Dalbrae Aquatic Robotic Team

Dalbrae Academy, Mabou, Cape Breton, Nova Scotia, Canada

Team Members: Alex Heukshorst, Milton Lywood, Alexis Dunphy, Gerald Mouland, Isaac Matheson, Danielle vanZutphen, Amanda Lowe, Carolyn Murphy and Hector the ROV.

Team Mentors: Ed Dunphy, Tom Malloy and Vincent vanZutphen

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Figure 1: *Hector the ROV named in honor of the HMCS Hector the first ship to bring Scottish settlers to Nova Scotia*

Abstract

Our ROV team is composed of eight members, all of whom are new to this project. This year MATE assigned each team three tasks to complete in an underwater environment. At the bottom of the pool there are multiple vent crabs in various locations throughout the field. We must retrieve three of these crabs and collect and retrieve three sample of a black smoker. A flow of warm water is flowing from the top of the hydrothermal vent; our task is to get the most precise temperature reading as possible.

Our ROV was carefully constructed to accommodate these tasks. Milling and wiring were two of the many processes needed to complete the ROV. We planned our budget for $3000CDN, plus donations of miscellaneous items, including PVC and ABS pipes, elbows and tees. Plexi-glass was another item used in the construction of our ROV. Our motors are simple outboard trolling motors modified and enclosed in shrouds to avoid any entanglement with our tether. Our ROV is equipped with two horizontal motors, one vertical motor and three cameras along with two temperature sensors

To accomplish the task of retrieving the vent crabs and smokers we set up two pneumatic grippers. For easier access we positioned one gripper vertically and the other horizontally. Once these objects are collected they are placed into a net and taken to the surface all at once. Our ROV, Hector, is the result of hundreds of hours of brainstorming, inventiveness and above all, teamwork.

Remote Operated Vehicles and Hydrothermal Vents

Throughout the history of man, we have been fascinated by the ocean. We have always searched for a way to find out what secrets lay lost in its depths. And now through advances in technology we are able to probe the depths with the help of Remote Operated Vehicles. One example is the discovery of Black Smokers. Black Smokers occur along hydrothermal vents found when water goes beneath the Earth's crust where minerals become infused with the water. When the heated water leaves the vent, the minerals solidify creating the black smokers. Under the sea, there are fascinating geological formations and amazing wildlife. These are amazing ecosystems that use chemosynthesis as the fundamental energy since they are so far from any sunlight. Unique and fascinating animals live there, such as: white sea anemones, mussels, snails, thumb-sized shrimp, crabs, fish and octopi. Hydrothermal vents are also being explored in fresh waters such as Yellowstone Lake, Wy.

Without the aid of ROVs, it would be almost impossible to investigate these wonders of nature. The role of the ROV is to explore the deep sea often bringing back samples of living and non living material. The pressure at these depths makes diving impossible. As a further danger, the water spouting out of the smokers can reach temperatures of 400 degrees Celsius, but because of the pressure, it stays in liquid form. A black smoker will often topple adding further risk to divers.

In 2006, Woods Hole Oceanographic Institution's Deep Submergence launched the ROV Jason/Medea. With this ROV, it was planned to explore "The Ring of Fire" which is a long stretch of underwater volcanoes that are found throughout the Pacific Ocean. It is actually two ROVs, the Jason, which is the main explorer part, and the Medea, which is used to control the tether.

The Jason was used to take the temperature of the hydrothermal vent and get samplers of the minerals. Also, Jason took back samples of the wildlife, such as crabs and mussels. The Jason provided a rare glimpse into the submarine life that was previously inaccessible by man. It enabled scientists to study the life in the deep sea and would seem to be the inspiration for this year's mission. An earlier prototype was used to explore the SS Titanic.

Without the aid of ROVs such as the Jason, this exploration would be impossible. Hector might not be in the same league as Jason, but it serves its purpose to show us what it's like for the builder/operator of commercial ROVs.

Figure 2: Remote Operated Vehicle Jason/Medea

(Woods Hole Oceanographic Institution)
(http://www.whoi.edu/page.do?pid=8423)

Design Rationale

When constructing our ROV, we began by looking at the required missions. Our guiding principal was to build an ROV and the tools needed to complete all tasks in one trip underwater. Commercial ROV operators, divers, sea urchin harvesters and others who explore the deep waters attempt to reduce the number of trips from ocean floor to deck side. This saves time, money and reduces safety risks. We felt our ROV should do the same. It was necessary to built two grippers to carry our rock catcher and net down in at one time to collect crabs and rocks in one trip. Whenever practical, we have built redundant systems into our ROV such as two temperature sensors, two grippers and variable buoyancy to bring Hector up to the surface if the vertical motor fails. Since we all were new to electric circuitry we decided to go with a hardware approach. By building the electrical system from scratch we feel that we have mastered this system and feel very confident that we can quickly trouble shoot any problems that may occur before or during missions.

