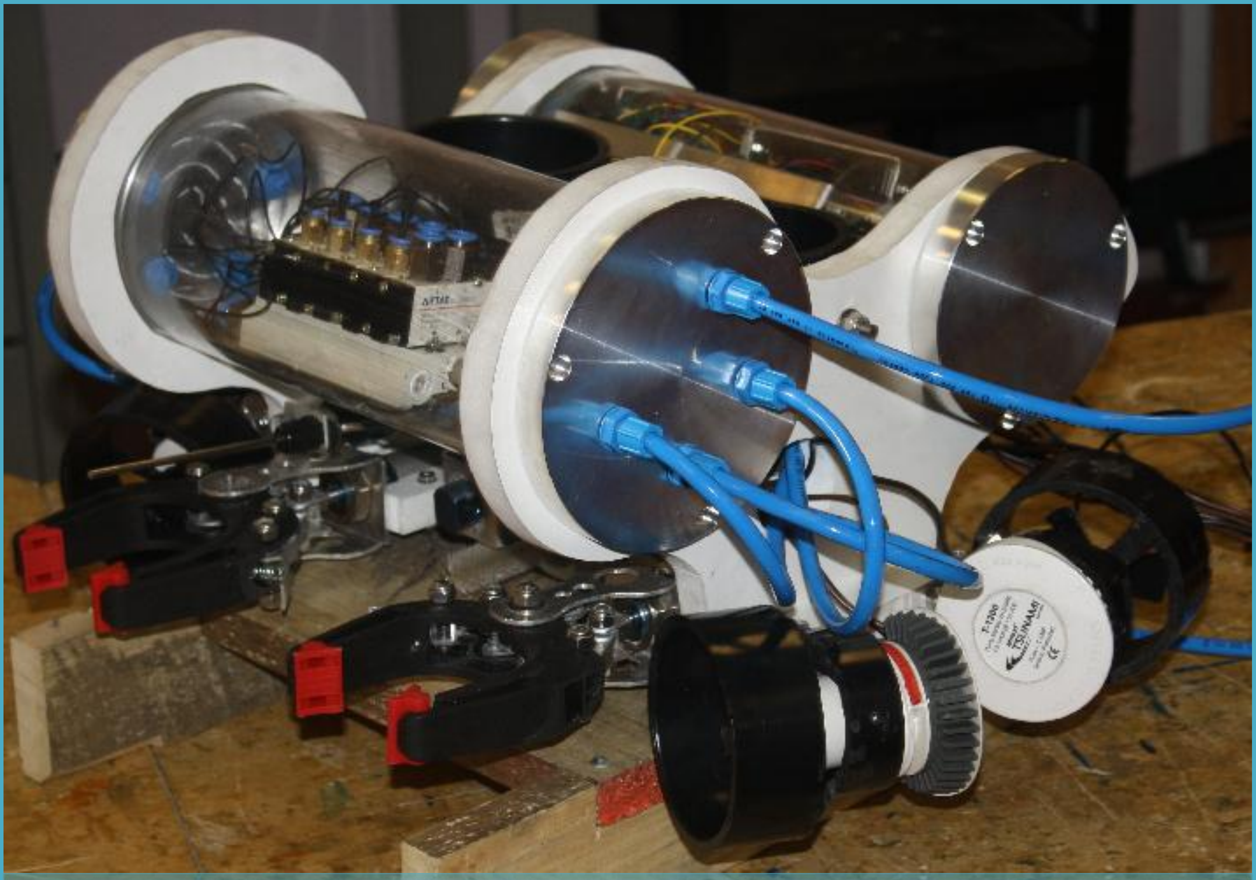
The Vision



NOVA MARINE

AUBURN DRIVE HIGH SCHOOL

Ryan Adderson- Head of Construction

Andrew MacMaster- Head of Design

Michael Adderson- Process Engineer

Cameron Francis- Public Relations

Cameron Mason- Construction Engineer

Justin Trainor- Process Engineer

David Zorychta- Assistant Programmer

Greg Horne- Head of Electronics

Dimitry Vinogradov- Lead Programmer

Spencer Farrell- Production Engineer

Melissa Kirchner- Technical Assistant

Ben Power- Construction Engineer

Jeremy Wentzell- Electrical Technician

Frank McMahon- Mentor

COLE HARBOUR, NOVA SCOTIA, CANADA

Abstract

This year, we at Nova Marine have invested much of our time into designing a brand new ROV, with entirely new systems, design and overall feel. Our approach was more scientific than in past years, as we focused the bulk of our efforts on brainstorming and coming up with creative solutions to problems as put forth by the MATE Center. We feel that this year we have advanced further than in any of the past 7 years of competition and are excited about the opportunity to demonstrate the capabilities of our ROV.

All of our systems were built completely from scratch, as we decided that we needed to improve every aspect of the ROV so that we could progress as a team. With an increased level of creative freedom, we set out to design an ROV that was as functional as possible, intuitively designed and aesthetically appealing. We have achieved these goals through a complete overhaul of our frame design, a new electronics and pneumatic setup, and other new integrations. These, along with the contributions of many new company members, have made our team ready for this year's international competition.

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Figure 1: The Nova Marine team

Design Rationale

Early Planning

This year Nova Marine dedicated more time towards designing and laying out all the aspects of the ROV before any construction was done. Several weeks were spent brainstorming ways to attack each of the challenges for this year's competition. The largest overhaul in this respect was the frame. In past years a PVC pipe frame was simply assembled before designing any payload tools. This year however, the payload tools were designed and built before looking at frame options. This allowed for the building of a frame of minimal size and weight giving us a sleeker and faster robot. It was these types of decisions made during the planning phase that allowed us to be more innovative and efficient in how we completed the tasks. The decision was also made to learn how to use the 3D modeling program SolidWorks to aid in the design phase. This allowed the ROV to be laid out with great detail in the components and tools to minimize wasted time and materials.

The Mini Sub

One of the earliest decisions in designing the ROV this year was the creation of an aptly titled *Mini Sub*. It was a small ROV that was quickly assembled as a means to test tools prior to the construction of the actual ROV. While designing and constructing various payload tools, it was common practice to attach them to the Mini Sub for a quick test run in the test tank. The Mini Sub is of fairly simple construction, using a PVC. This allowed for a rapid build, as well as making it very easy to add payload tools, and cameras; all of which were only temporarily fixed on the frame. The cameras used on the Mini Sub were attached using spring-loaded grippers which could be moved at a moment's notice to achieve the necessary view angle of a given tool.

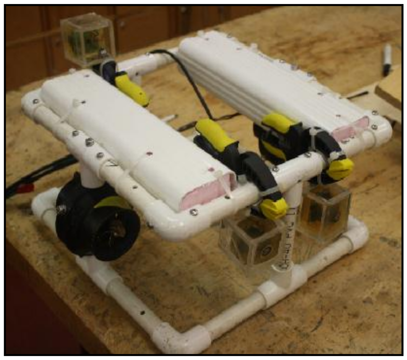


Figure 3- The Mini Sub

Our team set numerous deadlines early on in the design process and worked diligently to meet them. Although some of these were slightly optimistic in terms of team expectations, most deadlines were met without many problems. When deadlines weren't met, it was, in most occasions, the result of an unfortunate shipping delay.

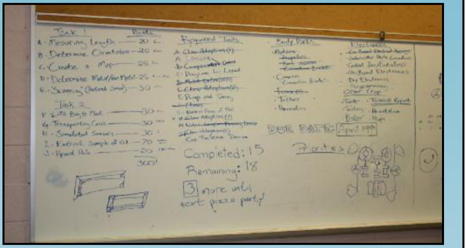


Figure 2- The ROV checklist

A list of all team goals, with items being crossed out as we worked through the process, covered an entire white board in our shop and was constantly being referred to. Although it was initially a simple checklist to ensure that we weren't missing any important pieces of the ROV, it turned out to be an essential tool that helped propel the team forward, as the team morale was always highest following a day in which several items got crossed off the list.

