each switch is connected to one thruster, and can give it full power or reverse. The control box also fits within our budget.

Video Camera: The ROV uses a DSP Underwater Camera with a 3.6 mm lens (Figure 3). This camera was chosen because of its many underwater capabilities. The camera can retain a suitable view when submerged in water. The cameras are compact, lightweight and durable. Another useful advantage of this camera is that it can easily be attached to our ROV with PVC brackets.

Figure 3

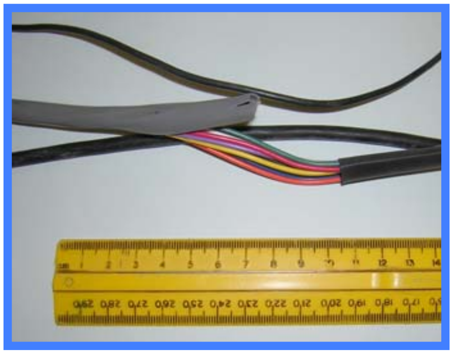


Figure 4

Tether: The tether selected for our ROV was based on our motors (Figure 4). It contains nine 18-gauge wires, which fit the general needs of our ROV because its diameter is not too large. Team N.O.R.T.H determined that 15 meters of tether would be sufficient and would not interfere with the completion of any tasks. We did add an additional motor to the ROV this year and therefore had to add an additional wire. The tether remains visible underwater, which is beneficial and convenient when maneuvering the ROV.

Thrusters: Team N.O.R.T.H agreed on 5 Mayfair Marine 1250 GPH bilge pumps motors for our thrusters (Figure 5). These 12 V thrusters drew less than 1 amp out of water and about 5 amps underwater. We attached a four blade plastic propeller with a 70mm diameter to each thruster. Using a simple pull test, each thruster was rated with a maximum thrust of 30 N. The thrusters are small and can be placed in the most efficient locations on the ROV.

Figure 5

Tools:

All of our tools have been given Inuktitut names – the language of the Inuit on Baffin Island – to represent the culture in which our robot was "born". When designing the tools we thought about present tools, animals, technologies and modified them to meet our needs.

<u>Mission 1</u> *Thread a messenger line through a buoy anchor ring and return it to the surface.*

Qarjuq (Arrow): The Qarjuq is made from three pieces of flexible wire (Figure 6a). The design allows the tip of the arrow to collapse readily (Figure 6b) and once pushed through the

Figure 6a

Figure 6b

Figure 7

buoy anchor ring, it flexes back into its original shape, preventing it from backing out. The wire chosen to build the arrow is light and very flexible. This design is based on traditional Inuit hunting tools (Figure 7) consisting of hooks with pointed barbs to prevent the prey from freeing themselves (Crowe, 1974). The tool is also inspired by designs of modern grappling hooks that deploy barbs or multiple backward-pointing hooks once the grapple is in place.

Nariaq (Fish Hook): The Nariaq is composed of magnets as well as slender hook attached to the end of a 1.25 cm inch PVC (Figure 8). The function of the Nariaq depends on the steel *qarjuq*, which is attracted to the magnet. The *nariaq* is guided by the ROV into the arrow once through. The magnets were tested to ensure they were strong enough to hold onto the arrow but weak enough to minimize the risk of being stuck on the anchor ring. If the magnets fail, a hook is angled slightly downward to catch the arrow if it is accidentally released. The tool was designed to pick up the arrow as easily as possible amongst a strong current.

Figure 8

<u>Mission 2</u> *Collect and return jelly fish. Collect and return sample of algae. Transport and return PAS to designated area.*

Nitsik (Crooked Hook): The Nitsik impales the jellyfish (O-ball), allowing the ROV to safely transport it back to the surface (Figure 9a). It is made of thin, flexible wire that can be altered easily (Figure 9b). The Nitsik has multiple bends and folds with different angles along its length. This allows the nitsik to hook onto the jellyfish efficiently and is difficult to remove once attached. There were many different prototypes where different shapes and placements of the bends were tested. A final shape was decided after multiple tests made in a sink with the model jellyfish and the hooks.

