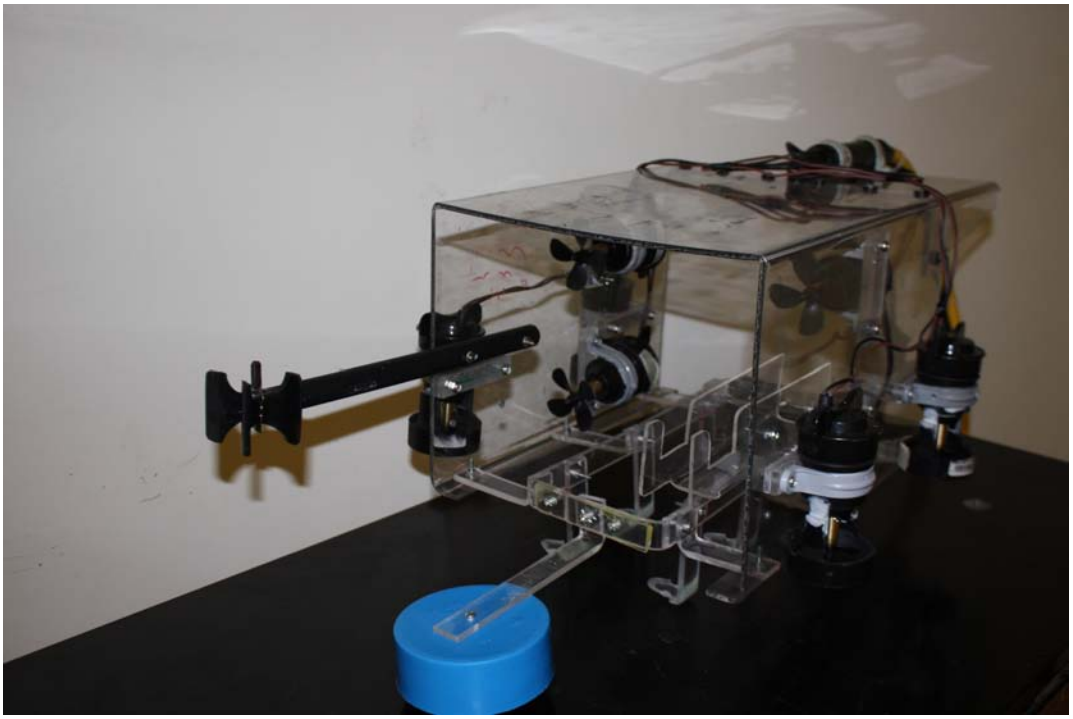
Technical Report

Ranger Class

Submitted by:

Inuksuk High School's

Guilty Spark



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

Yuri Podmoroff, Eric Blair, Anthony Tucker, Zachary Cousins, Duncan MacKay, Allan Heath, Nigel Audla, Lewis MacKay, Louis Lebel Wong, Jessamyn Mallory.

Mentors:

Steve Carter (top Left), Shawn Manning(top right)

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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) surveillance of the submarine and the locating of 5 damaged areas on the sub, 2) opening a door, placing, turning on / off, and retrieving an air supply hose followed by closing the door, 3) delivery of the ELSS pods from the carrying carousel to the submarine's cargo hatch, and 4) rescue of the crewmembers from the submarine.

As the ROV was being constructed we had to get out in the community and fundraise enough money to accommodate ten group members and two mentors. Once we were able to get our name out there, the actual fundraising was not difficult. 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. We all worked many hours together to complete the tasks at hand.

Throughout this experience our greatest lesson learned was that time management is a key ingredient to success. When everyone remained on task we were able to complete work effectively and efficiently.

All in all, we feel as though we constructed a great and efficient ROV and we would not have been able to do this without the tremendous amount of research conducted and the sponsors that helped us along the way. We like to thanks all the organization and sponsors who helped us reach our goal and eventually attend the MATE International competition. A complete list of sponsors is listed in the Acknowledgements section of this document.