Payload Tools

Claws

The robot incorporates two multipurpose claws designed to complete a variety of tasks. The team's focus was on designing small and simple claws which could serve to accomplish, with efficiency, the given missions. The claws are essential in carrying the lift bag, measuring the shipwreck, picking up corals and are integral in the attachment of the end cap on the oil drum. The claws were tested on the Mini Sub extensively in order to determine the exact spacing required in order for the cap release to function properly.

The claws are powered by a spring-loaded pneumatic piston. The piston pushes two metal bars forward which are connected to the right and left sides of the claw. These bars are connected at such an angle that when pushed forward, the claw closes, and when released, the claw is pulled open. The fingers for the claws were cut from a simple grabber and were adjusted to better serve their purpose.

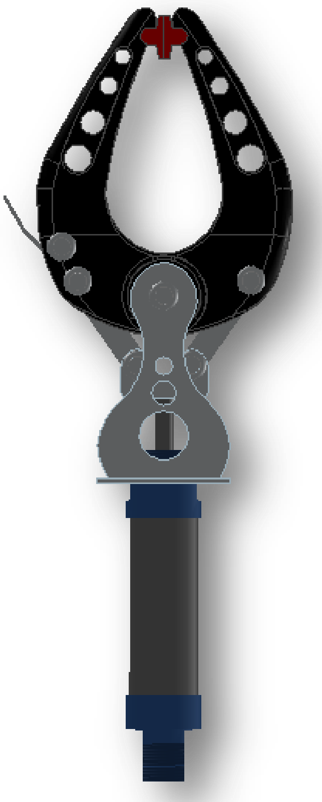


Figure 4- A SolidWorks rendering of one of the claws on our ROV

These claws are a vast improvement over the claws which were used in previous years. The compact design is ideal for the tasks of this year and the addition of a second claw allows the ROV to perform certain tasks such as the moving of the corals with increased speed. It was also decided that, although this was more complicated and involved much more precision in building, the added range of motion, as well as having a truly multifunctional claw, far outweighed the simpler option of using the basic and bulky claws that have been used in past years.

This year, the decision was made to implement a dual claw system. By including two claws, instead of the usual one, there is an increase in the flexibility of how we approach the mission tasks. This choice seemed quite obvious early on when the missions were read, as it was clear that the claws would be play an important role.

By having two claws, both corals can be collected in a single run, instead of having to grab them one at a time, which could slow the ROV down. It also was very useful when designing our cap release, as the final design would not have worked with only used a single claw.

Being able to solve problems in a creative way is something that appealed to the team early on, and being able to use the two claws in a multitude of ways is very beneficial

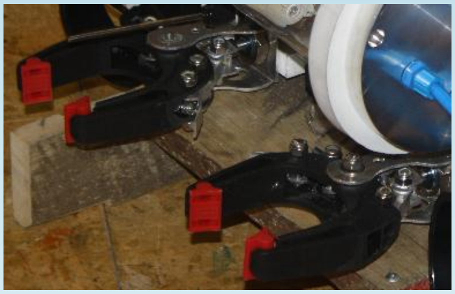


Figure 5- A close up of the dual claw system

Water Sampler

The water sampler consists of an extractor that feeds into two 60 ml syringes. This is a modification from the design last year, which used four syringes and was found to weigh down the ROV far too much and resulted in complications. Trying to move vertically with the added weight was a constant problem. With a more compact design however, the sampler was found to be far more efficient.

The sampler is located as close to the center of inertia as possible so that the additional weight of the water will have minimal effect on the ROV. The sampler works by a pneumatic piston that pushes the extractor back and forth. Likewise, the syringes are filled by a piston that pushes on their plunger and results in the vacuum force that draws the liquid into their chamber.

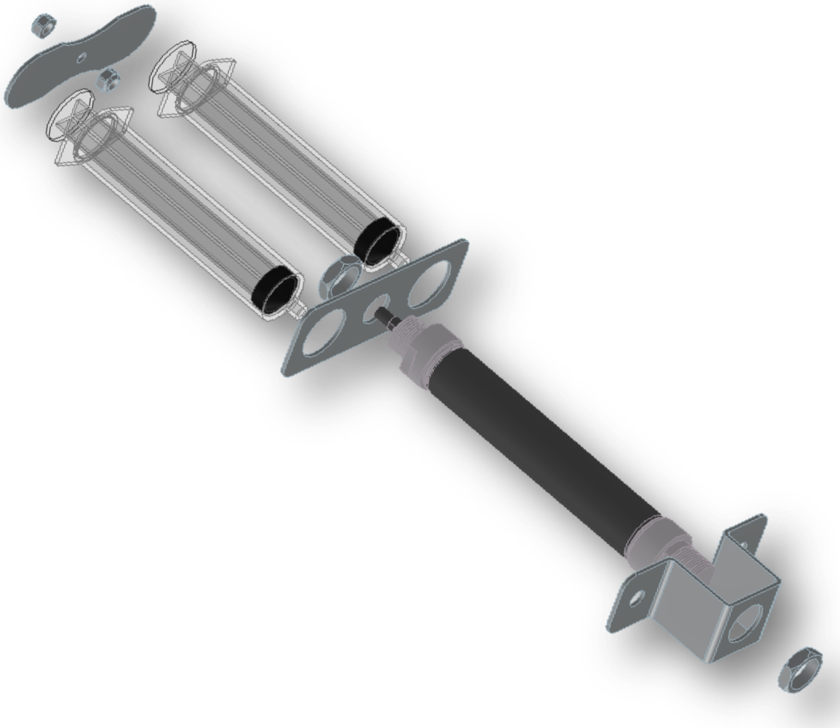


Figure 7- The exploded view of the water sampler

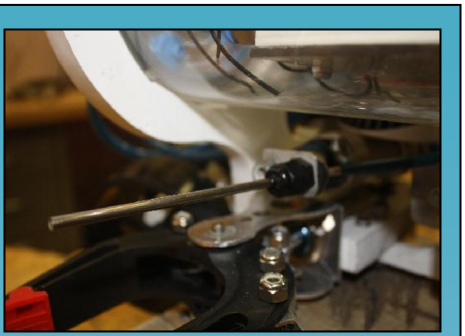


Figure 6- A close up of the extractor

In order to pierce the petroleum jelly in the oil drum, a simple metal straw which is attached to a small pneumatic piston is used. The extension of the piston pushes it through the jelly and allows access to the liquid. The metal rod has IV tubing connected to the back end which feed into the syringes in the water sampler.

The extractor is directly above the right side claw and is fixed to the frame with two PVC brackets. Fortunately, the extractor itself is very small compared to the other payload tools, allowing it to easily fit into small gap.

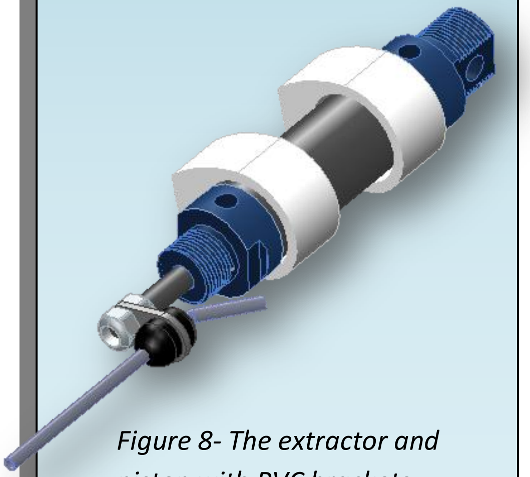


Figure 8- The extractor and piston with PVC brackets

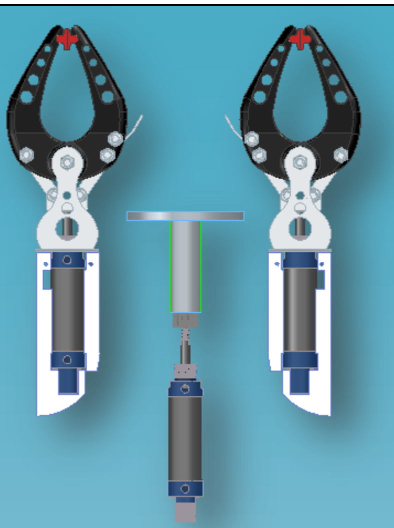


Figure 9- Piston is in its retracted position.

