MOUNT PEARL SENIOR HIGH

MOUNT PEARL, NEWFOUNDLAND, CANADA

Husky R.O.V.E.R.

Name	Role/Responsibilty	Grade	Career Goal
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Sean Purchase	Co-Pilot	11	Electrical Engineer
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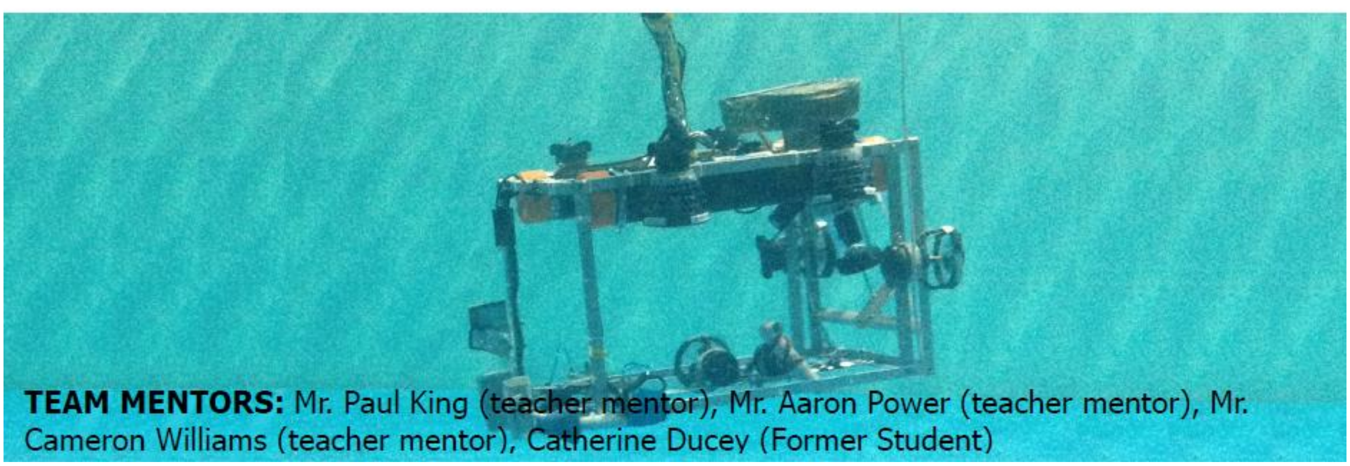
Julie Bennett	CFO (Chief Financial Officer)	12	Mechanical Engineer
Maria Halleran	Safety Officer	12	Pharmacist
Laura Johnson	Communications Officer	12	Chemical Engineer
Khafre Pike	Research Officer	11	Aerospace Engineer
Adam House	Tool Technician	12	Chemical Engineer
Colin Hunt	Tool Technician	12	Biomedical Engineer
Brad O'Leary	Fabrication Technician	12	Pharmacist
Ryan Hayes	Fabrication Technician	11	Electrical Engineer
Josh Hapgood	Pneumatics Technician	12	Sound Engineer
Connor Hynes	Prop Designer	10	Marine Engineer
Aloysius Ducey	Prop Designer	9	ROV Technician
Erin Fitzgerald	Technical Writer	12	Marine Biologist
Mary Pike	Technical Writer	11	Software Architect



TEAM MENTORS: Mr. Paul King (teacher mentor), Mr. Aaron Power (teacher mentor), Mr. Cameron Williams (teacher mentor), Catherine Ducey (Former Student)

Abstract

Husky R.O.V.E.R. specializes in the design and construction of underwater remotely operated vehicles (ROVs). For our latest project we have designed an underwater ROV, TMR1, to compete in the 2015 Marine Advanced Technology Education Center (MATE) International ROV Competition that takes place June 25th to 27th in St. John's, NL. The ROV is equipped to perform tasks associated with science under the ice, subsea pipeline inspection and repair, and offshore oil production, and maintenance in the arctic environment off the coast of Newfoundland and Labrador, Canada.

Our ROV is equipped with tools that have been designed to be small and versatile in an effort to overcome the challenges associated with the specific mission tasks. Some of these tasks include the identification and collection of arctic marine life, the determination of the threat level of icebergs, and the inspection, maintenance and operation of a subsea oil pipeline. Our ROV includes several specialized tools to complete the specific mission tasks, including: two separate collectors for marine life; a depth sensor; a versatile pneumatic claw; a valve rotator; a conductivity meter to test the grounding of a "leg" of the oil platform, and a modified bilge pump to push water through the oil pipeline.