Design Rationale

Figure 1: Side view of Salvation.

The name of our ROV this year is Salvation. This name was derived from the rescue-oriented tasks it was designed to complete.

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). This year the team made a major upgrade to a Lexan frame. 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).

Control System: Salvation, like our ROVs from previous years, is not controlled by a momentary switch system; but instead a fairly advanced analog control system. Last year using "Visual Basic" language, the team programmed 5 Electronic Speed Controllers interfaced to a laptop with a Logitech Extreme 3D Pro joystick and 2 Phidget 4X4X4 interface boards (Figure 2). This year the team adjusted the control system to accommodate our new eight thruster model. We accomplished this by wiring each of four pairs of thrusters to a pair of conductors. Doing this we essentially transformed our eight thruster model into a four thruster model; keeping the power (provided by more thrusters) while maintaining the simple control system created for four.

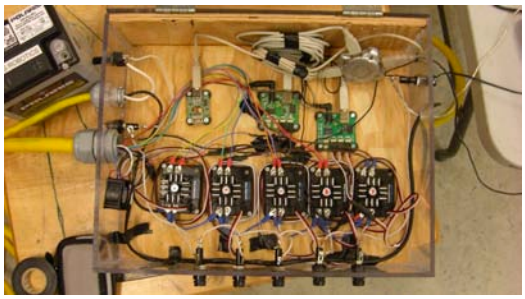


Figure 2: Phidgets and electronic speed controllers in the control box

Video Camera: The ROV uses a DSP underwater camera with a 3.6 mm lens (Figure 3). This camera was chosen because it has an excellent underwater view and can see well even in dim lighting conditions. The camera is small, lightweight and encased in a hard shell for protection. It is mounted to the tail of our ROV using a PVC bracket and a custom-made Lexan support. This position enables us a full

Figure 3: DSP Underwater Camera

view of our wide array of tools, while still maintaining perspective for forward travel.

Tether: In Team North's illustrious three-year history we have use the same extremely basic tether. This old tether had only nine wires although we needed ten. It was 18 gauge (G) although our thrusters had 16 G. It was negatively buoyant although we needed neutral buoyancy. With all these problems we ended up with a customized 'piecemeal' albeit functional tether (See Figure 4). This year we have made a complete upgrade to a professional grade unibuoyant tether. Our new 12-wire tether is 15 meters long and has an internal coax; this means there is nothing taped to the tether making it less likely to tangle (a problem we have had in the past).

Figure 4: (Above) Old tether showing extra motor wire, buoyancy, temperature sensor, and camera wire. Figure 5: (Below) New Simpler Tether

Tether Connector: As in previous years, we created a waterproof connection that is designed to protect the connections between the motors and the tether. It is filled with epoxy and a flooring compound to ensure the connections are waterproof. If the tether was pulled without the connector, the stress could cause these connections to fracture and pull apart. The cover protects these connections by keeping the tether at safe distance to prevent it possibly getting caught in the thrusters.