The planning process began when we fully understood the mission, the competition rules and the resources readily available. We initially had three motors, one camera and assorted connectors and pieces of PVC conduit. Our limit budget required us to be inventive and frugal. We built systems ourselves whenever possible. The grippers were far too expensive to purchase commercially so we designed, refined and constructed our own. Air pressure was used to power our grippers and variable buoyancy because it would not add any current draw to our system. Our cameras and motors, when at full speed under load, came close to 20 amps so we did not want to risk going over the 25 amp limit. Three cameras are used to give maximum visibility of the enclosure and the grippers. Two temperature sensors placed in our funnel system allows us to take the temperature reading quickly in sequence with the other tasks.

The end result of our work is a functioning ROV that came in on budget and has consistently performed the missions in one trip well within the allotted time. All systems and features of our ROV are discussed in greater detail in the following technical report.

Frame

FRAME DIMENSIONS

Weight 11.7 kg
Length 565 mm
Front Width 375 mm
Back Width 225 mm
Height 335 mm
Width to Outside Motors 700 mm

Figure3: Frame with motors and pontoons

Our frame was constructed out of one inch PVC piping. We decided to work with PVC because it is lightweight, strong, and we had a supply of scrap pieces donated by the electrical shop at Nova Scotia Community College (NSCC), Strait Area Campus. The PVC piping also allowed for easy attachment of the numerous tools employed on the ROV.

The shape of the main frame was manipulated using a variety of connectors. The frame was screwed together with self tapping screws allowing us take it apart quickly if necessary for repairs or alterations. The original frame without motors was built in the shape of a rectangular prism; having a length of 565mm, a height of 335mm and a width of 375mm.

Because the pool enclosure we are working in is relatively small, we decided the original frame was too big. We decided to reduce the rear half of the ROV to a width of 225mm. This reduction of the width of the frame allowed us to draw in the horizontal thrusters reducing the outside width of the ROV to 700mm. The thrusters are positioned on the rear of the frame to offset the weight of the grippers, cameras and the payload at the front.

While brainstorming the dimensions of our frame, we had to account for the fact that our vertical thruster needs about 100mm of clearance from the bottom of the robot. The frame was designed to allow easy maneuverability within the 3m by 3m enclosure, and also to make the ROV faster and more responsive.

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Electrical

Our control system consists of two control boxes (electrical and pneumatics). The electrical box is made up of 4 double poled double throw (DPDT) momentary switches, 4 single poled single throw (SPST) toggle switches, E-stop, ready light, fuse, portable ammeter, 2 camera hookups, one auxiliary hookup, # 16 gauge wire, capacitors and tether (# 18 AWG speaker wire). All connections were soldered to ensure a solid connection.

When we started to design our control box, we looked at the following aspects; safety, convenience, and function. It is all enclosed in a donated aluminum briefcase for easy transport. The inside was stripped and an aluminum plate used for the base for the panel.

Safety played a huge role in this project, both for ourselves and our ROV. Three main safety measures were incorporated into our control panel, an E-stop, a fuse, and an ammeter. Our power runs to the ammeter, onto the E-stop, then to the fuse, finally to the rest of the panel. An E-stop is a huge safety feature, for it will allows us to shut all power going to the control panel in case of an emergency such as something caught in the propeller or someone working around the motors. Our fuse is 25 amps, enabling us to limit the amount of power used by the ROV. The ready light easily lets us know if there is power to the panel. Experience has shown us that when a motor is damaged it will draw more current. The ammeter allows us to be aware of problems before they occur. It was used through out our testing and will be employed during the competition. A single poled single throw (SPST) toggle switch is wired with the ammeter so we can bypass it in case of failure of the ammeter.

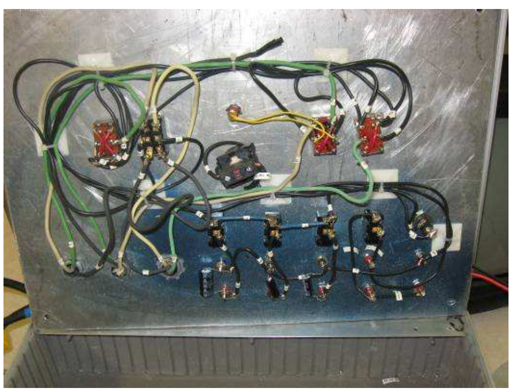


Figure 4: Underside of Electrical panel **Figure 5: Top of Electrical Panel**

We wanted to be able to disconnect our tether from the control box for easy and safe transportation and storage. It would have been nice to disconnect from the ROV but the risk of water damage was too great so we attached three female ends of a 120 volt extension cord to dry end of our tether and three male ends to our control box. The female ends were placed on the tether so that someone could not plug them into a wall socket causing 120 volts to go to the motor, likely destroying them. All cords are color coded for easy and accurate connection to the correct switches.

Team discussions on ergonomics led to the positioning of all switches. Our first decision was to place the E-stop directly in the center of the control panel for easy access. Next, we put our umbilical to our tether in the top right. Our switches for the motors were placed almost center so that our hands can rest comfortably on the surface of the box.

Having an all right handed team made our decisions easier since we did not have to accommodate for both preferences. These switches are double poled double throw (DPDT) momentary switch.