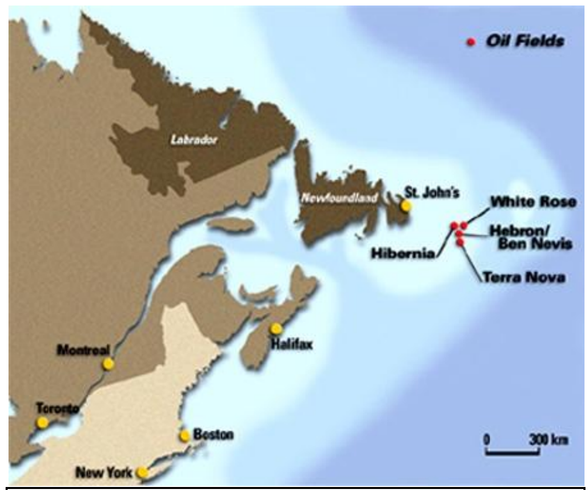


Figure 1: Map of oil fields surrounding Newfoundland.
Photo retrieved from: http://www.ctvnews.ca/ on 04-29-15

Husky R.O.V.E.R. of Mount Pearl, Newfoundland and Labrador, Canada has prepared this technical report. The report outlines the company mission, project management details, design rationale, challenges, and troubleshooting techniques. In addition, safety protocol, future improvements, financial report, references, and acknowledgements are identified.

Figure 2: Oil workers in Newfoundland prepare to move an iceberg off its course to prevent it from colliding with Hibernia.
Retrieved from: http://mentalfloss.com/article/26994/thin-ice-fight-control-arctic-economy 05-07-15.

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Company Mission

Since the collapse of the Newfoundland Fishery in the late 1980’s to early 1990’s, oil has become the province’s largest industry and has stimulated economic prosperity for the island. The jobs created by the oil industry have provided the province with many opportunities to become a world class centre for marine research and education (Offshore Energy, 2015). The capital city of St. John's is home to many marine education and research facilities, such as the Ocean Science Centre and the Marine Institute (the host for the 2015 Mate International ROV Competition).

There are many challenges associated with the oil industry in the North Atlantic and Arctic oceans. The waters surrounding the island are notorious for their unpredictability, including fog, icebergs and unpredictable weather. Fog forms when warm humid air is cooled below its dew point, the temperature at which water vapour condenses to form water droplets. Off the Atlantic coast, warm air masses moving north with the Gulf Stream are cooled when they encounter the cold Labrador Current, producing dense fogs along the Grand Banks off the coast of Newfoundland and south of Nova Scotia. As the air mass is cooled from below, a strong inversion is created (colder air is trapped below the warmer air) causing the fog to persist. Also, the frigid waters off of the province’s south coast have earned the nickname ‘Iceberg Alley’ due to the frequent presence of icebergs. This area has endured more than 500 recorded collisions between icebergs and ships, including the famous sinking of the RMS Titanic (Kennedy, 2014). Icebergs are floating chunks of ice, ranging in size from bungalows to small islands, that break off from the glaciers of Greenland and are carried southward by the Labrador current (Kennedy, 2014). The threat level of these icebergs is determined through the joint use of satellite imaging and monitoring vessels (Icebergs, Sea Ice and Fog, 2014). It is very risky for monitoring vessels to approach icebergs. Due to new oil developments in Canada’s frigid arctic waters that prevent divers from being employed, ROVs are being used for the first time in sub-arctic conditions.

These submersibles assist in determining the size of an iceberg, as 90% of it is submerged. If an iceberg is determined to be a threat, the offshore oil industry employs a number of methods to avoid impact. These include adjusting the course of Floating Production Storage Offloading (FPSO) vessels and in the case of fixed position oil platforms, towing the iceberg thus altering its course.

In consideration of these challenges, Husky R.O.V.E.R.’s newest model, TMR1 (The Mighty Ranger), was designed to be agile, robust, and manoeuvrable. It is capable of conducting scientific exploration in extreme arctic environments; inspecting, maintaining and repairing off-shore oilfield pipeline and production platforms.

Project Management

Husky R.O.V.E.R. is an ROV company consisting of 16 members. At the initial meeting, December 9th, 2014, the team identified time management and prudent financial planning as key aspects for success. To this end, the team started by identifying the strengths and interests of all the team members. Team members were then organized into two departments (Engineering and Business) consisting of 6 smaller divisions (Electrical, Tool Design, Fabrication, Communications, Safety, Financial) with a team leader who reported to the CEO.