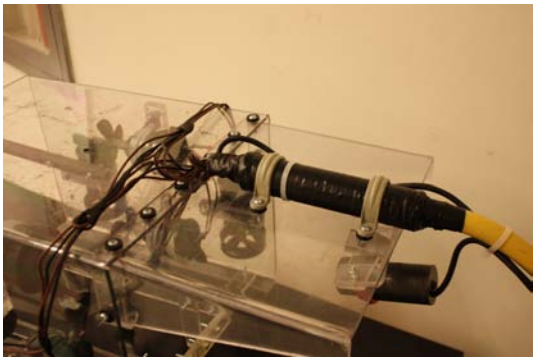


Figure 6: Waterproof tether connector

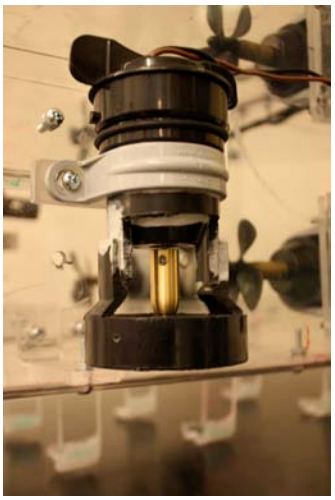


Figure 7: 1000 GPH Mayfair Marine Bilge Pump

Thrusters: Team NORTH used five Mayfair Marine 1000 GPH bilge pump motors for our thrusters (Figure 7). We choose these 12 V thrusters because they draw less than five amps underwater. These thrusters have served us well in all our previous competitions and are budget friendly, costing only $29.95. We attached a four bladed plastic propeller with a 70mm diameter to each thruster. The four vertical thrusters are positioned on the exterior corners of the ROV and are shrouded for protection. These thrusters control vertical motion and are able to achieve weak sway motion (this is accomplished by running the right and left vertical thrusters in different directions). The four horizontal thrusters are positioned in

the interior of the ROV to keep them independent of the vertical thrusters. Another advantage of mounting them internally is that they do not require protective shrouds. The four horizontal thrusters achieve forward and reverse motion as well as sway motions. Using a simple pull test, each thruster was rated with a maximum thrust of 30 N.

Figure 8: View from Camera for task 1

Payload Description

The accomplishment of this year's tasks involves a series of specially designed tools for the completion of the individual tasks.

Task 1: Requires the surveillance of the submarine and the locating of five damaged areas on the submarine. The only tool used will be the camera. The underwater capabilities of the camera make it ideal for task one.

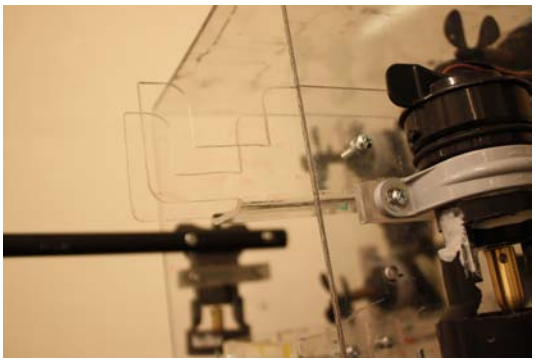
Figure 9: (above) *PokeNProd* tool for Task 2.

Figure 10: (Bottom) *Nunarm* used to pick up air supply valve

Task 2: Consists of opening a door, placing an air supply hose into the submarine, turning the air supply hose on/off, retrieving the air supply hose and then shutting the door. Two tools will be used for this task. One for opening/closing the door and lever, and another for dropping off and retrieving the air supply hose.

The door opener tool christened *PokeNProd* is simply a probe with modified PVC piping on the end designed to fit inside the handle of the door. It will be used to open/close the door.

PokeNProd is also used to open and close the air supply on the side of the submarine's conning tower. The modified PVC piping on the end of the probe is designed to fit over the handle at all angles for uninterrupted completion of this part of the task. With this design, the ROV will not have to release the lever halfway through to approach it from a different angle.



The tool designed to deliver and retrieve the air hose dubbed *Nunarm* is designed to hold the air hose at a forty-five degree angle

for easy insertion and retrieval. It is constructed from a single piece of Lexan bent into the desired shape. This enables it to remain lightweight and strong.

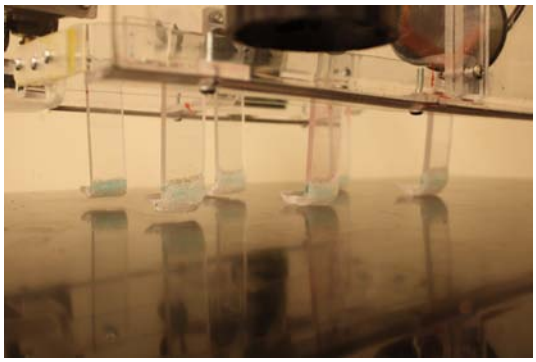


Figure 11: (Above) Hooks Used to pick up ELSS pods for tasks 3. Figure 12: (Side Right) Hooks picking up ELSS pods.