Figure 9a

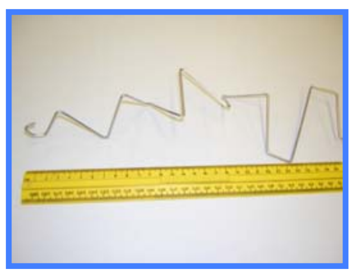


Figure 9b

Figure 10

Figure 11

Ulajujaq (Tornado): The Ulajujaq is used to collect the sample of the algae (ping pong ball) and bring it back to the surface (Figure 10). Team N.O.R.TH. designed the tornado with simplicity in mind. Like many of our other tools, the Ulajujaq depends on the flexible properties of its metal wire. Like a golf ball retriever (Figure 11), it uses pressure (provided by the ROV's thrusters) to force the ping pong ball into the middle of the coil, where it becomes secured. The Ulajujaq was made with precision to ensure the ping-pong ball can easily enter the system but cannot float back out.

Figure 12

Figure 13

Tuugaaq (Tusk): Team NORTH designed a tool that picks up the PAS like elephants use their tusks to uproot trees or lift heavy objects (Figure 12). In our case, the heavy object is the PAS, and it will be dominated by our tool – the Tuugaaq (Figure 13). It is constructed of multiple 1.25 cm PVC joints and semicircular 1.25 cm PVC pipes. The "V"-shaped end of the Tuugaaq allows the PAS to be picked up securely and safely from the base while the curvature of the tusks prevents the PAS from falling out. The design of the tool is light yet sturdy; we are anxious to watch the tusks in action!

Mission 3 *Install a gasket in the wellhead and inject hot stab into the wellhead's protective cover.*

Figure 14

Talik (Arms): In our previous year, team N.O.R.T.H learned that two pieces of PVC worked extremely well in situations that involved carrying items (Figure 14). This year, Team N.O.R.T.H decided to use two pieces of 1.25 cm PVC as well as 45^o joints for mission three. The arms are angled 45^o upward, greatly reducing the risk of the items slipping off. The design has been tested on a model of the wellhead and performed exceptionally well. The design of this tool resembles the shape of a human elbow bent at 45^o. Humans are often seen carrying objects, such as baskets, with their arms bent and the weight resting on their elbows. The design of this tool allows multiple objects to be collected securely on each arm.

Troubleshooting Techniques

Structural

The pool in Iqaluit has been closed many times this year. Instead of waiting to test our ROV, Team N.O.R.T.H. put two very different models into development. Having two ROV's really helped us to continue moving forward when we ran into problems with one model.   Multiple tools were also designed for the same reason; to efficiently run through and improve from tests and trial runs when the pool was finally available for testing.

Electrical

While wiring the electrical system of *Nanook*, we had several methods of ensuring the effectiveness and performance of each component. Each motor was tested individually to check for any manufacturing errors in the motor or its momentary switch. We also constructed the circuitry in series with 6A fuses connected to each motor's circuit. This method can easily identify the area of malfunction if the robot's control system fails. A check of the easily accessible fuses will show which motor has failed and the system can be serviced accordingly. Troubleshooting in this manner saves time that would be spent searching for the area of malfunction and makes a quick servicing possible. We decided to use one control box when testing our two trial robots to save time and supplies. We had to devise a way to have a control box, which would be versatile enough to support either four or five motors. Our first ROV model utilized four motors. ROV *Nanook*, the second model, makes use of five motors. To do this we added an additional switch in series with a 6A fuse and connected this addition to the existing electrical system. The tether wire that we use only carries nine wires but our five-motor robot requires ten, two for each on-board motor. To correct this mathematical dilemma, we connected an additional single wire to the tether. Our control box can now support two different robots with no complications.

Challenges Faced

Materials can become quite a hassle to obtain while living in a Northern region of Canada. How does a team cope with absence of tools, or lack of item quantity? They must be proactive. Anticipating an upcoming problem can ensure that things go ahead smoothly and productively. For example, PVC is our primary building material and has been kept in adequate supply, though it can occasionally be difficult to obtain. By simply ordering extra, and/or by saving as much as we can, we eliminate the impeding of progress due to PVC shortages.

Another one of the challenges that the team faced was learning how to program in the C# language. We had a workshop in December to learn this skill over just a few days, but we didn't employ these skills until several months later. This left us with the problem of trying to remember all of the complex information required to program our ROV, and use our knowledge to design a program. We had a great deal of trouble doing this. It seemed that no matter what any of us did we could not get our programs to work properly. Sometimes the program would work the first time, but when we wrote new code to add to the program, it would shut down. As of writing this report, we have yet to complete a program that can properly control the ROV. The team is currently trying to find a mentor with programming knowledge who can help us, but we are drawing from a limited pool of resources.