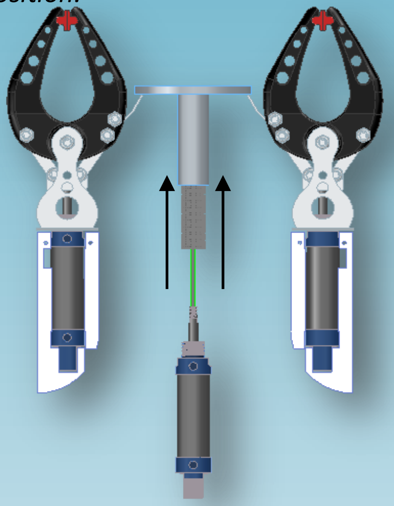


Figure 10- Piston extends and spring-loaded metal brackets hold cap in place.

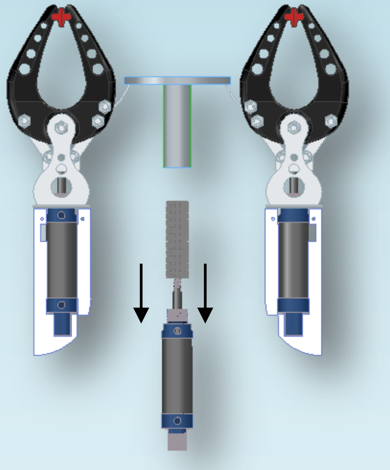


Figure 11- The piston retracts back to its original position without the cap.

Metal Detector

For the task in which several debris piles must be analysed to determine whether or not they contained metal, the team was able to obtained a small, 15mm long metal detector. This device fits into a small hole in the claw and is capable of detecting metal as long as it is within 50mm of the debris. The controller is programmed so that it will vibrate whenever the sensor is activated in addition to triggering a response in our graphic user interface. This assures that the pilot will be made aware of any trace of metal contained in the debris.

Figure 12- The metal detector

Cap Release

The cap release device is made up of two parts, the piston and the locking mechanism. The piston consists of a single pneumatic piston with a test tube cleaner attached to its shaft. The shaft extends enough to bring the cap out past the locking mechanism so that when it is retracted the cap will be completely free of the test tube cleaner, reducing the risk of breaking the cap from the oil drum when the ROV retreats. The test tube cleaner creates a force of friction between the bristles and the PVC pipe so that it does not slip off.

The locking mechanism consists of two spring-loaded hooks that are built into the side of the claws. They have compression springs that allow the wellhead cap to push past the hooks but will release once the cap has passed, locking the wellhead cap at full extension. The original hook design was problematic because it failed to lock properly. This was improved by adding a small piece of metal that will contact the side of the claw, forcing the hooks to lock.

Measuring Distance

To measure the length of the shipwreck this year the team had a few ideas including the use of a water-proofed laser pointer. Ultimately, it was decided that an underwater camera would take a picture from one end of the shipwreck and use trigonometry to calculate the distance to the other end of the ship. This can be accomplished because the angle of vision of our camera is known and the actual diameter of the PVC pipe on the other end of the ship is given. The formula for this can be seen in Figure 13.

$$\text{Distance} = \frac{(\text{Length of Screen})(\text{Actual Length of PVC})}{2(\text{Length of PVC on Screen})\tan\left(\frac{\text{Angle of Field of Vision of Camera}}{2}\right)}$$

Figure 13: the formula used to determine the length of the sunken ship

This method proved to be incredibly efficient (within .5 cm) as long as a high resolution camera was used. A high-resolution board camera was located and waterproofed specifically for this purpose.

Figure 14- A typical pneumatic piston

Pneumatics

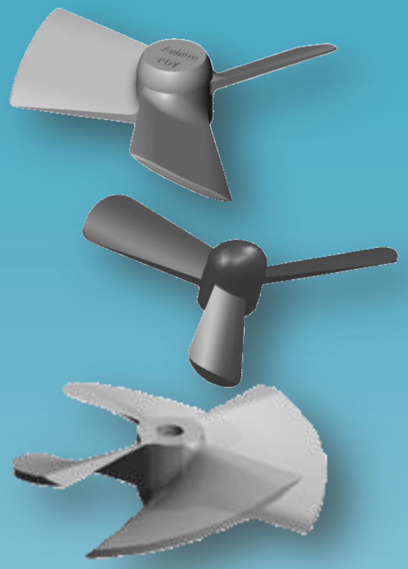
In last year's competition, six pneumatic tubing lines were used for three pistons, making the tether very stiff and ultimately slowing down the robot. With the expected number of pistons this year rising to five, more pneumatic lines would have been required slowing down the ROV even further.

The solution was the use of a five way pneumatic multiplexer which was placed inside one of our two acrylic tubes. This way, only two tubes were needed travelling down to the ROV. It was a difficult component to master, but it proved to be one of the most useful pieces that was purchased, as it cut down the tether size, increasing speed.

This year, pneumatics are a major component of our design, as five pistons are used in the various payload tools. This would have required numerous tubes going through the ROV which could have become very messy. To simplify the setup, as well as reduce the number of bulkhead fittings needed on the 5 inch end caps, springs were inserted (see Figure 12) into four of the pistons. By doing this, only one tube is needed for each of these pistons because when the air pressure is shut off, the spring will revert to its normal position.

The exception to this is the water sampler. Last year the water sampler moved too slowly, so adding a spring to the piston was decided as being too risky. Also, since air pressure must be maintained in order to keep the spring retracted, the water sampler would have used up the majority of the air pressure once the sample was taken. For these reasons, the water sampler still uses two pneumatic tubes.

Figure 15- The rod of the piston from one of the claws with a spring



Figures 16, 17 & 18 (from top to bottom): SolidWorks models of several propeller prototypes

The above images show some of the propeller styles that were tested for use on our thrusters. In the end the propeller in Figure 16 was shown to be more efficient, and more powerful than the propellers that were used last year. Coupled with stronger bilge pump motors thrust has been increased significantly this year.

Having the ability to print custom propellers this year has been very exciting and gives the team an added level of creativity. Being able to experiment with a greater variety of propellers has also been beneficial as the team now believes that we have enough speed to accomplish the missions with sufficient speed to earn a time bonus.

Thrusters

For thrust this year, our company decided to use Tsunami bilge pumps, which were stripped down to act as thrusters. The bilge pumps were chosen for having large amounts of power, while having minimal current draw, as well as being light weight. As with last year, vectored thrusters are used for all horizontal movement, however, the angle has been adjusted to be closer to 30 degrees, instead of last year's 45. This will give our ROV more manoeuvrability than in previous competitions. The design also has a pair of vertical thrusters located in the center of the frame.

A new, exciting feature is the use of propellers which were made by a 3D printer. The design team created numerous models in SolidWorks and tested them in a simple contraption to see which would be the most powerful. In the end, a simple three blade propeller won out, and is used on all of the thrusters.

Figure 19- Setting up the initial test run to see which propeller was most powerful, while also having minimal current draw.