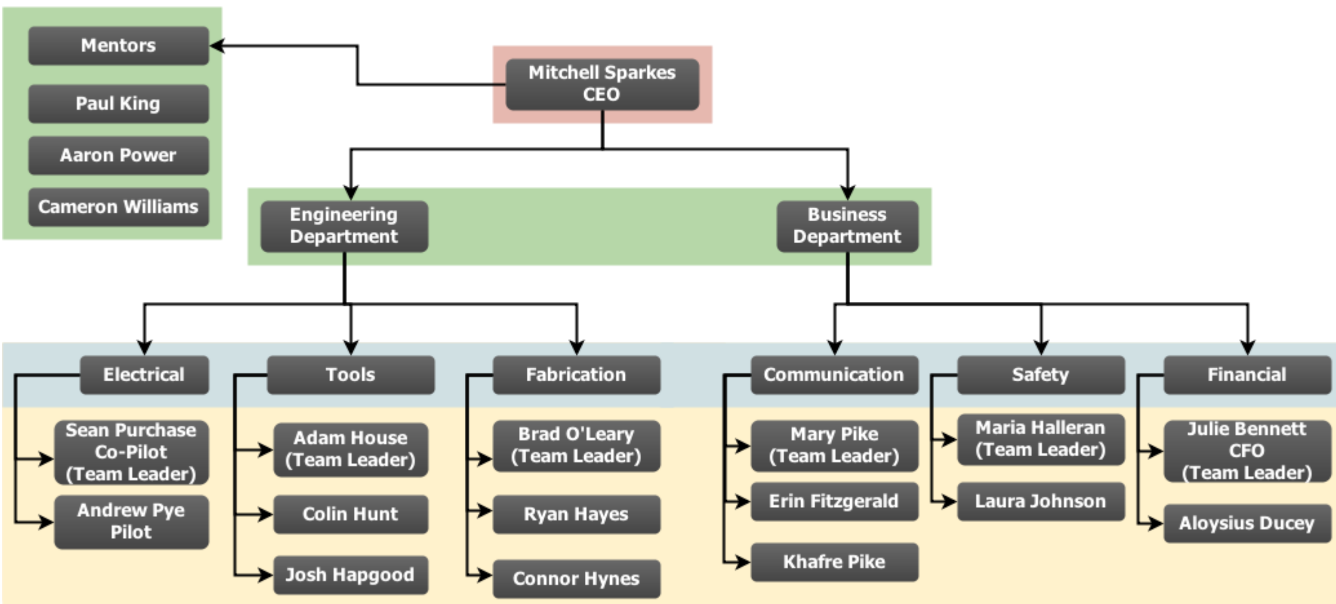

Figure 3: Organisation structure of Husky R.O.V.E.R. (Credit: Mitchell Sparkes)

Upon reviewing the MATE competition manual, daily brainstorming sessions were held to identify all possible solutions to accomplish the mission tasks. Using a shared Google document, all members recorded brainstorming ideas and possible development plans. Large group meetings were held on a weekly basis where ideas were debated and decisions were shared. A six step design model (See figure 4) was followed to help keep the project on track.

This design model was an important instrument to help organize ideas, develop solutions, and allow all members a voice in decision making. The team had to resolve a variety of problems, including: frame design, buoyancy, propulsion, and tool options. By continuously modifying and improving ideas, we eventually arrived at our current design rationale and vehicle systems within budget.

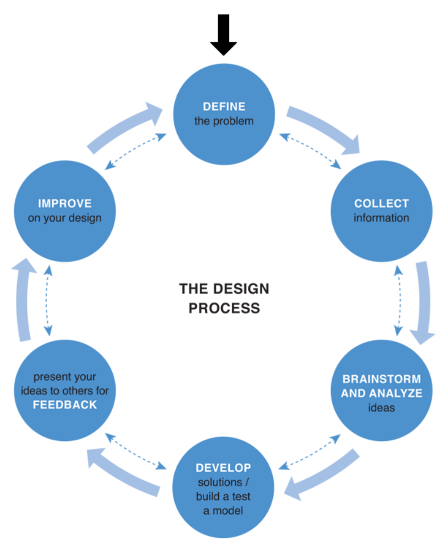

Figure 4: The Design process. Retrieved from http://discoverdesign.org/design/process

Project Costing

A large portion of project management involves managing resources: human and financial. Project costing and planning how to best use our $750 budget was challenging. However, through donations (monetary and in-kind) from our school and community, and reusing the tether and thrusters, a new ROV was built approximately $120 under budget. Without the support of our school, community sponsors, the Marine Institute of Technology and MATE, this project would not be possible.

Fortunately, the international competition was held in our home province, St. John's, NL and budgeting for travel and accommodations was not an issue. Therefore, the Husky R.O.V.E.R. team has a surplus of funds ($2769.27) to purchase new thrusters and a tether next year. Below is a table indicated our expenditures, income, donations and balance.