Organizing meetings that all of our members were able to attend was an issue. Most of us are employed and all team members are involved in other extra-curricular activities; this left scheduling a major problem. Even after team members compromised, there were still times where not everyone could attend. One of the ways in which we dealt with this was by separating the team into two groups that met on different days. This did lead to gaps in knowledge among team members, but it was the best we could do.

Lastly, finding a practice area was a challenge. The town pool was closed for much of this year so we could not use that facility. There were few other options in terms of water. Lakes or the ocean were not practical for obvious reasons, (they were frozen). All we could do was endure the wait until the pool was open and prepare as much as possible.

Lessons Learned

We have learned a number of lessons this year; the biggest was not to move too fast too quickly.

While the control box with toggle switches performed extremely well last year, it lacked the control and precision that only a joystick could offer. This year, Team N.O.R.T.H participated in a workshop to learn about basic programming and joystick control. The workshop included topics such as programming in C#, joystick-ROV interfacing, as well as new hardware such as servos, Electronic Speed Controllers (ESC) and interface boards. The workshop provided by Dwight Howse and Clarence Button was very informative; by the end of the two-day long workshop, our robot was performing under the precision control of a joystick, assisted by a program created by the team. Although the team was excited to learn this skill, our knowledge was still limited and we were not successful in programming for *Nanook*. The experience and knowledge gained from the workshop is very important, as it is the team's first glimpse at the possibilities of C# programming and we believe it will give us an edge in future competitions.

Team member Conor Mallory showcasing that he learned many lessons this year.

Discussion of Future Improvements

Our biggest improvement for next year will be to employ our programming skills and build a customized control interface for our ROV. Programming a command interface was a big goal for the team this year; unfortunately, it was also a big obstacle. While programming, the inexperienced programmers encountered many bugs and glitches in the code; though the errors were minor, it did cause enough trouble to slow our progress significantly. Next year, we plan to arrange another workshop and expand our knowledge in programming. With newly gained experience, we should have a program up and running in no time

Another improvement our team will have to make will be to increase publicity in the community. A lot of people in Iqaluit still don't know what an ROV is; this limits help from potential sponsors and mentors. Next year, we will have a campaign early in the year asking for all the possible support so that we can secure help with programming and fundraising earlier in the year.

Time management, as we are still learning, can always be improved. During the end of the year, we had to fundraise and make final touch ups on the ROV at the same time. Next year, our first order of business will be to fundraise. We will raise the necessary money earlier in the year up until February, that way we will have the rest of the year to work on the ROV.

Another huge obstacle that impeded the team's progress was the lack of testing facilities. With all the large bodies of water frozen most of the time, the only possible testing site for *Nanook* was the Iqaluit swimming pool. Being the only pool in Iqaluit, it is constantly busy and our test and task simulations are often cut short by rentals and other clubs/organizations. The pool was also shut down for part of the year for maintenance. One improvement we planned for next year is to construct our own test tank. Though the construction materials and size has not been finalized, plans have been drawn and the team agrees that it would be an advantage to be equipped with our own private test tank.

Life at the Poles

Imagine a city where your house is on stilts (Figure 15), the food is mailed to the store daily by plane, water needs to be delivered to your house everyday (Figure 16), and school is often closed because a blizzard will not cease. This is just a glimpse of life near one of Earth's poles. When people think of the north, they automatically think snow, cold, and Santa Claus. However, life in the north is so much more. There weren't always houses, fuel for heating, and weather predictions. For centuries a unique people, known as the Inuit, have lived and survived in this harsh climate near the North Pole.[1]

Figure 15. House on support beams in Iqaluit.

Figure 16. Home-Water delivery in Iqaluit.

Every Arctic community is located beside the ocean – there are no inland communities. And each community is considered by the government to be isolated, since there are only a handful of communities that have roads that connect them to other populated centers. This isolation is most difficult in that it makes the delivery of goods and services challenging – and very expensive. Many goods can be flown in, but it is much cheaper to have things shipped via the ocean. That can only happen in the summer months as most communities are "frozen in" by October. Fuel is an important part of survival in the north. Each community must have a year's supply of fuel delivered by ocean tankers and stored for the year in large storage tanks.