The design also uses ABS pipe converters as kort nozzles. These act both for safety and functionality, shrouding the blades from the external environment, and directing the water flow in one direction. Using an air powered cut off wheel, large sections were removed from the pipe converter to allow for the smooth flow of water. This is a large improvement over last year's kort nozzles which were awkward and had minimal effect.

Frame

This year, the design team departed from the usual frame design, which was a cube made from PVC pipe. It was decided that this created too many problems with connecting various components, as well as not being very swift. A common practice of the company in previous competitions was building the frame first, and then simply throwing everything onto it, which created large amounts of undesirable empty space.

The frame was constructed using 3/4" PVC sheets which were cut to specific shapes using a jig saw. This gives a new level of control over the exact shape of the ROV, and allowed for a far more elegant design. The frame consists of two identical pieces of the PVC sheet. Everything except for the four horizontal thrusters can be found between these two pieces.

Many brackets were made from this PVC sheet as it was found to be easy to work with and inspired creativity in solving problems with spacing and positioning. The water sampler was a good example of this as the design required fitting the syringes into the middle of the frame, which was difficult until the construction team cut two new brackets which were found to be very smooth and simple.

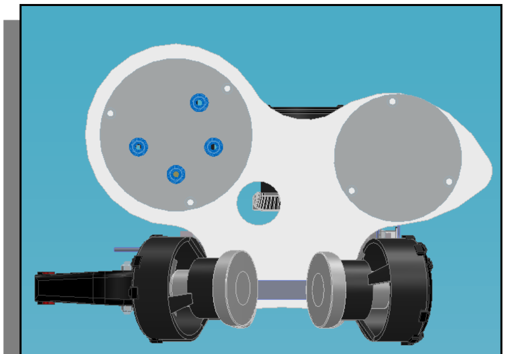


Figure 20- Side view of the ROV

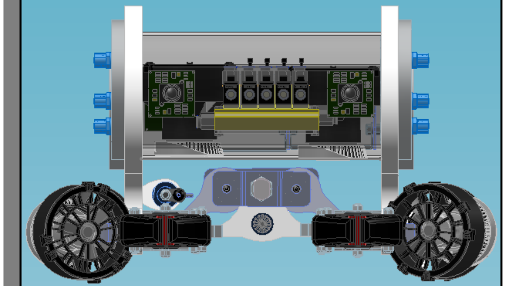


Figure 21- Front view of ROV

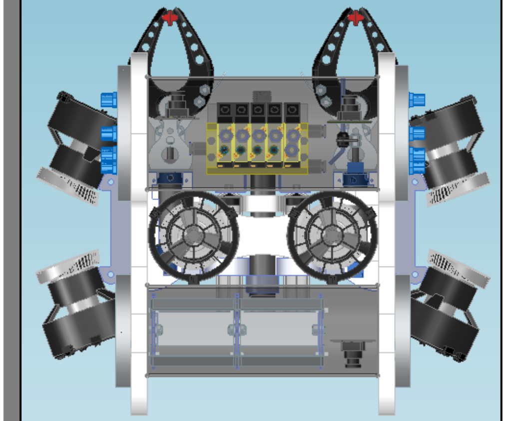


Figure 22- Top view of ROV

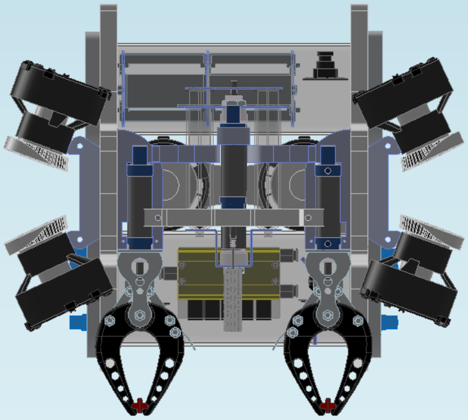


Figure 23- Bottom view of ROV

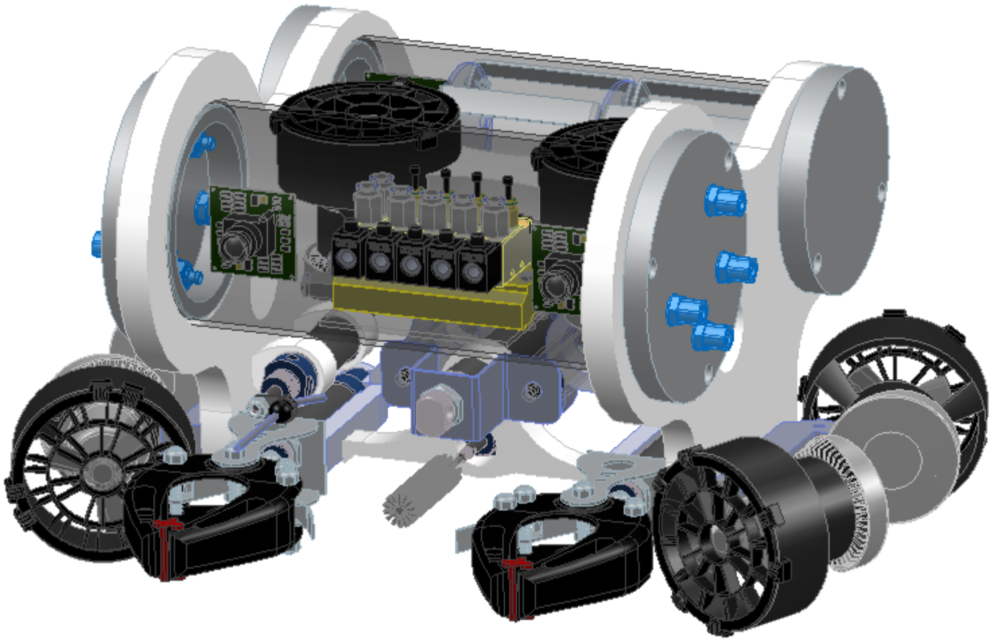


Figure 24- SolidWorks rendering of the ROV

This year, with some of the electronics being on-board, Nova Marine has decided that end caps were necessary for the acrylic tubes. A simple design was made in SolidWorks, which was made at the Nova Scotia Community College using a CNC machine.

These caps became an integral part of the buoyancy system. After our initial testing, it was determined that about six kilograms of mass would be needed for the ROV to achieve neutral buoyancy. The end caps made up a large part of this mass, weighing a combined three and a half kilograms.

The front caps each have four holes drilled for pneumatic tubes and another one for the electronics and cameras that are located in front. The back caps only have holes drilled for electronics, which use multi-pin, waterproof connectors.

Figure 26- One of the end caps with the pneumatic tubes plugged in

Buoyancy

Buoyancy is always a difficult part of designing ROVs. This year it was decided to use a pair of large acrylic tubes to house numerous electronic and pneumatic components and the design team saw that this could also be used as a means of buoyancy. Since the tubes are mostly filled with air, the team thought that they would be able to cancel out virtually all of the heavier pieces of the ROV, although some additional positive buoyancy was expected to be necessary.