Type	Category	Expense Description	Amount
Purchased	Hardware	Screws, bolts, nuts	$46.87
Purchased	Tools	Bilge Pump	$20.88
Purchased	Hardware	Cable Ties	$19.19
Purchased	Hardware	Loom Wire Cover	$16.59
Purchased	Hardware	Pneumatic tubing	$51.41
Purchased	Electrical	Electrical wire, tape, shrink wrap	$35.97
Purchased	Hardware	Aluminum (angle and Flat)	$205.54
Purchased	Hardware	Prop materials (ABS and PVC pipe, elbows, fittings and valves)	$134.29
Purchased	Service	Poster Print	$100
Subtotal Purchased			$630.74
Donated	Hardware	Metal World Inc. -Steel plates	$40 (CMV)
Donated	Service	Keltic Steel Inc.- Weld Frame	$50 (CMV)
Donated	Sensors	Sea Force Technology - Cameras	$600 (CMV)
Donated	Sensors	Coastal Marine Ltd. - Depth Sensor	$100 (CMV)
Donated	Camera	MPSH - 360^0 Camera	$400 CMV)
Donated	Hardware	MPSH - Pneumatics Kit and Compressor	$300 (CMV)
Subtotal Donated			$1490.00

Reused	Thrusters	MPSH ROBOTICS CLUB - 7 bilge pump thrusters	$210
Reused	Electrical	MPSH ROBOTICS CLUB - Tether	$400
Reused	Electrical	MPSH Robotics Club - Control boxes	$200
Subtotal Reused			$810
Donated	Cash	Triware Technology	$300
Donated	Cash	Rutter Inc.	$250
Donated	Cash	Brian Johnston	$100
Donated	Cash	Marine Institute Regional Competition	$750
Donated	Cash	Marine Institute Regional Competition (Prize)	$2000
Subtotal Donated			$3400
Subtotal Purchased			$630.73
Subtotal Donated			$1490
Subtotal Reused			$810
Subtotal			$2930.73
Subtotal Income			$3400
Balance			$2769.27

Subtotal Donated			($1490)
Subtotal Reused			($810)
Total Savings			$2300

Design Rationale and Vehicle Systems

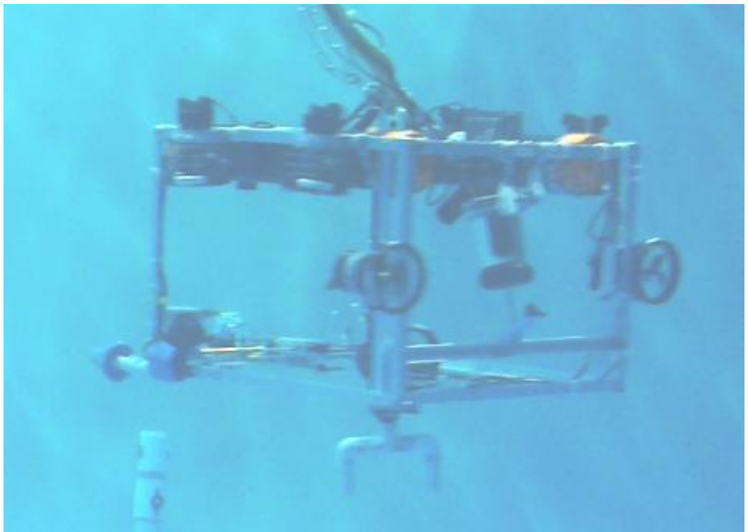

Figure 5: TMR 1 in action at M.I. flume tank (Credit: Khafre Pike)

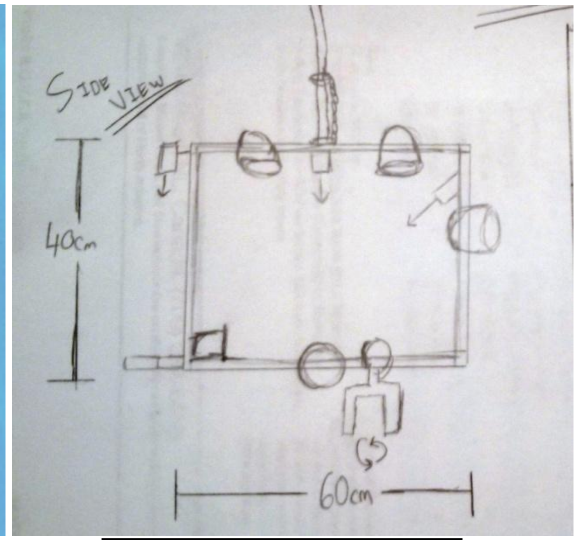

Figure 6: Sample Sketch. (Credit: Sean Purchase)

The design of our ROV and subsequent vehicle systems was dictated, in part, by the mission specifications provided by the 2015 MATE competition. Accordingly, the ROV had to be small enough to fit through the 75 cm x 75 cm ice hole, count species and sample organisms, deploy a passive acoustic sensor, collect iceberg data, replace a corroded section of oil pipeline, prepare a wellhead for the delivery of a Christmas tree, test the grounding of anodes on the "leg" of an oil platform, measure the height of a wellhead, and control the flow of oil through a pipeline.

In developing an ROV to meet these mission tasks, eight main components were considered: frame design, buoyancy, propulsion, tools, tether, electronics, control, and cameras. In order for the ROV to function properly all components needed to work effectively together. Therefore, detailed research, planning, and decisions were a necessity.