Task 3: This task involves the delivery of the Emergency Life-Support System (ELSS) pods from the holding carousel to the submarine's cargo hatch. It also requires opening/closing of a wheel-locking hatch followed by the pickup and delivery of five ELSS pods. One tool for this task (the *Hexaclaw*) was specifically designed as multipurpose for the completion of two parts of this task. It consists of a rectangular-shaped piece of Lexan attached to the ROV with six bent Lexan probes attached to both pickup the ELSS pods and to lock/unlock the hatch on the submarine. The hooks are spaced the correct distance apart to fit into the cross-braces on the hatch-wheel. The ROV will then rotate horizontally 180 degrees until the hatch is locked/unlocked. This tool also uses its hooks to collect the U-bolts on the ELSS pods for transport to the submarine. The pods are then delivered into the submarine's cargo bay via a swaying movement by the ROV while over the bay opening.

The other tool used in this task is the *PokeNProd* probe previously mentioned for the completion of task two. This tool will utilize its modified PVC pipe end to hook underneath of the hatch cover and open/close it.

Task 4 is the rescue of the crewmembers from the submarine. A mating skirt is needed to dock with the submarine's escape hatch. We used a 5 ¾ inch cap as the mating skirt and attached it to a Lexan probe to distance it from the ROV. This distance prevents the *Hexaclaw* from interfering with the mating action.

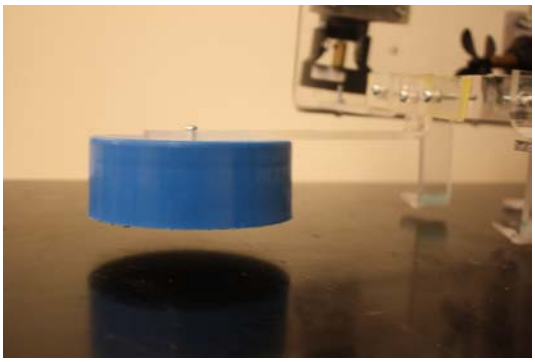


Figure 13: Skirt used to "mate" with submarine in task 4

Troubleshooting Techniques

This year we decided to use a completely new design for our ROV. We wanted to improve on how well it traveled through the water and its ability to turn. We originally made the majority of our tools out of Plexiglas, but changed them into Lexan to match our ROV, increase strength, and decrease weight.
Another thing we had trouble with was regular trips to the pool to test designs. We went to the pool once to test our original design and we have only gone back a few times for tool testing and buoyancy. A major thing for us to get used to was our new design and how to mount our new tools. Unlike last year and the year before where we had a previous ROV to get ideas from, this year we started from scratch. This will become easier in the following years assuming that we will continue to use the same ROV design.

Last year, we used Vector Works to create the design schematics, but we decided to do all our work on Solid Works for our new design. Unfortunately final products were not created due to time constraints. Next year we plan to design all of our ROV on Solid Works and use a CNC mill to mill our parts.

Some working habits that we will improve on for next year would be, better meeting times, to start working on our tools earlier, to create a final design, and less trial and error.

Challenges Faced

Figure 14: Allan Heath getting frustrated with the robot!

Team NORTH faced a wide variety of challenges this year including those of financial, technical, mentor inexperience and those concerning team member availability (for fundraising events, working on the ROV etc.).

The largest challenge we had to face was working together. Throughout the year most all of our work was split up into solo or micro group projects which, at completion all parts were meshed together. This left us with some large holes in what we had finished, which we fixed by having people do what needed doing by themselves and then meshing that in as well.

Figure 15: Duncan being Duncan

Getting all members of the team to attend the meetings was once again a challenge. As some of our high school's top academic, athletic, and artistic students many of us

are involved in a lot of other activities which often overlapped with group meeting times. In addition, some students on the team have part-time jobs, which interfered as well.

Raising the funds was difficult, considering we had to raise $36 000. 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. We decided that a key component to raising this sum would be to increase the team's publicity and attract supporters from within the community.