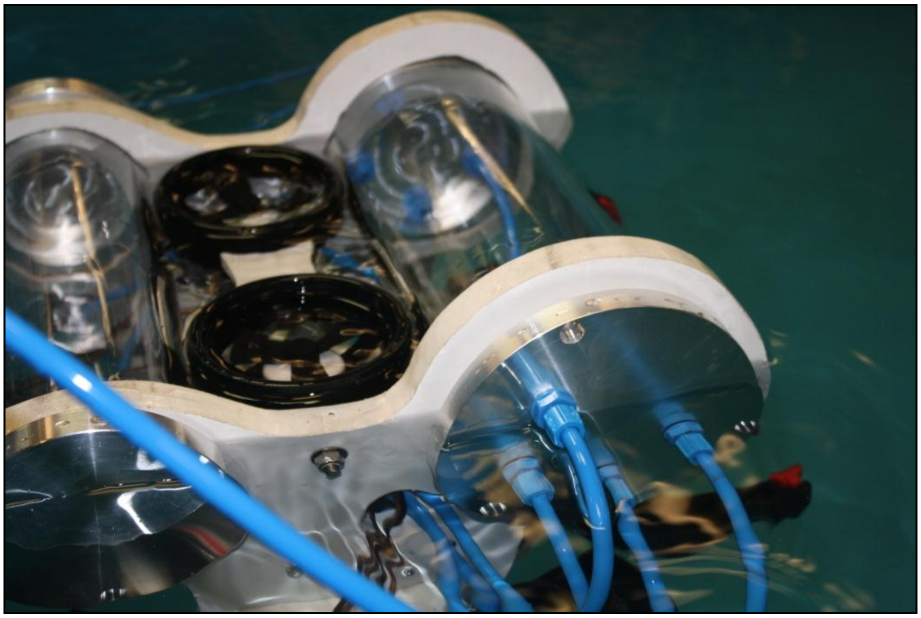


Figure 25- The first buoyancy test following the acquisition of the end caps, which caused a large change in buoyancy

The tubes made the vehicle incredibly positively buoyant, and forced a design change. Originally the end caps for these tubes were to be made out of plastic so that they wouldn't weigh the ROV down. Instead, they were machined out of aluminum to add some mass in the easiest way possible. The pneumatic multiplexer was also very useful at this time, as it weighs one kilogram on its own, which helped bring down the ROV further. By this point a large amount of our buoyancy problems had been solved, and by adding some stainless steel to the bottom of the ROV, the vehicle was stabilized.

Electronics

On-Board Electronics

Last year was the first year that Nova Marine attempted to use on-board electronics, and it was a complete disaster. The housing was not water proof and leaks were a constant problem. The problem was rectified this year however, as the ROV uses a pair of acrylic tubes and aluminum end caps with an O-Ring to create a watertight seal. The end caps were designed by team members and made at a local community college using a CNC machine.

Since the electronics were housed in cylinders, wiring needed to be very precise. In the 4" tube, sheet acrylic was used to cut discs that fit into the cylinder and are connected by several metal brackets, which also act as heat sinks. This tube houses several sensors, such as a gyroscope, solid state relays and humidity sensor, as well as the six motor drivers.

Figure 28- The pneumatic multiplexer

On the inside of the 5" housing, there is a pneumatic multiplexer, as well as a pair of cameras which are positioned over each of the claws. A small piece of acrylic was cut so that the multiplexer would stay in place. The cameras on the other hand, are attached using a piece of PVC pipe which has been cut and drilled to support the cameras.

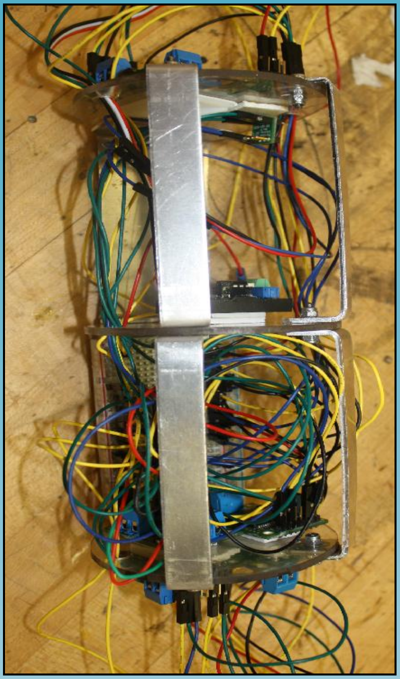


Figure 27- The disks with the various on-board components

The electronics disks contain all of the motor drivers and other sensors. All of these devices are wired together as seen in Figure 27 through the use of a small breadboard. Using the breadboard simplified the process of connecting the electronics because the amount of soldering required was significantly reduced, and if an error was made, it could be corrected very easily. This component is a snug fit inside the 4" acrylic tube.

This year the program for the robot was written using the Arduino software. This allowed for the use of libraries for the PS2 controller and sensors. With this we were able to receive more feedback from our program for easier troubleshooting and manipulation of the code.

The Pololu motor drivers have diagnostic pins which can be used to communicate with the Arduino microcontroller to give feedback on the efficiency of the system. This allowed the team to find the optimal settings for the Pulse Width Modulation pins to get the most thrust out of each motor. The microcontroller also has 55 data pins for sensors and onboard electronics, all while using under an ampere of current. The use of a microcontroller is a huge advantage over direct connections using only relays and switches because of the range of compatible sensors and the ability to create a program that is unique to the robot.

Figure 30- A closed control box

Surface Electronics

A goal this year was to have the control system contained within easily accessible and transportable boxes. Two executive 46cm x 33cm x 15.5cm aluminum briefcases were used. Each briefcase contains a monitor, video multiplexer and the 12V DC power lines. The first case contains the 12V 25Amp fuse and the main rocker switch. The second case houses the Arduino mega, high amperage solid state relay, PS2 controller and the amperage sensor.

Figure 29- One of the control boxes with the monitor velcroed in

Connections going into the cases go as follows: Power enters the first case from the external power source and is jumped to the second case through banana plugs. A USB cord connects the laptop to the Arduino mega and the Arduino mega is connected to the signal tether from the second case. Power is also sent down from the second case. Video tether is split between the two cases. Using this setup allows the robot to be easily transported, constructed and ready to drive. The PS2 controller makes driving the robot user friendly and allows easy manipulation of controls. The aluminum briefcases as control boxes are rigid and give a professional edge.

Software

The electronic system this year is a vast improvement over last year's design. With the use of more complex electronics and programming, the electronics have become a major part of our ROV. One of the most impressive additions to the electrical system was the inclusion of an Arduino MEGA 2560 microcontroller to control the behavior of the ROV. These worked in conjunction with 6 single motor drivers which are held in a cylindrical container on the ROV itself, as this cylinder serves as the junction in which all of the wiring can be organized and send each wire out to wherever it needs to go.

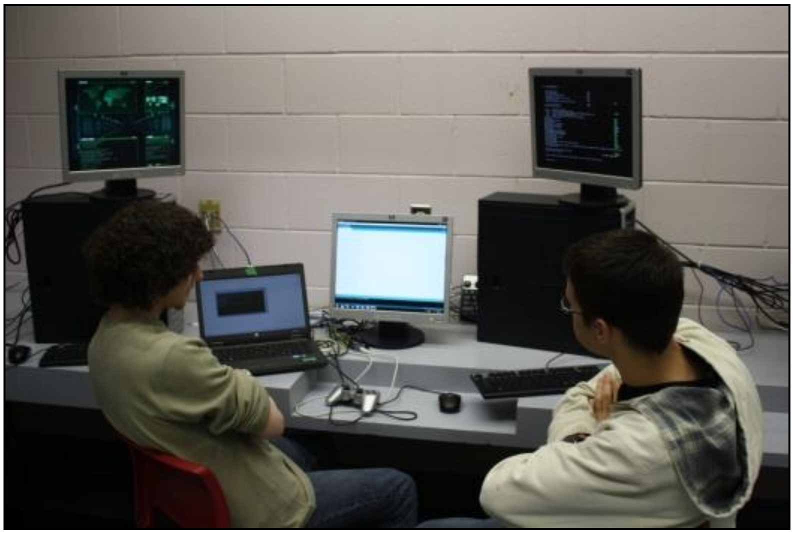


Figure 32- The two programmers hard at work writing code

Expanding on the simplified code from last year, which was used to give variable control over the motors, many new features have been added. These included a graphic user interface which, through data collected from the gyroscope, gives an image of our ROV's current angle and position. There is also an added feature so that in the event that the current exceeds 25 amps the various systems can be prioritized, meaning that the horizontal motors will shut off first, followed by the verticals. By doing this, the safety limit for current will not be exceeded, while not sacrificing performance.