The Inuit culture is one of Canada's most interesting. Life at the pole calls for intelligent use of materials and resources. Inuit have adapted to their harsh environment by developing unique, shelters, clothing, and diets. Inuit used caribou, seal, and musk ox for clothing, nourishment, and even to heat themselves.[2]

Using what resources the northern climate can provide, Inuit survived to this day, still using several traditions of their ancestors. Using snow to build igloos on hunting trips, a sled called a qamutik (Figure 17) to travel utilizing "dog-power" (Figure 18), a traditional knife called an ulu to cut meat, and the quilliq for warmth (Figure 19), the Inuit have kept their culture alive. Their adaptability to life at the pole allowed for their survival, which brought them to be one of Canada's most intriguing cultures.[1]

Figure 17. Qamutik in Iqaluit.

Figure 18. Sled dogs in Iqaluit.

Figure 19. Quilliq.

On the contrast, the South Pole is inhabited by those who wish to do research or take an adventure of a lifetime. These visitors use their own culture to bring out the best of life at another harsh climate. The South Pole is covered in ice and snow, just like the North Pole. Seeing as there are no permanent habitants of Antarctica, there has been no direct culture associated with the South Pole. The only people who are considered to "live" at the South Pole are the researchers from Amundsen-Scott South Pole Station (Figure 20).[3,4]

Figure 20. Amundsen-Scott South Pole Station.

The South Pole Station is used for a variety of research including biology, climate change, astronomy and many more. Most stations in Antarctica are permanently inhabited by researchers and owned by a variety of countries. These countries include the United States, South Africa, Germany and even Chile[3].

The poles create one of the most harsh and unforgiving environments on the planet. For humans to take up residence atop the ice and snow, amid the ice flows and blizzards, special precautions must be taken ensure survival. The Inuit, an ancient and unique culture, adapted themselves to their frozen homeland by wisely and effectively using what little resources and materials available and has survived extraordinarily well. On the other hand, man at the South Pole survived, not by adapting to the environment, but by isolating it. The research stations at the South Pole are insulated and warmed using modern-day technology to ensure the inside remains habitable despite external conditions.

Citations

[1]Wikipedia, www.en.wikipedia.org "Inuit anthropological analysis". Accessed May 11th, 2007

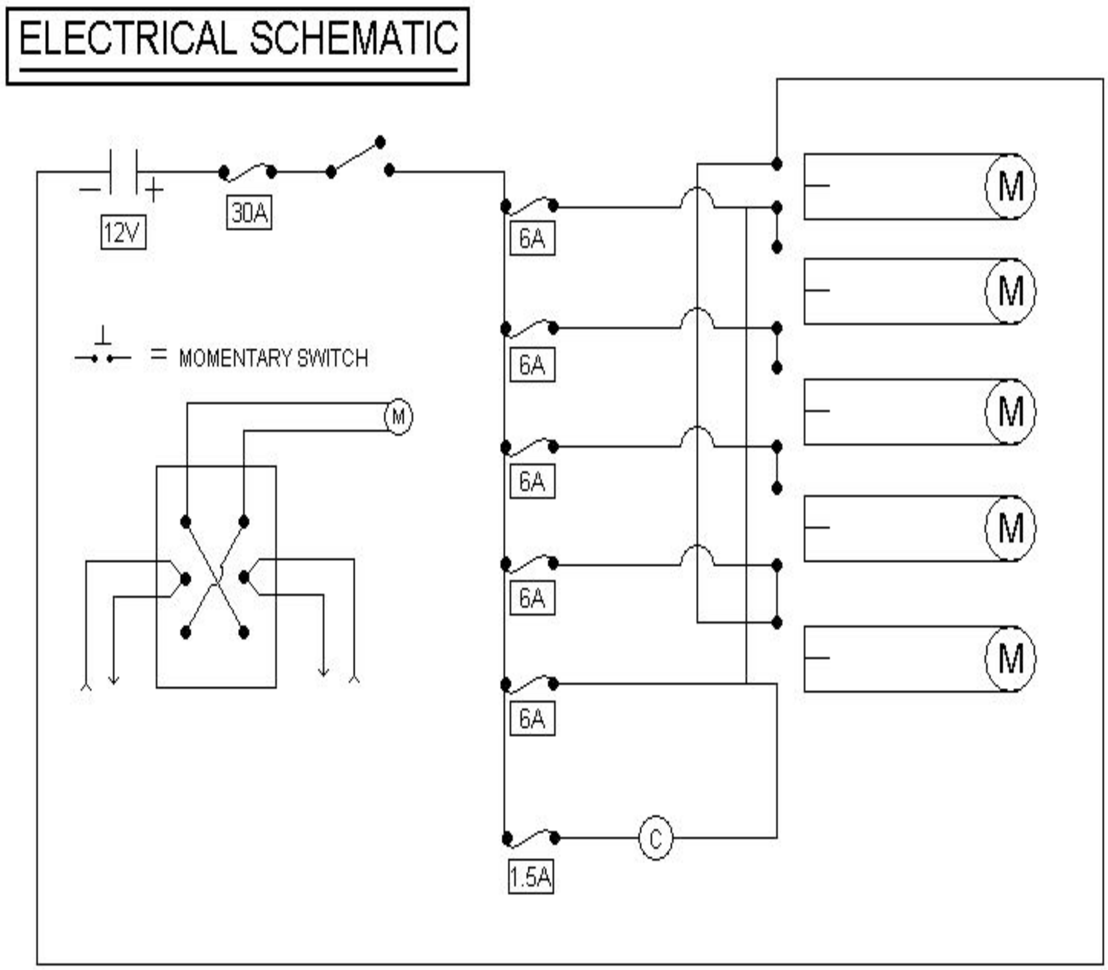
[2] Crowe, K.J. 1974. A History of the Original Peoples of Northern Canada. Arctic Institute of North America. McGill-Queen's University Press, Montreal and London.