In order to put ourselves in the public eye, we handed out copies of the information brochure we made last year and passed them out to potential supporters. Our greatest success was the Nunavut Tradeshow where we displayed a booth and also reused our eye catching poster from last year to keep up the public interest in underwater robotics. Baffin Regional Chamber of Commerce (BRCC) has again kindly agreed to cover the cost of printing the brochures and buying the team shirts, jackets and hoodies. At the end of the tradeshow during a gala, the team was auctioned off to do chores for a day, earning a whopping $4600.00 nearly double last year's already impressive sum.

Figure 16: Members of Team North in Igloolik promoting Underwater Robotics

Team NORTH's geographical location was once again problematic this year. Many materials we used needed 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 ROVs advancement frequently depended on a piece of material we didn't have, and the team would have to make due until it arrived. One example of this was the idea we composed for picking up the ELSS pods which involved pneumatic pistons, yet due to the time required to get the parts we were forced to invent a simpler way of achieving that goal.

Lessons Learned

This year our team decided to switch the material we would be using to build our ROV. We decided to try something new and build our ROV out of Lexan instead of PVC tubing. Although we are happy with our final product, we learned that we needed to do more planning. The team learned that in order to use a new material we must first be sure we have all the needed equipment, such as a plastic bender.

Working with this new material was a great learning experience, and helped us realize many things we should have done ahead of time.

Figure 17: Working on the new tether

Time management is key when it comes to having a deadline, we learned this the hard way, when we realized that we had little time left, and a lot of work to do. We also learned that the work needs to be spread out amongst all the team members on different parts of the ROV instead of wasting our time and working on the same task. The realization was made that time goes by quicker than expected and every minute counts. Overall, the most important lesson we learned was to stay on task and use our time wisely.

Discussion for further improvements

One of our main future improvements from last year was to cut the size of the team down, this did not happen due to the fact that we don't have the heart to turn people away, anyone who is interested in underwater robotics should be able to enjoy the experience. This may be a goal again for next year, but it is unlikely considering only one of our team members will be graduating.

An improvement we are sure of for next year is to get all of our supplies ordered right away so that we aren't waiting for them to get here in later stages of building. Due to the fact that we live in the arctic and can only have things shipped to us, it can be very tough to get the supplies we need in time.

We would also like to have a room in our school that is dedicated to our robotics organization. We would not have to pack up and unpack our equipment at the beginning and end of each meeting, therefore saving time. Having days of the week that worked foe everyone would be another helpful improvement. This was challenging this year considering the size of our team.

Figure 18: Dr. Clarence Button doing a special in-service for all members.

Research

There are many organizations involved in submarine rescues, but at the forefront of submarine rescue systems and technology we have OceanWorks International. OceanWorks International produces unmanned sub-sea work systems that have done such things as aide the Navy. OceanWorks has greatly expanded its technology in areas such as; advanced tethered remotely operated vehicles, emergency life support pods, submarine emergency ventilation systems, and launch and recover systems. (http://www.oceanworks.com/submarineTelecom.php)