Figure 31- Our PS2 controller

Last year, Nova Marine created a custom control box which contained all of the buttons and joysticks for the ROV's controls. It was a very bulky system which caused as many problems as it solved. This year it was decided that it would be easier to simply use a PS2 dual shock controller as our main means of control.

Not only did many members of the team have familiarity with the layout of the controls, but it was also far easier to program all of the controls through various readymade libraries. The control scheme was designed to be very familiar to the team members, with a control scheme similar to that of many computer games. This made the process far simpler and created a very smooth control system.

The competition this year requires teams to map out the layout and orientation of the ship and the debris field. To accomplish this task Nova Marine is using a RoBoard RM-G146 9-Axis Accelerometer, Gyro and Compass. The gyro has 9-degrees of function in 3-axis, the compass has 3-axis magneto-resistive sensor and the accelerometer also functions on 3-axis.

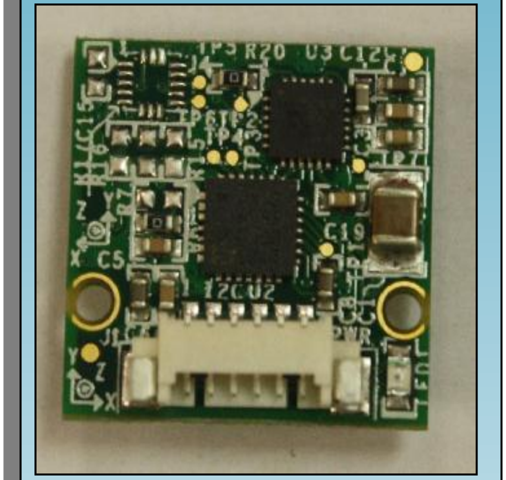


Figure 34- The gyroscope

These sensors are all contained in one board that is positioned inside the electrical housing on the robot. The sensors communicate the values to our microcontroller that reads the values and displays them on screen for the driving team to analyze. Details about the robot can then be viewed, such as the current angle, speed and direction in which the robot is travelling. This aids us in the creation of the map and orientation of the shipwreck.

Cameras

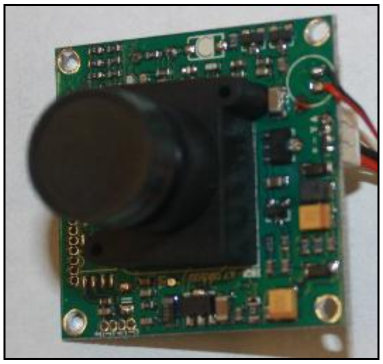


Figure 33- A board camera

This year, the company decided to try and reduce the number of cameras on the ROV, and, in large part, succeeded. Compared with the six cameras of last year, this year the ROV only has four, one of which is a still camera used specifically for measuring distance. This was due to most of the payload being located in close proximity to one another, allowing for fewer cameras.

The three cameras used for video are all located inside of the electronics housings, two in the 5" one in front, and another in the 4" one in the back. The two cameras located in the front are positioned directly over each of the claws, while the camera in the back is positioned off center, to the right if viewed from the back.

Tether

The tether this year is about 20 meters long and consists of four tubes. Two of these are pneumatics, and are directed to the front housing where they attach to the pneumatic multiplexer, while the other two are used for the electronics housing and control all electrical functions. This is far smaller than last year's tether as the design uses two multi-pin connectors which would plug into the electronics housing and control the motors, sensors and all data which will be relayed to the surface. Having this smaller tether will make the ROV more manoeuvrable as well as less congested, since the wires can be more streamlined as they extend to the various payload tools of the ROV. Small buoys were attached to the tether to ensure that it was neutrally buoyant and would have no effect on controlling the ROV in the water.

Challenges Faced

One of the many challenges we faced this year was in the acquisition of new parts. Since a considerable number of the components we required cannot be obtained locally, many of our purchases were made from international retailers. Due to this we were forced to delay production of the ROV, making our already tight schedule even more pressing. Our bilge pumps, cameras and nearly all of our electronics arrived weeks and even months late.

Shipping time was not the only setback as we received certain components in unsuitable vessels. Our pneumatic multiplexer, for example, had some minor damage after being shipped from Hong Kong in an envelope. While dealing with these delays, our team was still able to focus efforts in other areas, most notably allowing for more time to be spent in the design stage of the project. We were also able to gain a better grasp of SolidWorks, the program which was used to design components.

Nearing completion of the robot we began the initial testing in our 3000 liter test pool. One of the first tests was to run the motors to measure the amperage and the increase in speed from last year's motors. We immediately realized a problem with the horizontal motors where any forward movement resulted in the robot rotating its face slightly upward causing upward movement.

This was devastating to our horizontal movement so we acted to solve this right away. We elected to change the angles of the thrusters to decrease the vertical spin when the robot accelerates forward. We also decided that decreasing the power of the thrusters would reduce the torque on the top of the robot. To accomplish this, blade length is such that the kort nozzles act only as a shroud not as a thrust amplifier. This design approach did not affect the performance of the robot and it ended up reducing the amperage drawn significantly.

Figure 35- A team member cutting through the sheet PVC

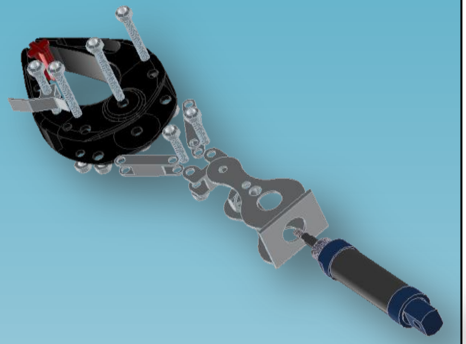


Figure 36- An exploded view of one of the claws

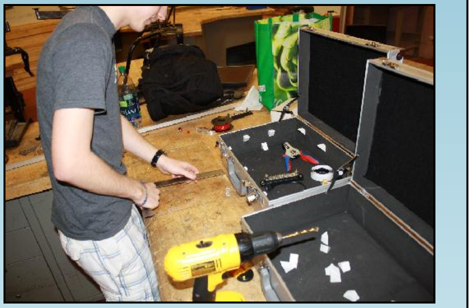


Figure 37- Working on the two control boxes

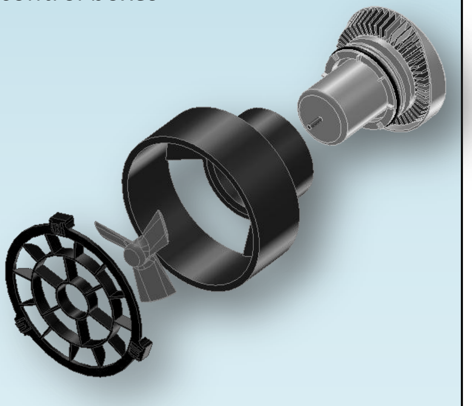


Figure 38- An exploded view of a thruster

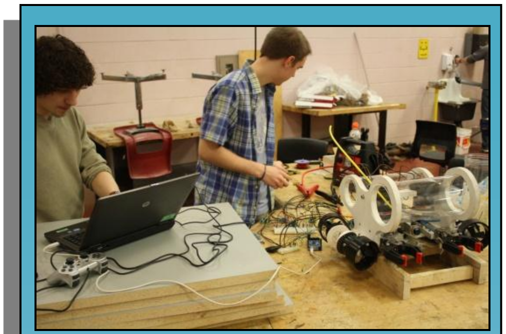


Figure 39- The first dry test of the thrusters and their variable control

Figure 40- Testing buoyancy in the tank

As testing was a higher priority this year, our company decided that we needed a more convenient means of testing our payload tools, as well as ROV buoyancy. A 3000 liter test pool was ordered which could be used for simple testing and for practicing individual tasks. This simplified many projects, such as correcting buoyancy, because we were able to test the buoyancy and make adjustments without ever leaving the shop; something that has always proved problematic for our company. Purchasing our own pool was also a great investment for future teams, as it will be useable for years to come.