The vast majority of the time we were working on our own. However whenever we needed expertise, our mentor Ed Dunphy would try to arrange for some one with that expertise to join us for a day or two. One such person was retired electrician and substitute teacher Tom Malloy. We determined the position of each switch or electrical connection and made a rough sketch of the circuits. Mr. Malloy then helped us make a wire schedule. This was very convenient when we were wiring the control box. It also helped keep the back of our control neat because all of the wires are numbered. We have a list of all wire schematics and numbers at the bottom of the control panel in case of problems. Mr. Malloy was also able to help us take our hand drawn circuit diagrams and create a more professional looking diagram with Auto Cad.

Convenience involves our fast and easy hook up to the tether with a 3 prong 120 volt plug. Attached at the end of our camera wires are banana clips for easy access. There is also a single poled single throw (SPST) toggle switch controlling each camera in case too much power is being drawn or something is wrong with the camera we can cut them from the circuit. We inserted three capacitors in our control box. These are attached the positive and negative jacks for our cameras. It was decided to put these in so the cameras would not flicker as much when the motors were being turned on.

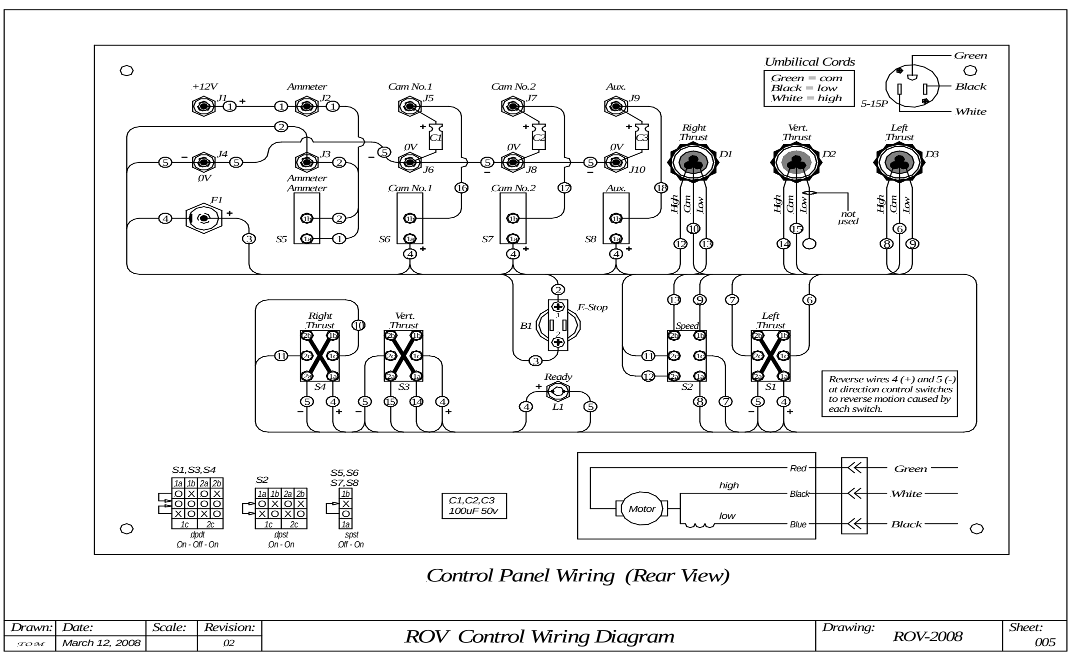


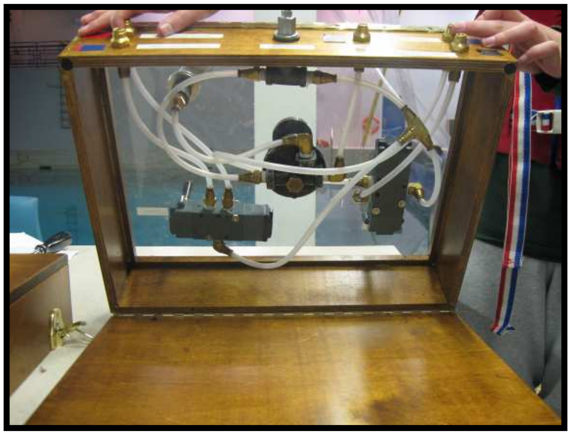
Figure 6 Electrical Schematics
F_1 is Fuse

Pneumatic Control Panel

Earlier prototypes of Hector had only one gripper. To achieve our goal of completing the missions as quickly and accurately as possible in one trip we decided to add another gripper. This caused a problem because the previous pneumatic control box was now too small and difficult to use. The pneumatic hoses were constantly becoming kinked and there was no room for all the necessary equipment. Our pneumatic specialist, or "Air Heads" went to work building the vertical gripper and a larger, more effective box .The new box is composed of a large wooden box that opens in two parts. The top comes off for easier access to the control and the bottom is hinged to allow easy access to repair any problems. The bottom is hinged to open for easy access. There is an input plug at the back to connect to the compressor as well as 5 friction lock connectors for out going hoses to the grippers and variable buoyancy compensator. The compressor is set at 40psi or 273 kPa. The horizontal control valve is stationed on the right and pivots left to right to match the placement and movement of the horizontal gripper. This set up also applies to the vertical gripper, except it is stationed on the left and pivots up and down. The regulator is positioned in the middle with a pressure gauge to enable the pneumatic driver to monitor the pressure going to the ROV.