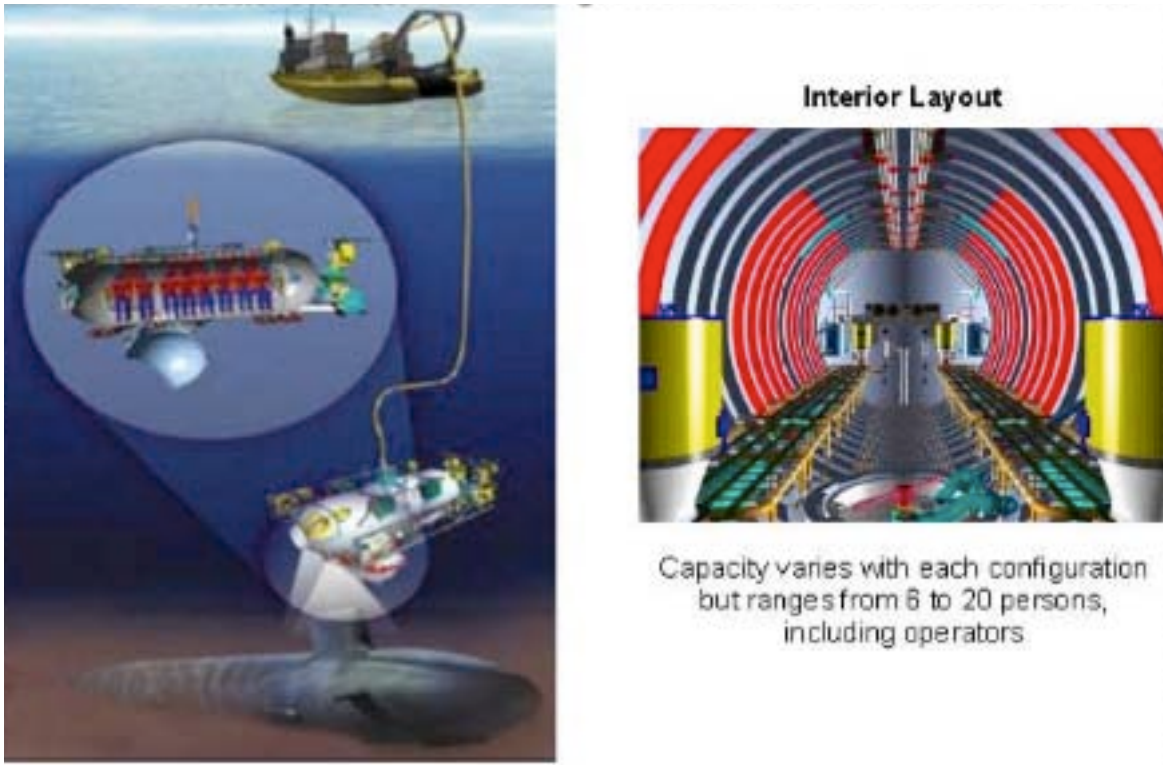


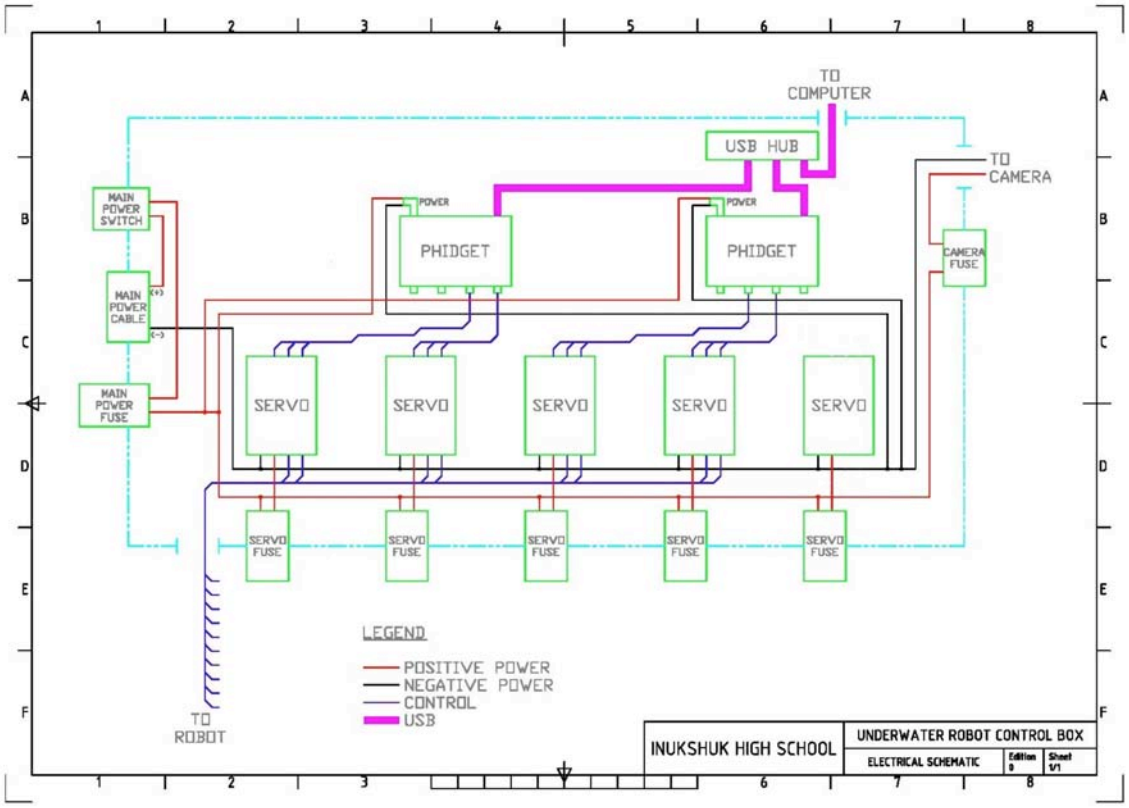
Figure 19: Submarine Rescuer system 1

OceanWorks International valued services include; design, manufacturing, test and integration project management, training, and technical support for both commercial industry and military clients. The one challenge that OceanWorks faces that we do not have to worry about are the harsh environments of deep-sea exploration. (http://www.oceanworks.com/submarineRescueSystems.php)

Figure 20: Submarine Rescuer system 1

Much like the ROV we were tasked with building, OceanWorks ROVs are built with; a skirt, buoyant tether, launch and recovery systems (supports pods), air transport options, and feature durability in up to depths of 500 to 730 meters. Due to creativity and ingenuity, OceanWorks International is able to build cost effective, commercially available, and easily operated ROVs.