Safety

Here at Nova Marine, safety is one of our top proprieties, next to building a great robot of course! To start, whenever we were to cut material, safety goggles were the first thing we'd check. Next, we were trained to do things safely such as cutting or die-grinding. In addition, we added a guard to the kort nozzles to protect the propellers and prevent entry of foreign objects. Concerning the electronics, a 25 amp fuse was installed to insure the current never exceeds the necessary limit. There is also a humidity detector in the electronics housing to monitor the heat and humidity and ensure it stays within safe limits.

Testing & Troubleshooting

Our testing consisted of two main devices; our mini sub and test tank. The mini sub was used to test the designs of different payload tools and analyze whether or not the components would work. Following a test run, we would have group discussions about whether or not the tool worked to the standards we had for it. After this, we would brainstorm ways that we could improve upon our design.

Once the entire ROV had been assembled, the test tank was used for the initial practice runs where we tested the complete pneumatics system, the buoyancy and the thrusters. We also went to a local public pool for full testing of the systems of the ROV in all of the mission tasks. By doing this, any flaws in our design were able to be adjusted. Anytime designs were changed, we tested it in the test tank at school first before testing in a larger community pool.

Future Improvements

Throughout the design and building processes of our ROV we encountered and overcame many problems. From these experiences we were given valuable lessons which we will surely apply in future years. The first thing we hope to improvement on in years to come is how we budget our time. We suffered this year as many deadlines were surpassed on account of things like late part deliveries, inefficient construction methods and disorganised juniors who lacked the necessary guidance of experienced team members. We believe that if we took steps like ordering parts well before we required them, better acquainted ourselves with different tools and building processes and made sure directions were given with clarity to the newer members of the team, then we could greatly improve the efficiency of our team and quality of our product.

Lessons Learned

Our team has learned many lessons that will help our future robotics club perform at a higher level. We attained the necessary knowledge to coordinate and cooperate with our teammates, making for a much more interactive environment for the construction of our ROV.

Figure 42- The shop where we did most of the construction

This allowed people the freedom to work on something that interested them, while still being actively involved with the team, and helping their teammates. As American industrialist Henry Ford once said “Coming together is a beginning. Keeping together is progress. Working together is success.” This quote explains the development of our team, from a simple group of people coming together, to creating a successful ROV in less than 6 months of being together. This lesson will help us in our future endeavors, no matter what they may be, as this lesson is universal, and to be successful we all must learn it at some point in our lives.

From a design standpoint, one of the largest differences between this year and last year is our use of computer modeling in the creation of our ROV. Some of the members of the team took the time early in the year to learn how to use the SolidWorks program, and we used this skill to completely change how we designed our ROV. The frame was originally designed in SolidWorks before bringing to life, as were several of the payload tools.

Figure 41- Original SolidWorks model of sheet PVC frame

It not only helped in the design process, but also helps with the technical report, as well as providing a virtual version of our ROV which can be shown to potential sponsors without having to drag the entire robot with us. Compared to last year, when Rhino was used, it is a vast improvement. This will help members of the team going into engineering in the future, as 3D modeling is fast becoming a major component of design work, and our team took advantage of the access which we had to the program.

As a team this year, we have seen a lot of growth in our abilities in all fields of this competition. From the beginning of the year we were determined to leave no stone unturned in the development of our vehicle. Although plenty of things went wrong, and frustration with delays and a few sudden and unexpected problems, our team did an excellent job of persevering through it all.

The members who have been involved with this project before worked to ensure that the rookies were learning, which was very beneficial. Having a large team allowed us to spread out the work load and focus on numerous projects at the same time.

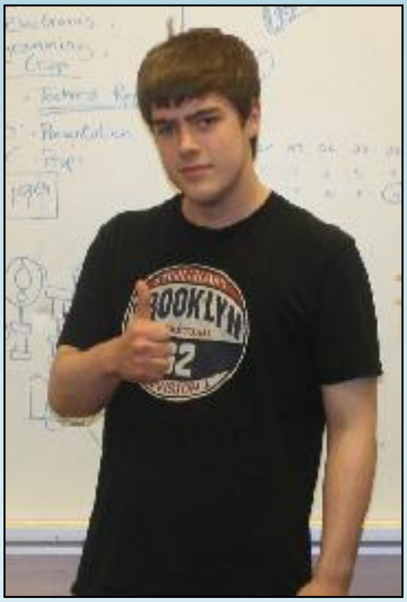


Figure 43- Ben Power and his signature "thumbs up"

Reflections

This was really a great year to be on Auburn's ROV team because I learned a lot and had a lot of fun. We had many members that were extremely knowledgeable in their chosen fields (electronics, software, designing / building) which made the experience very enriching. Some of my favorite things this year were helping with the building of the ROV, going to Dalhousie to see their engineering department and 3D printer and seeing the ROV in the water for the first time. I think the most important thing to do when you're new is to show up and be willing to participate with a positive attitude; something that really helped with this was Ben Power's constant optimism and his signature "thumbs up" even in the face of complete failure. Throughout the year I think I've grown and learned a lot and am excited to continue this experience next year.

-Justin Trainor

The robotics team at Auburn Drive High was a great experience; having no previous knowledge on the topic, and nothing but a desire to learn and absorb what was going on around me, I'm glad I made the choice to commit. One can take away a lot from such a club: team work, electronics, programming and a good idea of some of the projects you'll encounter in engineering, as well as what you can accomplish in a large group. In addition, we had such a variety of specialties on the team, those of us who were new had the choice to learn about what interested us the most which was a great opportunity. When we needed help with anything, we had the experience of multiple members of the previous year's team who attended the internationals in Texas, to get us through our problems. All in all, after what we've been through this year, I'll never regret my being part of the Auburn ROV family!

-Ben Power

Budget

Source	Item(s)	Cost	Value	Donation
Donations				
Dept. Of Labour				$2,500.00
Imperial Oil				$5,000.00
Payload				
Princess Auto	Spring Clamp, Al Cylinder, Caster Threaded Digital Caliper, Ratchet Clamp 6"	$88.90		
Canadian Tire	Holesaw Kit, Threaded Rods	$17.29		
Metals R Us	Aluminum Sheet 1/8", Aluminum Sheet 1/4"	$103.21		
Trans World	Stainless Steel Threaded Rod, Nuts, Locknuts	$42.39		
West Marine	Bilge Pumps	$319.99		
Recycled Items	Pneumatic Pistons,		$200.00	
Dalhousie	Propellers		$250.00	
Electronics				
Jentronics	Epoxy, Shrink Seal	$63.03		
Robot Shop	Voltage Regulator, Arduino Mega 2560 MC, Sensor, 400 Tie Point Breadboard, Jumper Wires, Pololu Current Sensor, Metal Detector Board, Motor Board Pololu Motor Driver, Compass	$985.95		
The Source	SPST Oval Rocke, Lugs/ Terminals, Shrink Tube	$31.00		
Last Game Store	PS2 to USB Port	$22.94		
Futerlec	Solid State Relays	$86.09		
Plusbee	4 Sets of 20m AV Cables	$67.26		
Jetview	underwater Day/Night Camera	$137.51		
Dragonmarts	Pneumatic Multiplexer	$104.00		
Cases Unlimited	Al Cases for Control System	$150.70		
Festo	Pneumatic Fittings	$72.61		
Camera 2000	Cameras w/ Mic x2	$94.28		
Home Depot	Acrylic Sheets for Shelves	$27.58		
Atl. Hardchrome	O-Rings		$30.00	
Recycled Items	Shrink Tube, Wire		$200.00	
Frame				
EM Plastics	Komatex PVC Sheets (Frame)	$159.07		
Polymershapes	Tubes for Frame	$92.39		
NSCC	Endcaps		$1,500.00	
		$2,666.19	$2,180.00	$7,500.00
Total Value of ROV:		$4,846.19		
Remaining Funds:		$4,833.81		