Figure 8: *Alexis working on the original controller*

Figure 7*: U***nderside of pneumatic control panel***



The Motors

We had many difficulties with our motors right from the beginning. Our original idea of salvaging the motors used from last year's team was not to be since chlorine had damaged the seals and the silicone used to seal the motors. This required use to research a motor and supplier. We eventually decided on using a 12 volt trolling motor from Sevylar. These motors are designed for use with small boats so are powerful for moving our lightweight ROV. The difficulties working with the original motors and new motors are discussed in more detail in the Challenges sections of this report.

The horizontal motors were attached to the frame using PVC piping. The PVC was cut to a length of 40mm and inserted into the motors' shafts. The shaft and PVC were sealed using a 3M marine grade adhesive/sealant and attached to a tee on the frame using rivets. For extra protection, we decided to fill the small piece of PVC full of 3M silicon, along with the rivet holes.

The vertical motor was harder to attach. The shaft is a fitted inside a larger diameter T with a reducer to fit the frame. The other end had a fin which we used to further secure the motor. The fin fits in a slot in a piece of conduit and then bolted to the conduit. The vertical motor is placed at the center of gravity which was found experimentally and high enough to avoid the danger of catching the prop in anything on the bottom.

The motors are heavy and powerful offering 25 N of forward thrust and a speed of 50 cm/s. With each motor drawing only about 7 amps running at high speed, we can stay below our 25 amp limit. In order to eliminate the chance of our tether and other foreign objects from damaging our propellers, we built shrouds out of two steel seven to five inch ductwork reducers. These shrouds also increase the efficiency of the motor in the forward direction by funnelling the water.

The motors are placed near the rear of the ROV to counter balance the weight of the pistons, grippers, and the payload. This position made the ROV handle smoothly and responsively. They are placed on the outside of the frame to increase torque and shorten the turning radius.

Figure 10: *Horizontal motor with shroud*

Figure 11: *The Left Motor*

Safety

Learning the importance and necessity of following proper safety procedures has been a very large part of our team's ROV experience. When we first started constructing our ROV we were constantly reminded by our mentors of what the proper safety precautions were but very quickly these safety rules became automatic. Now if a member forgets to practice safety, rather then a mentor, it is usually another member who reminds them.

While in the shop, goggles were a must when sawing, drilling, or soldering. When dealing with adhesives disposable gloves were also used. Before using a new shop tool, we were always given an explanation of basic operations, all safety features and any associated dangers. When using these tools we had to be accompanied by one of our shop mentors. We were very particular in cleaning up our work space after we were finished with it. A messy work area leads to accidents.

While on the pool deck, life jackets were mandatory. Before launching our ROV into the pool we always tested the three motors and two pneumatic grippers. To ensure no chance of injury to members located near these mechanisms, commands given were always repeated by the technician before they were carried out. This also reduced occurrences of miscommunication. At the pool where we practice, the deck is 1.4m higher than the water level. To diminish any chance falling into the pool, a gaff and launch rope are used when lifting or lowering our ROV into the pool.

PERFORMANCE RESULTS

Periodically we tested the performance of our ROV to evaluate any changes implemented.

CURRENT DRAW

	Low Speed Forward	High Speed Forward	Low Speed Reverse	High Speed Reverse
Left motor	5.5 amps	7 amps	5.5 amps	7 amps
Right motor	6.5 amps	8 amps	6 amps	7.5 amps
Both motors	10.5 amps	12.5 amps	10 amps	13 amps

	Up	Down
Vertical Motor	8 amps	9 amps

	Forward/up	Reverse/up
All motors high speed	19 amps	16.5 amps

Thrust

Motor Direction/Speed	Thrust (Newtons)	Speed (m/s)
Forward High Speed	25	0.47
Forward Low Speed	22	0.42
Backwards High	10	0.22
Backwards low	6	0.1

Buoyancy

To obtain sufficient buoyancy our ROV is equipped with four pontoons, two on either side, all of which are filled with positively buoyant foam. These pontoon's were built using 2" PVC piping, mainly because it was lightweight, readily available and could be cut to any desired length. The two pontoons on either side of the ROV are connected using 2" PVC elbows. Although we sealed all four pontoons with marine adhesive, in case of leakage, we decided to use foam which would not compress due to water pressure at the depth we would be operating. Cutting the foam into the appropriate cylindrical shape we inserted it into our pontoons before sealing them. In addition to our four primary pontoons we have one miniature pontoon located on the left side of the front of our ROV. This pontoon was added to counterbalance the weight of our vertical gripper especially while carrying the basket.

Figure 12: *Alex fitting foam into a pontoon*

Our pontoons are each 610mm in length. In determining this length we weighed and approximated the volume of each major component of our ROV. Our main source of weight came from our three Sevylar motors, which accounted for 6.6 kg of the total 11.7 kg mass of our ROV. To compensate for this weight, we approximated our pontoons needed to occupy 5000cm^3. This would make our ROV slightly negatively buoyant, or have a density of just over 1 g/cm^3. In deciding where to place our pontoons we experimentally found our ROV's center of buoyancy and positioned the pontoons accordingly. We made our pontoons slightly longer than the frame and by doing this, if weight the were added to either end of our ROV we could stay level by sliding the pontoons forward or back.