Frame

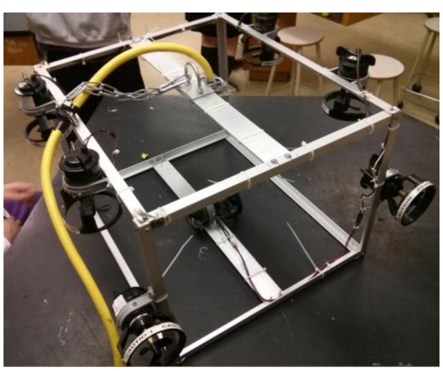

Figure 7: Frame of the TMR1 (Credit: Mitchell Sparkes)

Three options were considered for the frame's material. The first option was a rectangular frame constructed from 3.1cm ID (1 1/4 inch) polyvinyl chloride (PVC) pipe and fittings. The second option was a similar design made from 1.9cm x 0.24cm angled aluminum. Finally, the third option was a frame fabricated from 0.20 cm thick clear polycarbonate (Lexan) sheet.

Based on our research, aluminum was the material of choice since it is readily available, lightweight, easy to cut and fabricate into a frame. While the Lexan and PVC pipe were moderately cheaper, they were not readily available and provided more challenges for fabrication and tool placement. The final ROV frame size consisted of 1.9 cm x 0.24 cm angled and flat aluminum, which was 60 cm x 50 cm x 40 cm. Given the large frame size, tool and camera placement was much improved from previous products. Furthermore, once the frame was designed and fabricated, consideration for a propulsion system was required.

Propulsion System

An efficient propulsion system is crucial to completing the mission tasks. Two possible thruster systems were researched: a 12 V Seabotix BTD-150 thruster and a 12 V Mayfair 500GPH bilge pump. After a careful cost and performance analysis, it was determined that the BTD-150 thruster was the superior choice since it drew less current under load (2.7 A) and provided more thrust (2.2 kg). However, the cost ($500 per unit) was nearly 20 times more than the Bilge pumps ($25 per unit). Therefore, based on our limited budget of $1000, we chose the 12 volt - 500 GPH bilge pumps. While these motors drew a larger current (5.0 A) under load and provided less thrust (0.8 kg), they were suitable to propel the ROV. Seven of these motors were extracted from the bilge pump housings and dismantled. A 40 mm three-blade propeller with 4mm of pitch was secured to a brass hub using a 6mm set screw.

Figure 8: Example of horizontal thruster.
(Credit: Mitchell Sparkes)

The ROV is fitted with four main vertical thrusters, which are strategically placed at the corners of the frame. Each front and back pair is wired in parallel to provide quick up and down movement and pitch control.

Additionally, there are two main forward/reverse thrusters placed at the rear which give us fairly good speed and control. Our final thruster is placed at the bottom centre of the frame, perpendicular to the driving thrusters. It is used so that the pilot can move side to side without having to turn and re-adjust.

Pneumatic System

The ROV contains a pneumatic system which is used to power the claw. This system is designed by VEX Robotics. It contains a 150 ml reservoir (20 cm x 4cm) attached to an air compressor regulated to 40 psi. This system is controlled by a main shut valve which is connected to 4.0 mm x 2.5 mm tubing to the two pneumatic solenoids. The air flow between the reservoir and the two double acting pneumatic cylinders is controlled by these electric valves. The pneumatic solenoids are controlled by the VEX micro-controller module. This micro-controller contains the program written in easyC and it processes all signals received from the wireless controller operating on a 75.45 FM radio frequency.

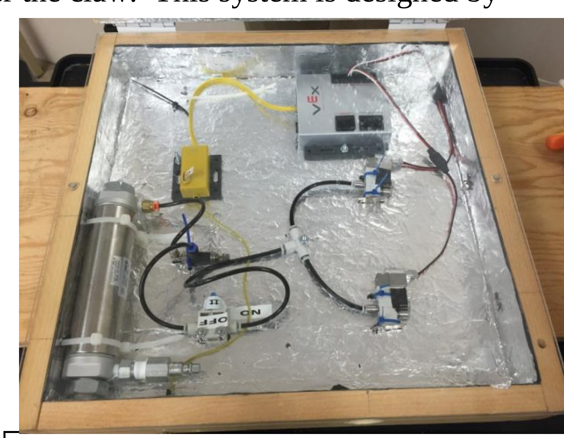

Figure 9: Vex Pneumatic System. (Credit: Mitchell Sparkes)

The operation of the claw depends on the air pressure applied to the piston. When the compressed air is directed into the front of the cylinder, it applies pressure to the piston causing it to retract (length = 15.6 cm). Similarly, when the compressed air is directed into the back of the cylinder, it pushes against the piston causing it to extend (length= 21 cm). With a 10 mm cylinder bore (diameter) and a 689 kN/m² (100 psi) internal pressure the maximum force of 54 N (12 lbs) can be applied by the pistons.