Acknowledgements

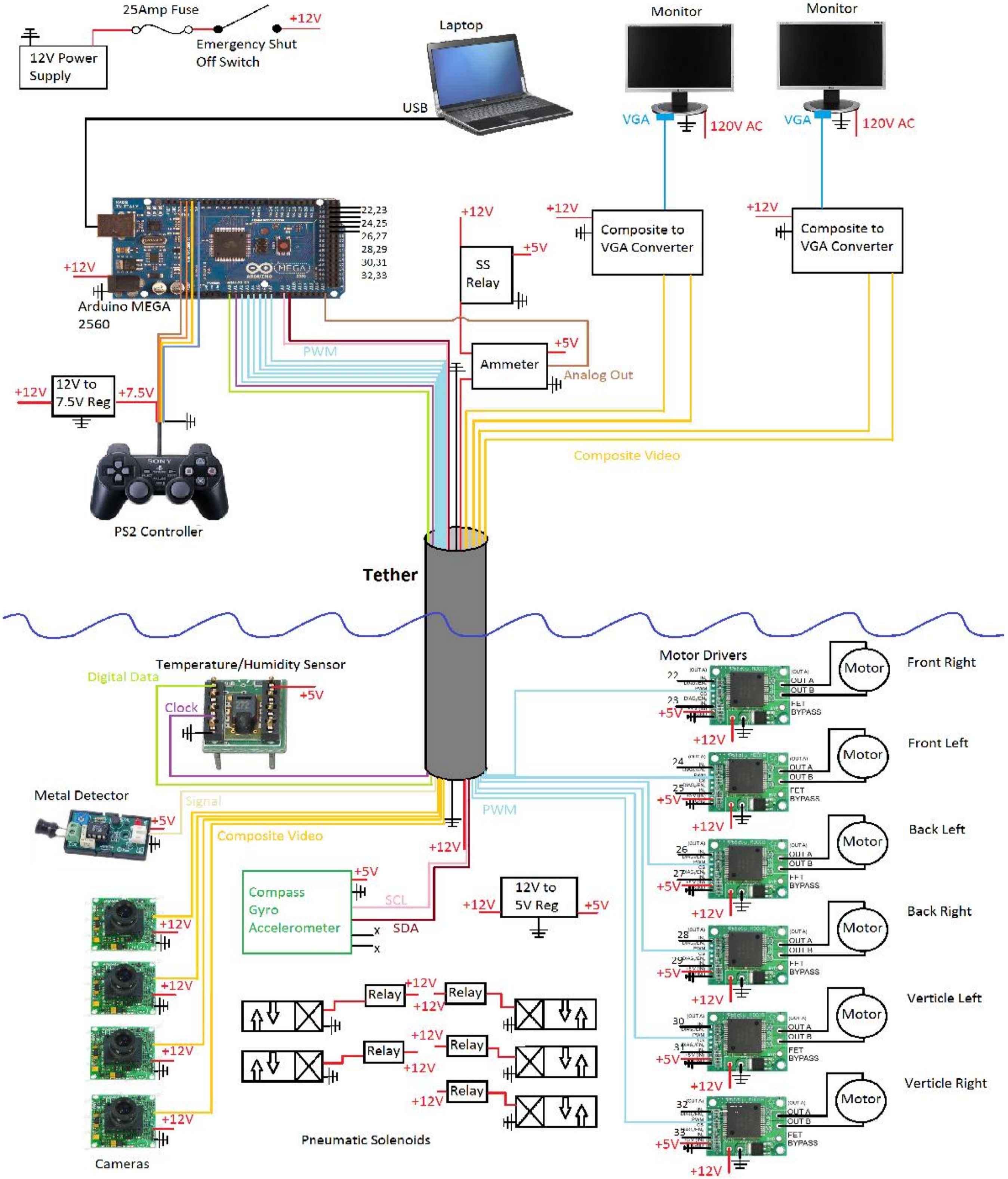
MATE	For giving us the opportunity to compete in the ROV competition
Imperial Oil Esso	For their generous donation and continued support of this project
nscc	For allowing us to use their CNC machine to cut out the end caps for our electronics housings
NOVA SCOTIA Department of Labour	For their generous contribution to this project
DALHOUSIE UNIVERSITY *Inspiring Minds*	For allowing us to use their 3D printer for our propellers and thruster housing covers

Frank McMahon- For the time, guidance and instruction that he put into this project as a mentor.

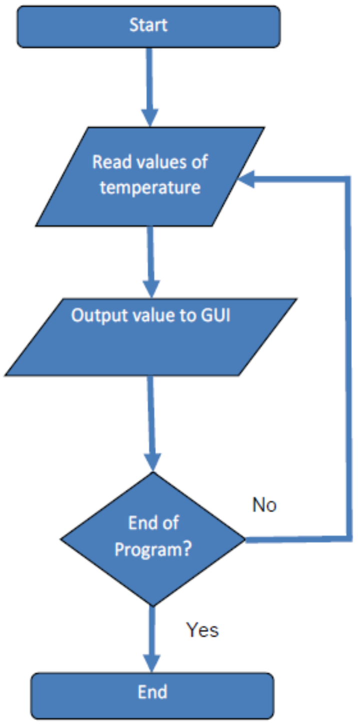
Wayne Costello- For his insight and guidance throughout the building and designing process.

Appendix

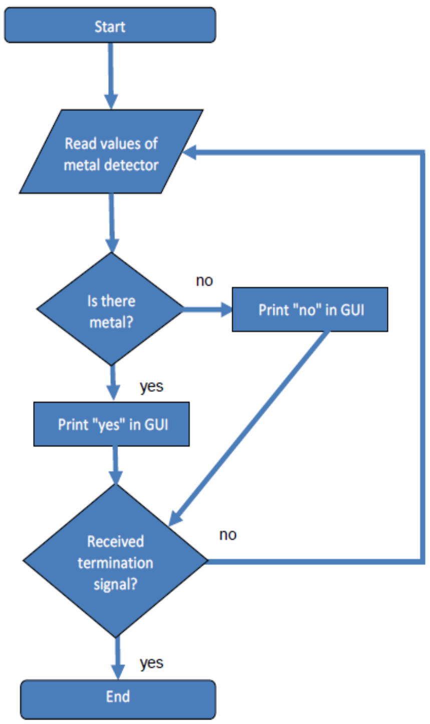
Electrical Schematic



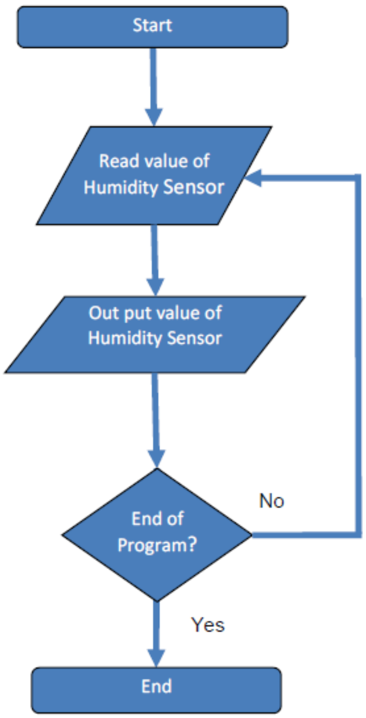
Temperature Sensor



Metal Detector



Humidity Sensor



Controller