We choose to be slightly negatively buoyant since so many tasks are performed near the pool bottom. We did not want to have to keep employing the vertical thrusters to stay down. Our variable buoyancy can be used to adjust buoyancy if needed.

To assist our vertical thruster we decided to create a device to obtain variable buoyancy. We achieved this by inserting an adapted motor cycle inner tube into a 2 inch diameter PVC pipe which had several holes drilled into it allowing water to flow in and out freely. This pipe was connected to our air regulator via our tether. By inflating or deflating our inner tube we were able to acquire variable buoyancy. The co-pilot on the pneumatic controls adjusts the pressure. About 25 psi or 273 kPa will fill the tube and, along with our vertical motor, provides the upward force required to propel our ROV up the black smoker when scrapping for rocks and again when we pick up the net at the end of the mission. This system can also bring Hector topside if the vertical thruster fails. Dense Styrofoam is also added to the tether at strategic places so it will not push down on the ROV.

Tools for the Remote Operated Vehicle

Our tools were designed with our mission rationale of finishing all tasks with one trip. We will begin with the gripper system. We knew that we would have to design and build some sort of device that would allow us to grab or manipulate objects. Our initial plan was to purchase a fully functional arm, but after spending several hours searching the web, we could not find anything to fit our needs (e.g., inexpensive and functional). So we decided to create our own arm.

We decided to go with pneumatics for a variety of reasons. We were worried about exceeding the 25 Amp limit. We had access to various controllers and connectors at the community college and pneumatics is a fairly simple system of air in and air out.
The gripper is constructed from a Mastercraft vice gripper. This device's original function is to secure materials to the work bench and hold them in place tightly. We removed the locking mechanism and gripper pads, and then cut a hole in the left handle where the arm of the cylinder was later attached. We filled the gripping mechanism with a piece of rubber we cut to shape. The left handle was securely attached to a piece of Plexiglas. The Plexiglas was chosen for a number of reasons; it was lightweight, transparent, and fairly durable, as well as easy to cut and drill.

The most difficult aspect of building the gripper was getting the arc movement correct. Our salvaged cylinder's stroke was too long, so we had to construct a metal bushing to be mounted in the cylinder to limit the stroke. The 861 kilopascals-rated cylinder is fed by 2 pneumatic lines, one to open and one for closing action. The lines are fed with air by a conventional 120 volt air compressor, located above the surface with the output pressure set to 40 PSI. When we decided that we needed a second vertical gripper, we measured the required movement of the gripper arm and purchased a piston that would do the job. The vertical gripper has a piece of aluminum custom milled by one of our teammates to perform two tasks. It allows us to reach down into end-caps and it holds the net that we carry our crabs and samples.

To quickly capture three black smoker samples we designed and built a rock catcher out of wire mesh and a tin can. This device fits into our horizontal gripper and is scraped up the side of the black smoker until three samples fall into the mesh. It is then released into the net with the crabs.

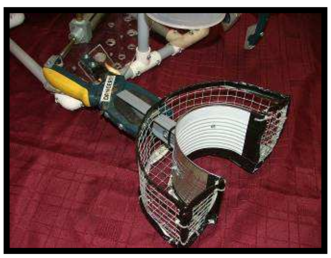


Figure 13: *Rock catcher* in gripper

Figure 14: *Enclosed Thermistor* And CBL

Divers and sea urchin harvesters usually carry a net down with them to allow them to collect their treasures in large bunches and then bring them to the surface by hand, rope, or air bags. We liked this idea and adapted a fishing dip net to lay on the pool bottom.

We fly the ROV down to the bottom, bringing the basket with us in the vertical gripper. When we reach the bottom we set it down in the playing field for easy retrieval. We use the rock catcher to obtain three black smoker samples and land on the top of the vent and position our thermistor above the water flow to obtain a reading. Once this is completed, we move to the basket picking up one crab with the horizontal gripper. The rock catcher and crab are placed in the basket. Next we proceed to collect two more crabs placing them in the basket. After finishing the last mission, we grab the basket by the handle with the vertical gripper and retreat to the surface.

To get the temperature reading we used a small (4 cm) thermistor that was donated by Satlantic of Halifax, N.S. A thermistor measures the resistance between two wires. The resistance increases as the temperature decreases. Initially we attached the thermistor to 18 gauge speaker wire that would stretch back to multi-meter. The thermistor is potted in a 5 cm shaft to make a rigid tool. We filled the shaft with epoxy to make it water proof and to secure the fine wires of the thermistor with just the tip sticking out. Next, we needed to find the relationship between the resistance given on the multimeter to the temperature. The thermistor was placed in a container of water along with a thermometer. A table of values with the resistance reading and the corresponding temperature was created and with the use of a graphing calculator we performed some regressional analysis to determine the best equation relating the two variables. As expected the relationship was inversely proportional. Once the ROV is positioned to take the temperature of the fluid flow, a resistance reading will be obtained from the multi-meter and a simple conversion will give the temperature reading. This worked well in testing but not in trials. We decided that the speaker wire may have offered too much resistance or there was too much interference from the other wires. We then built another unit using shielded four strand wire. This worked much better but our confidence was shaken. Using a Texas Instrument Calculator Based Laboratory (CBL) temperature probe we spliced into cable and added a 20 m length of CAT 6 cable and found it to be very fast and accurate. Since the temperature reading is such an important part of the mission we have decided, in the spirit of redundancy, to use two systems. Our sensor technician determines all readings and communicates them to the judges.