Electrical Schematic



Electrical schematic diagram completed by members of Team North Robotics Club

Figure 21: Electrical Schematic

ROV Software Flow Chart

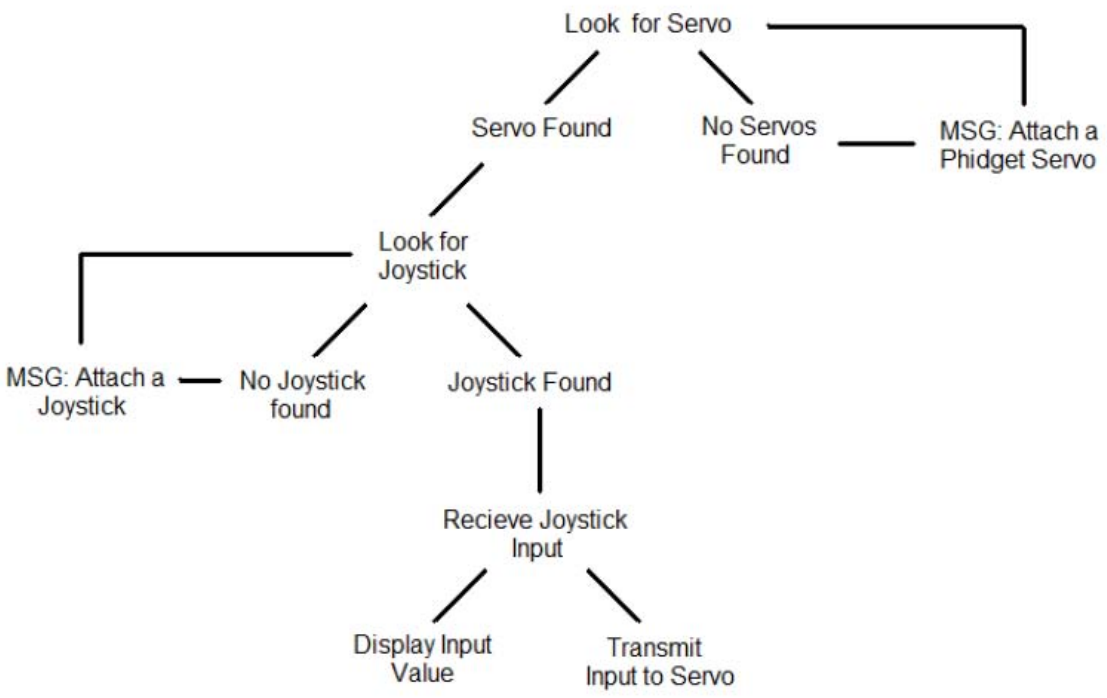


Figure 23: Software Flow Chart

Programming

Last year's competition was the first year we used Servo controllers and our created programming software. The new way of controlling our ROV *Techtonitron* (last year's model) gave us precise controlled movements which helped with the planting of the temperature sensor in the hydrothermal vent. This year we kept the same control system with a few minor adjustments.

Our ROV frame is lighter so we can afford to add more thrusters. We added three thrusters, bringing us a total of eight (four vertical and four horizontal). Due to this, we had to make some minor changes with the wiring. We originally had five servo controllers but we only need four with our new setup. Each servo controls two thrusters; left horizontal, right horizontal, left vertical and right vertical.

Within our program we made some small changes such as removing the fifth servo and changing some of the values so we have new movements. We also got rid of the text boxes in the form for the temperature, as they are not needed in this year's competition. After testing the new control system, the ROV has performed well and we believe it will do us proud in the international competition.

Reflections

Robotics is a great and fun experience. I learned many new things and had fun building the ROV. It is also a good thing to have on applications to colleges or universities.

Robotics has been a great way to work with others, and learn new things while still having a great time. We took a chance with new materials, and hopefully improved our ROV.

In my 3 years on the team I have learned many skills such as time management, leadership skills and more specific skills such as soldering. Go Team North!

This year robotics has had many challenges. We have introduced new materials and equipment, with that being said this has made it more interesting and enjoyable.

This year was a big challenge. Using new material slowed us down but in the end we managed to make it work. We shifted gears and completed our ROV.

Robotics is a unique experience, great for having fun with friends and building an awesome ROV.

I liked being a member of the robotics team because I enjoyed being exposed to the technology involved in this experience.

Robotics has been a way to apply science and technology to a real life situation and have some fun along the way.

Robotics is awesome, definitely the highlight of my year. The people are amazing and the experiences are great.

This is my first year of robotics, it has been a very enriching experience filled with new friends, new knowledge and great times.

Budget Sheet

TEAM NORTH ROBOTICS

Budget Sheet

September 2009 – June 2009

Expenses	
Return airfare from Iqaluit to Ottawa	$12,330.00
Return airfare from Ottawa to Boston	$6,200.00
Accommodations in Ottawa	$740.00
Accommodations in Boston	$2,000.00
Ground Transport	$2,000.00
Materials for the ROV (including, monitor, servos, ESCs, tools (drills) etc)	$1,500.00
MATE t-shirts	$300.00
Meals	$5,000.00
Activities in Boston / Buzzards Bay	$2,500.00
Shirts, Polo's, jackets	$3,300.00
TOTAL EXPENSES	$35,870.00

Revenue	
MATE travel stipend (pending)	$1,000.00
Canteen	2,500.00
Team member contributions	1,000.00
BRCC (trade show and Donations	13,000,00
Raffle Tickets	15,342.00
Comedy Event	1,500.00
Video Editing	700.00
Savings from Past Years	11,340.00
Skills Canada	1500.00
TOTAL REVENUE	**$36,682.00**

Acknowledgements

Inuksuk High School

Would like to thank the following supporters of the 2008 – 2009 school year. All of the following have donated or supported our team in some form. Team North Robotics Thanks You!

Inuksuk High School

Baffin Regional Chambers of Commerce

Northmart

Arctic Ventures

DJ's Sensations

Studio 2628

First Air

Dr. Clarence Button

Skills Canada

Iqaluit Music Society

Kakivak Association