Piston force calculation:

(Cross Sectional Area of Cylinder) x (Internal Air Pressure) = Force

pi x (5 mm ^2) x 689 kN/m² = 54 N or **21.6 N at 276 kN/m² (40 psi)**

Figure 10: Piston Force. (Credit: Mitchell Sparkes)

Reservoir Specifications: **Cylinder Specifications:**

Length	20 cm	Length	Dbl.- Compressed - 15.6 cm / Extended - 21.0 cm.
Diameter	4 cm	Stroke	5.08 cm
Cylinder	Wall 3.2 mm	Cylinder Bore	10 mm
Weight	308 g	Weight	20 g
Volume	150 ml	Maximum Pressure	0.7 MPa
Cylinder Strokes	45 Strokes from 100 psi to 25 psi	Maximum Output Force	54 N @100 psi 22 N @ 40 psi

Figure 11: Reservoir and Cylinder Specifications. (Credit: Mitchell Sparkes) Retrieved from http://www.vexrobotics.com/275-0276.html

Tools

This year's unique mission tasks motivated our team to develop novel approaches to the tasks required of our ROV. As a result, all of our tools are original designs that we either hand-crafted or purchased and modified. The size of our ROV is much larger than last year since we needed to improve the viewing capability of our cameras and allow more space for attaching tools. The design for each tool underwent extensive prototyping by providing detailed drawings, modeled using cheap materials (such as cardboard) and testing these models before fabricating the final product. Our vehicle was tested at our school in our indoor testing pool (measuring 1.83 m x1.83 m x0.91 m) and at the Mount Pearl Summit Centre before the regional competition. We have developed the following tools to accomplish this year's mission tasks: pneumatic claw, algae collector, sea urchin collector, depth sensor, valve spinner, bilge pump, and a conductivity meter.

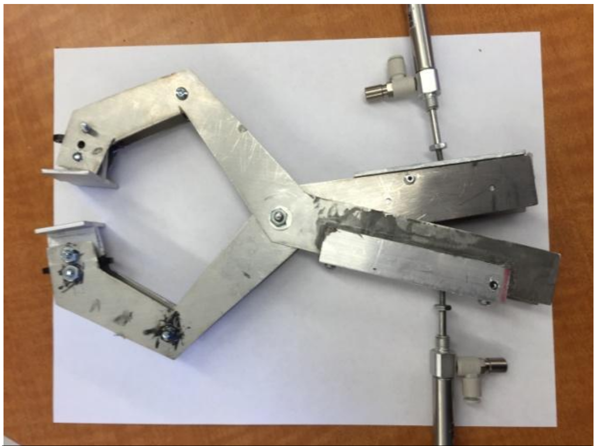

Figure 12 : Pneumatic claw. (Credit: Mitchell Sparkes)

Based on this year's mission tasks, the pneumatics team decided that it would be beneficial to build a new pneumatic claw for the ROV. The claw was an original design which we fabricated from 4 identical pieces of galvanized 16 gauge steel plate, cut into hook-shaped pieces and hinged at the middle. The claw opens and closes with the force provided from two double action pneumatic pistons. This claw is a versatile tool used to accomplish several parts of the missions. In mission #1 (Science under the Sea) it will be used to deploy the passive acoustic sensor to the designated area. In mission #2 (Subsea Pipeline Inspection and Repair) it will be used to attach a lift line to a corroded section; install and secure an adapter flange; install a gasket into the wellhead; and deliver and insert a hot stab into the wellhead.

In mission #1 (Science under the Sea), the pilot and co-pilot will navigate through the ice hole to collect a sample of algae, a sea urchin, identify and count species of sea star and measure the dimensions of an ice berg and determine its threat level. Husky R.O.V.E.R. had brainstormed and pro-typed many different tools to complete these tasks. However, after testing the following tools were designed and used.

Figure 13: Algae collector. (Credit: Khafre Pike)

An algae collector was created from a combination of a Tupperware™ and elastics. This device was strapped to the ROV using a bungee cord. By pushing the ROV against the algae, the algae will be forced through the space between the hair elastics, effectively trapping the algae inside the Tupperware™ container. This device was inspired by the ball cages at Wal-Mart.

The sea urchin, simulated by a hollow o-ball, is collected with ease using a simple straight metal hook.

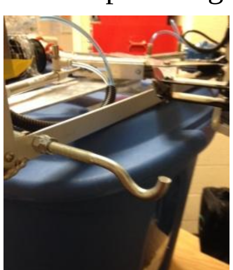

Figure 14: Hook (Credit: Mitchell Sparkes)

The Uniden ultrasonic depth sensor, donated by Coastal Marine Ltd, is used to measure the dimensions of the iceberg to determine its threat level to the pipeline. It was modified to include a hinging mount that locks at two positions, horizontal and vertical. A monitor is connected to the control box to record the distance. This sensor is also used to determine the height and length of the wellhead in mission #3.