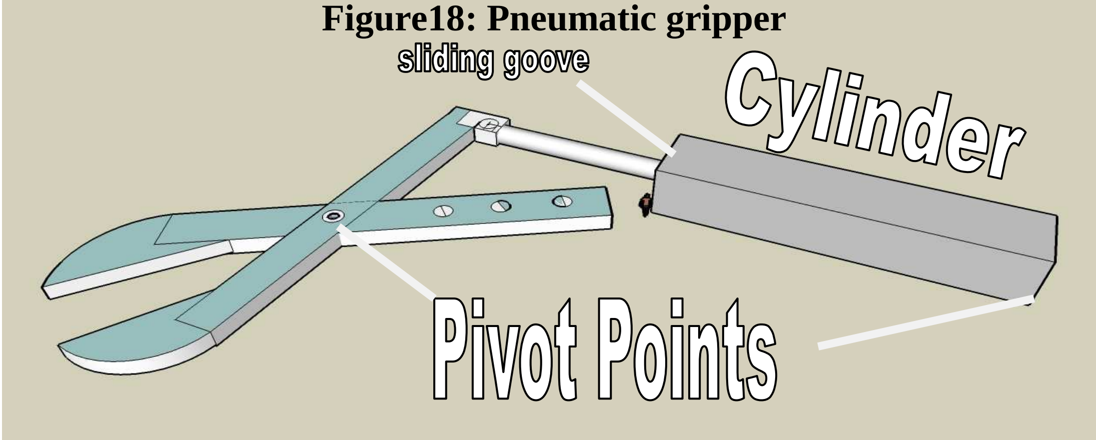
We placed the thermistor in a funnel that is located at the front of the ROV. The pilot will position the funnel over the black smoker and drop onto it. This funnel will allow us to stay in position to take an accurate reading. The thermistor is positioned so that when the ROV sits on the black smoker the end will be right in the water flow. The funnel will also enable us to take a more accurate reading of the outflow water with less interference from the surrounding water. It is necessary to allow some water flow out of the top of the funnel other wise we have an air pocket which will interfere with movement of the ROV or excess water flow could push the ROV off the black smoker

Figure 15: *The Basket*

Figure 16: *Vertical Gripper*

Figure 17: *Horizontal gripper*

Figure18: Pneumatic gripper



Challenges

As a team, we faced many challenges. Living in a rural community means a lot of travel. The nearest pool available for testing was over 4.0m deep and required about 3 hours of travel time and some missed suppers. With a lot of fundraising we were able to pay some cost of meals to ensure that all team mates could participate. While building and testing our ROV the challenges were many. Mastering buoyancy, motor failure, camera positioning and constructing our pneumatics box were just a few.

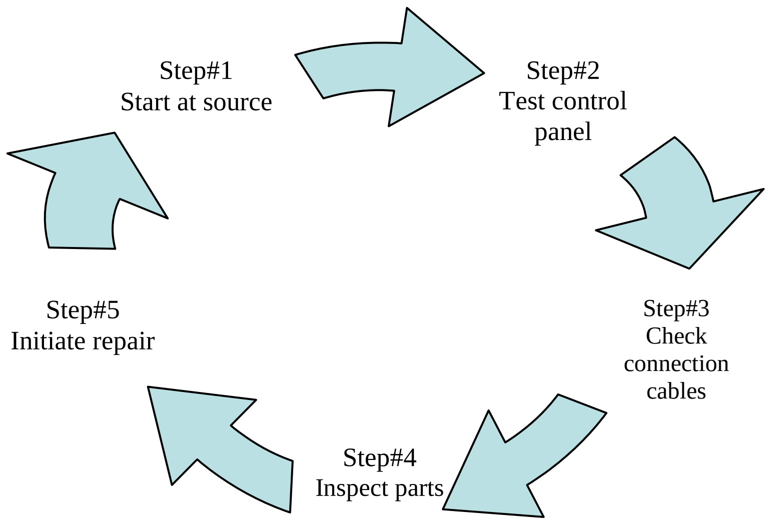
By far, our biggest challenge came from the motors. The motors we planed to use on this year's robot were the three 12 volt Sevylar trolling motors from the previous year. However, after doing testing, two of these were deemed unreliable. They were drawing too much current and were found to have taken in water. We think that working at over 4 m depths and the chlorine water from last years competitions and trials damaged the seals. We decided to order 2 of the same motors since they were powerful, affordable, and easily attached to the frame. The motors are designed to sit at the end of a metre long shaft with the throttle at the other end. The first thing that had to be done was to cut the shaft to a practical length. This was where we ran into our first problem. We marked off the first pipe to be cut at a length where the motor wouldn't protrude too far from the frame. We cut through the outside pipe, but unfortunately also into a coil of wire that lay beneath the external pipe. It turned out that this coil of wire was the speed coil, which works as a resistor for slowing down the current, and giving the motor a low speed. This mistake was made because the speed coil in last year's motors was actually inside the motor, not inside the shaft. No information that came with the motors suggested this change. Luckily we were able to solder the coil without causing any further damage. There was a loss of some wire that we thought might cause this motor to have a very different slow speed that the other, but the difference was minimal.