[3] Wikipedia, www.en.wikipedia.org "Amundson-Scott South Pole Station". Accessed May 11th, 2007

[4] Answers, www.content.answers.com Photo Accessed May 31st, 2007

Note:
All spelling of Inuktitut words confirmed by Malaya Audlakiak, Inuktitut teacher at Inuksuk High School

Electrical Schematic



Budget

TEAM N.O.R.T.H
Budget Sheet #1
January 2007 - June 2007

Expenses	
Return airfare from Iqaluit to Ottawa	$7,500.00
Return airfare from Ottawa to St.Johns	$7,579.79
Accommodations in Ottawa	$550.00
Accommodations in St.Johns	$1,620.00
Ground Transport	$1,600.00
Materials[1]	$2,500.00
MATE t-shirts	$280.00
Meals	$2,700.00
TOTAL EXPENSES	**$24,329.79**

Revenue	
Raffle Tickets (Nov.)	$6,600.00
Donations from Parent-Teacher Night	$300.00
Canteen Duty	$680.00
Hot Dogs and Chocolates	$502.00
Rotary Club	$1,000.00
MATE travel stipend	$1,000.00
Student Contribution	$4,400.00
Elks Lodge	$1,000.00
Royal Purple	$1,000.00
Royal Canadian Legion	$1,000.00
Raffle Tickets (May)	$6,000.00
Bagging Groceries	$2,000.00
TOTAL REVENUE	**$25,482.00**

Donations	Donators
Six Thrusters	Dwight Howse
Workshop	Dwight Howse and Clarence Button

1. This includes PVC,screws,servos,tools,etc..

TEAM N.O.R.T.H
Budget Sheet #2
November 2006 - December 2006

Expenses[1]	
Return airfare from Iqaluit to Ottawa	$1,500.00
Return airfare from Ottawa to St.Johns	$500.00
Hotel Room and Per Diems	$1,300.00
TOTAL EXPENSES	**$3,300.00**
Revenue	
Donation from Department of Education	$2,800.00
Donation from Capital Suites	$500.00
TOTAL REVENUE	**$3,300.00**

1. Expenses for workshop held at Inuksuk High School by Dwight Howse and Clarence Button

Personal/Professional Reflections

Each team member was interviewed. This is a summary of our reflections.

Samuel Carter: Being on the robotics team has allowed me to realize my interest in the applications of technology. I am a team player and I recognize the value of an efficient team when completing a project.

Seane D'argentcourt Printup: During the process of learning to build a Remotely Operated Vehicle and create a Technical Report, I realized that this experience will stay with me the rest of my life. I now have skills with tools that I'd never dreamed to acquire, and won't forget them.

Chris Guo: Robotics was an enjoyable experience because I got a chance to interact with different people and had a lot of fun working on the robot. I also learned a lot of new things about programming and electrical works.

Kent Heath: I have found robotics to be a fantastic way to spend my time, stimulating the mind in many ways. My role(s) in the robotics club has taught me a lot about technology and even more about people.