Figure 15B: Depth senor monitor. (Credit: Mitchell Sparkes)

Figure 15A: Depth sensor (Credit: Mitchell Sparkes)

For completion of mission #2 (Subsea Pipeline Inspection and Repair), Husky R.O.V.E.R. decided to use the pneumatic claw for most parts of this mission, as mentioned above. However, to turn the valves in mission #2 and #3, we designed a special tool called the valve spinner. This tool was fabricated from 1/2" PVC pipe and attached to the shaft of a modified bilge pump. The valve can be open or closed by reversing the current using a double-pole double- pole switch. Using this design and a dedicated camera, we can easily descend view the pipeline and turn the specified valves. As mentioned, this device is also used in mission #3.

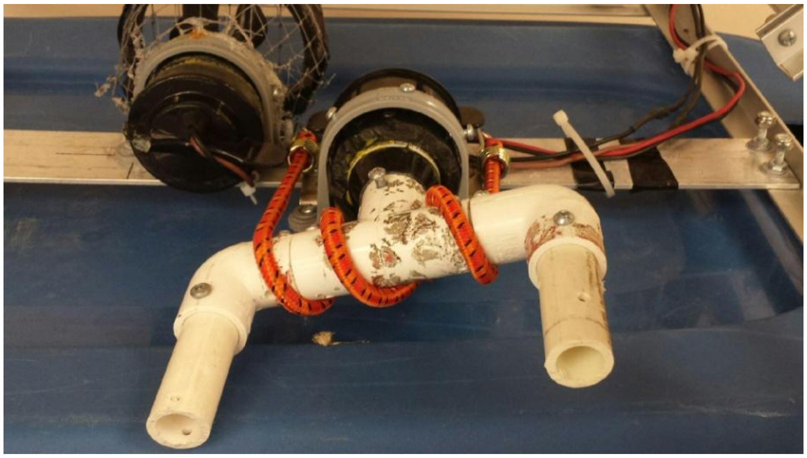

Figure 16: Valve Spinner. (Credit: Sean Purchase)

For completion of mission #3 (Offshore Oil Production and Maintenance), Husky R.O.V.E.R. developed and tested two new tools, a conductivity meter and a bilge pump. The conductivity meter is used for testing the conductivity of the “leg” of the oil platform. It is constructed from two curved pieces of steel which make perfect contact with the anodes of the "leg". These contacts are connected via two 18 gauge copper wires which run in the secondary tether to a multi-meter. By using curved metal instead of flat metal, the surface area of the steel is maximized to easily contact the anodes to be tested.

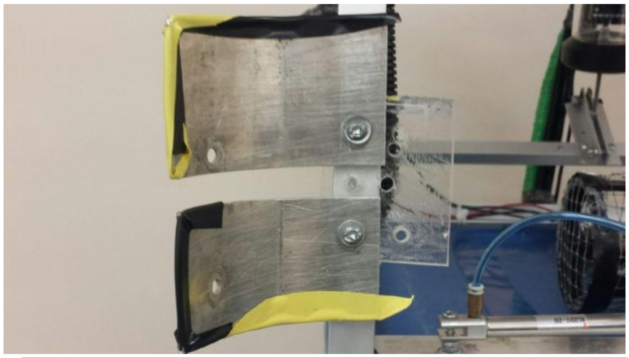

Figure 17: Conductivity Meter. (Credit: Sean Purchase)

The 12 V DC 200 GPH bilge pump was purchased from Princess Auto and modified using ½” PVC pipe and a plunger to fit tightly into the pipeline inlet. It is capable of pumping water vertically 1.5 m at 10 GPH. Therefore, it is more than capable to push water through a specified horizontal pipeline.

Figure 18: Bilge Pump. (Credit: Sean Purchase)

Tether

Figure 19: TMR 1 tether and tether storage. (Credit: Sean Purchase)

The 13.7 m neutrally buoyant tether connects the top-side power and electrical components to the ROV motors and tools. It consists of 6 pairs of 18 gauge insulated wires used for propulsion and one 24 gauge twisted pair of wires for conductivity meter. A secondary tether, consisting of four 18 gauge wires, four pneumatic lines and four video lines are strapped to the main tether. While the four wires are used to power the valve spinner and strafing motor, the pneumatics lines power the claw and the video lines connect the onboard cameras to the TVs. By adding a secondary tether, small foam pieces (5 cm x 2 cm) were added 1 m apart to keep the whole tether neutrally buoyant and not affect the manoeuvrability of our ROV. The tether is crucial to the operation of the ROV since it serves as the lifeline for the electrical systems.

Electronics

There were several different decisions to make concerning the design and development of our control scheme and electrical system for this year's ROV. One of the main aspects of our system involves two separate control boxes, one for the pilot, and one for the co-pilot. The ROV is powered with a 12V bench power supply with a maximum current draw of 25A. We wired a fuse holder on the positive lead of our main power line, directly after a banana plug, one of which can also be found on the negative lead. This fuse holder was required to always hold a 25A fuse, ensuring that our equipment and personnel would be safe in case of a short circuit or other failure. Our main power lead (12 gauge copper wire) goes through a strain relieving connector and is then distributed throughout our system through the use of power distribution blocks, the majority of which are found within the co-pilot control box.