We felt confident in our motors until the night before our regional competition when we encountered a major motor problem. While doing a routine motor test, we noticed an unusual sound coming from our left thruster. After disassembling the motor, we found it was full of water, and one of the permanent magnets was out of place. The chlorine water had deteriorated the adhesive used to hold it the outside of the housing. The water entered our motor from the seal at the propeller shaft. This occurred because the water pressure, at the depths we were operating, was too intense for the seals. These motors would normally be less than 1 meter underwater. All attempts at repair were unsuccessful so we went to the shop and brainstormed. A few weeks earlier Alex had spent a day making one functional motor out of spare parts from last years motors. This was our only hope. The damaged motor was cut out of the frame, the vertical motor was moved to one side for balance and the rebuilt motor was placed in the vertical position. The frame was reassembled and the wires were soldered and sealed. A quick test in the pool showed that the motors were ready to go. It was at this moment that we all realized how much we had learned and how much of a team we had become. We were able to perform this major refit under a great deal of pressure with no assistance from mentors or experts.

For the international competition, we ordered two new motors for our ROV. One of these will replace the motor assembled from spare parts while the other will replace our right thruster, which was also struggling during the regional competition. To ensure a similar occurrence does not happen again, we are using a high pressure seal on the shaft. Although these problems required time and money, they also led to a much greater understanding of the workings of our motors. We are now confident and better prepared to tackle any further problems we encounter.

Trouble Shooting

When a problem occurs, we found it easiest to start from the source of power (i.e. battery or compressor).The next step was to check the controls and make sure all lines were connected. If the problem was still occurring, we followed our tether to the robot, inspecting cables and hoses. We then check the actual part on the ROV. Once we find the source of the problem, we attempt a fix and then test before we re-enter the pool to assure there are no further problems. This technique was used in the regional competition when our pneumatic operator felt a loss of pressure and went strait to the compressor, which had been altered.



Lessons Learned

Some of the many lessons learned included things about safety, team building, hands on skills, and compromising in decision making. Over the course of the year we have paid close attention to safety while building our ROV. Many first time experiences with tools were made more comfortable with the emphasis on safety.

Most of the construction and testing of the ROV was performed at the Port Hawkesbury campus of the Nova Scotia Community College. When advice was needed we spoke to faculty members who would inevitably spend some time talking about their courses, job experiences and training. This exposed us to a wide variety of future career choices.

To create our control system we had to understand all components of series and parallel circuits. Our electrical controller circuit was planned and paper, a wiring schedule was set and we began. Soldering wires to wires and wires to switches is now an easy task as we have learned a variety of soldering techniques. It seemed every person we asked had different techniques. Team members developed their skills through practice before wiring a major component.

The biggest lesson was probably the importance of team work. We were not classmate or friends initially but as time went on we became close. In school we often work alone on projects or tests but this is a project no one individual could complete so communication and “soft” or people skills became very important. Before making any major decisions, every team member had to address the issue and state their choice. This required us to be informed and able to communicate. We all felt like our opinions mattered and that no one individual was dominant and even though you may not agree with every decision it was important to learn to support a decision once it was made.

Future Improvements

It is hard to think of the future when, for us, it seems we have only just begun. Yet there are some things we would do differently if we were to do it again.

We would consider making Hector smaller. Our robot is functional, but it is just a bit clumsy in the three meter squared enclosure. We would also consider using a video game joy stick or adapting 12-volt drill triggers to control our motors allowing us to have more variable speed.

For another educational experience and to add to our technical report, we would take a course in Auto-Cad. This would allow us to make better looking and more accurate diagrams of our frame and control boxes. By starting earlier next year could allow more time for these experiments.

Clearly a lot of problems could have been avoided if we had replaced the major seals of our motors with better quality, high pressure seals. We wanted to be independent but this was a case where seeking out help from experts would have been a great idea. Much can be learned from those who have more experience.

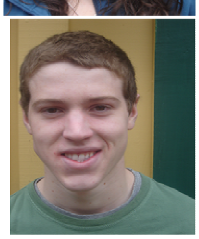
All in all we are happy with our ROV's capabilities, and feel ready to compete.

Reflections

Gerald Mouland is a graduating member of our team. Gerald was a primary tool designer and was the creative force behind the poster. "This has been one of the most rewarding experiences I have had the pleasure of being involved in. To see something through from initial planning to an end product I can be very proud of is something I will remember for the rest of my life."

Amanda Lowe is currently in grade eleven and team co-captain. She has taken ownership over all things electrical.
"This has been one of the best experiences of my life. It has opened the door to a career opportunity as an electrician"

Carolyn Murphy is another graduating member of the Dalbrae Aquatic Robotic Team. She helped take on the challenge of designing and wiring our electrical panel. This is her first year on the team, but she will carry these experiences and memories throughout her life.
"I walked into this project not knowing the difference between a male and female plug, now I can tell you everything and anything about our electrical systems and why we did what we did."



Milton Lywood is one of the graduating members of our ROV team. His primary area of focus was buoyancy; however he also aided in the construction of the pneumatics box and is team captain. "Throughout this process I learned that not everything works out as planed the first try. However if you continue working hard your efforts will eventually show results."