George MacKay: I learned many valuable life skills during my experiences with the underwater robotics team. Prior to this experience I was very interested in the specifics of robots and now hope to someday become an engineering expert.

Lewis MacKay: It made me feel important to be contributing to a team as great as Robotics. It was a fun and educational activity to do with my free time that otherwise could have been spent doing less productive activities.

Conor Mallory: This experience has been beneficial to me. My new knowledge of programming has opened up new career paths and opportunities that I look forward to exploring.

Brandon Moyles: Well, apart from just being around some friends, this robotics experience has taught me to juggle responsibilities. Sure, it can get hard and very frustrating, but so long as I can pull through and learn from the experience, I think that it is worth doing.

Lauren Solski: Robotics has opened my eyes to another field of life. Being a person who is mostly interested in the "artsy" side of life, I have been introduced to another career opportunity.

Oshea Jephson: I have been in robotics for two years. Robotics has given me a chance to apply what I learned in school to a real world scenario - FINALLY!!

Wally Picco: The robotics team allowed me to express my creativity and hands-on abilities that I can't normally express in school. My experiences on this team have been invaluable.

Acknowledgements

Throughout our endeavor into the world of robotics, Team N.O.R.T.H has been given help from many important people and corporations. Team N.O.R.T.H could not have made it to Newfoundland without their help. We would like to give a HUGE thanks to:

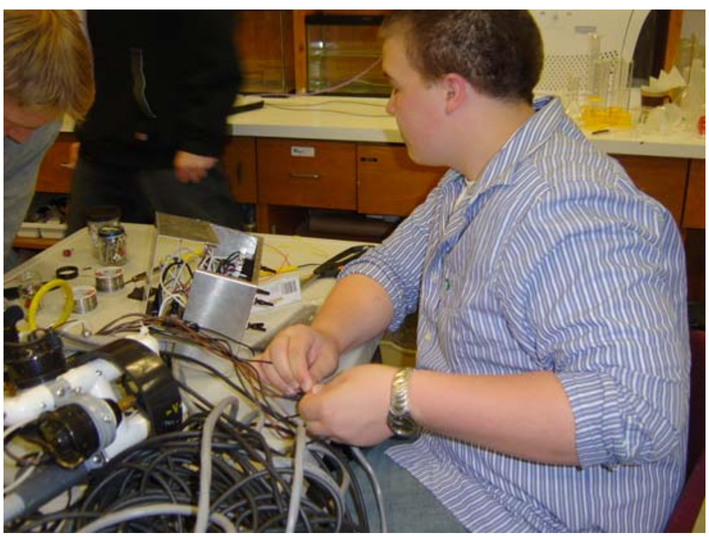
First Air
Nunavut Department of Education
Inuksuk High School
Northmart
Baffin Canners
The Royal Canadian Legion
Northern Lights Cafe
The Elks Lodge
Arctic Ventures
DJ Sensations
The Rotary Club of Iqaluit
Royal Purple
MATE
Dwight Howse
Clarence Button

Photo Journal

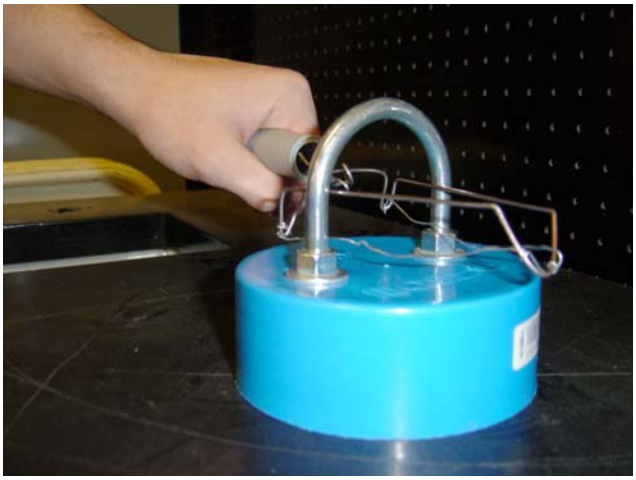
This is a collection of photos illustrating Team North hard at work.

Chris and Lewis designing tools for *Nanook*

Brandon keeping track of the team's budget.



Kent attaching and waterproofing *Nanook's* tether.



The *Qarjuq* being tested on a model anchor ring. The test was successful

Nanook equipped with prototype buoyancy cylinders.

The *Talik* being tested for angle and length.

George and Brandon cutting PVC for tools and *Nanook's* frame.