Danielle van Zutphen is a grade ten student. She was involved in the design and construction of the pneumatics box and the grippers.
"By taking part in this competition I have been able to learn many new skills around tools and how to work with a team. Overall it was a great experience and I would recommend it to anyone."

Alexis Dunphy is in grade ten whose area of expertise was constructing and controlling the pneumatic grippers and the variable buoyancy
"This experience is like no other. I have been in many clubs and teams, but none compare with ROV. I have never had so much fun or worked so hard on any project in my life. I love this experience ".

Alex Heukshorst is a grade eleven student. Alex was most interested with the electric motors, along with the frame and tools.
"I had a blast with this years ROV team. With all of the problem solving and designing, the experience really got me interested in a career of engineering. I can play guitar too."

Isaac Matheson is currently in grade twelve. This is his first year on the ROV team. His main area of focus was the frame. During the competition Isaac will be one of the team's two pilots.
"The importance of teamwork, listening to others and contributing ideas is one I will carry into my future plans"

References

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http://www.ocean.udel.edu.
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Electrician Tom Malloy

Acknowledgements

It is said that it takes a village to raise a child; this saying surely applies to this project. Our success would not be possible without the help of many. We will take this opportunity to thank all the people who made this possible.

First of all we would like to thank NSCC without whom we would never have been able to complete this project. They generously donated pool time and access to shops and tools. They also organized the regional competition and set up funding for travel expenses to California.

We would like to thank Marine Advanced Education Center (MATE) for organizing this on an international level and creating such a challenging task. There were many people who helped us complete this project. We would like to say thank you to Tom Molloy for help using Auto Cad to turn our hand drawn sketches into professional looking documents, Rand Heartly who let us use his shop for machining, and Brenda Dunphy who helped organize this project from a regional level. Also, Ed Dunphy who was our mentor, he organized, drove and gave up much of his time to this project. Without him there would be no Dalbrae Aquatic Robotic Team.

Thanks must also be given to the Dalbrae community for their support of our endless fundraising. There were bingos, raffles, draws and work opportunities made available for us to raise the required funds.

Last, but not least, we would like to thank the judges for sharing their time and experience.

The full list of all of those who contributed financially or donated material below is an indicator of the support our team received.

Lake Mabou Farms Ltd.
Matheson Building Supplies
MacKeigans Pharmacy
Essentially Yours Hair Salon
Seaboard Tire
Fair Isle Motel
B& N Distributors
Haverstock Funeral Home
Gordies Welding
Causeway electrical
Wilson’s Carpentry
MacKiegans Pharmacy
U.A. local 682 Apprenticeship Training Fund
Victoria Court Dental
Ideal Concrete
East Coast Credit Union
Canadian Tire
Royal Bank of Canada
Nova Scotia Power
Standard Auto Glass
Central Supplies
NewPage
NuStar Energy
Whycocomagh Lions Club
Exxon Mobil
Nova Scotia Community College
Nova Scotia Labour and Workforce Development
ENCANA
Nova Scotia Energy
TechNova
MATE

Appendix A

DART ROV BUDGET 2008

Donations

Name	Amount $	In Kind
Ideal Concrete	500	
Lake Mabou Farms	150	
MacKiegans Pharmacy	250	
Seaboard Tire	100	
NS Power	200	
New Page	500	
B&N Distributors		215
Canadian Tire		499
Central Supplies	50	
Gordies Welding	50	
Wilsons Carpentry	100	
Haverstocks	100	
Royal Bank	50	
NuStar Energy	200	
Standard auto glass		20
Cause way electrical		20
UA local 462 apprenticeship fund	500	
Victoria Court Dental	100	
MacKiegans Pharmacy	200	
Totals	3050	754

Money Earned

Dec. Bingo	142
Jan. Bingo	90
Feb Bingo	228
HS hockey	200
50/50 frisbee	69
Raffle	640
Total Earned	1369

Total Money In 4419

Expenses

ITEM	COST	DONATED	SALVAGED	ESTIMATED COST
Underwater camera	240			
3 Syvylar motors	451			
PVC and conectors for props	79.23			
pneumatic piston	95			
pneumatic hose	42.5			
nuts and bolts	52.25			
pnuematic connectors	30.34			
shrink tube	43.99			
switches for motors	48.31			
velcro for props	45.09			
connectors for frame	43.94			
glue, tape, tie wraps	172			
rivet tool and rivets	32.75			
connectors/tubes for bouyancy	38.6			
Tech report supplies	65			
marine silicone	22.59			
fishing dip net	32.18			
teflon	7.49			
caulking gun	7.99			
rubbermade containers	59.99			
Third camera	175.4			
Printing of Poster	150			
funnels	42			
Meals	258			
one vertical motor			s	200
60 ft pnuematic hose			s	
elbows and tees		d		35
180 ft of speaker wire		d		45
horizontal piston			s	70
swithces		d		50
pnuematic controller			s	125
plexiglass sheeet		d		30
thermistor and cable		d		50
2 Mastercraft vice grips		d		17
Total Donate/salvaged				**622**
Total Expenses	**2235.6**			

Appendix B

Motor Electrical Schematic