Each connection is attached to the system through power distribution terminals, and is then sent down the tether to the vehicle, where all necessary connections are made through proper soldering techniques, and are then finally wrapped in heat-shrink tubing.

Control System

Figure 20: Pilot and co-pilot control system for the TMR 1. (Credit: Sean Purchase)

Every employee of HUSKY R.O.V.E.R. had an opportunity to contribute to the design of our control scheme, and when the system was built, every employee had an opportunity to practice piloting the vehicle.

The co-pilot control box houses three double pole-double throw switches, two single pole single throw switches, an ammeter to monitor current draw, and a variety of strain relieving connectors to ensure nothing will come loose during operation. The two double pole-double throw switches on the top of the control box operate the four vertical converted bilge pump thrusters found on the ROV. Each switch controls one pair of thrusters; the two aft thrusters and stern thrusters are wired in parallel. This gives us the ability to control the pitch of our vehicle while under operation, allowing us a wider range of motion and the ability to tackle a wider variety of tasks without the need for special equipment. A double pole-double throw switch is used for our valve opener device, allowing us to either tighten or loosen valves as desired. A single pole single throw switch controls our bilge pump which we use to inject fluid into a pipeline. The remaining single pole switch is for the main power to our entire system, this single switch acts as a full stop in case of emergency, breaking the positive lead coming into the box from the bench supply.

The pilot control box houses a distribution block, a data unit for a SONAR device (Uniden QT 206), and three Canakit UK1125 bi-directional motor controllers, which operate on the premise of Pulse Width Modulation (PWM). PWM operates by quickly pulsing a current on and off many times every second, essentially allowing us to control a thruster with a potentiometer. These motor controllers are rated up to 7A each without ventilation, and can be pushed further with ventilation and a fan like we have installed. Each motor controller operates a single thruster independently; left, right, and a strafe or side-to-side motor can individually be controlled at a variety of speeds in either push or pull configurations. This control box is connected to the co-pilot box through a custom wiring loom made in-house.

Figure 21 : Canakit UK1125 bi-directional motor controller. (Credit: Sean Purchase)

Cameras

Figure 22: 360° camera. (Credit: Khafre Pike)

The ROV contains 3 fixed view cameras (CVC620WP) and 1 rotating 360 ^{0} cameras. The fixed view cameras, used to view tools, are waterproof to 18 m and contain a 3.6 mm lens which provides a 92^0 viewing angle under water. The main driving camera, a 360 ^{0} rotating camera, is placed at the rear of the frame to provide the pilots with a larger field of view. It also has a 3.6 mm lens (92^0). However, it has the ability to pan 360 degrees using a remote control. This provides the pilots with a great view of the surroundings when performing the missions.

Figure 23: 620WP camera.

(Credit: Khafre Pike)

One problem we encountered with the cameras involved the electromagnetic interference of the tether and the LCD television. Each time the pilot would power up the thrusters, the TV would blink on and off. To solve this issue we immediately began a troubleshooting technique (see p.17) to eliminate probable causes. It was determined that the refresh rate signal on the LCD TV interfered with the electrical signal in the tether. To correct this problem, we used a CRT style TV and placed another fixed camera as a backup.

Effective problem solving and trouble shooting are necessary skills in ROV design and construction, especially when it comes to optimizing ROV performance and making it neutrally buoyant.

Buoyancy

The buoyancy system of any ROV can be achieved using a variety of materials, including high density foam or ABS pipe. Initially, we considered foam; however, we decided that due to its compression at greater depths, it would lose flotation and therefore the stability of the ROV would be compromised. Resultantly, the buoyancy was constructed from the alternative, a 7.6 cm diameter section of ABS pipe and an end cap. The pipe was chosen because it would resist compression under extreme depths and be easy to measure and cut.

To achieve neutral buoyancy, Archimedes Principle, was invoked. The weight of the ROV (110N) was equal to the weight of the water displaced by the ROV. Next we determined the approximate volume of pipe needed to displace this amount of water. By knowing the mass of the ROV and the density of water, the approximate length of pipe was calculated. Since the volume of water displaced was approximately 4867 cm^3, 42 cm of ABS pipe was cut into 2 equal sections and placed on the ROV. Once the buoyancy was calculated, it was checked and tested in the pool. Small additions of mass were required since the ROV was still slightly positively buoyant.

Figure 24: ABS pipe for buoyancy of TMR 1. (Credit: Mitchell Sparkes)

The pilot and co-pilot checked and tested the manoeuvrability of the ROV until they were satisfied with its performance. The completed ROV is fully functional and capable of completing all missions. A system integration diagram shows the finished product.

System Integration Diagram

At the time of brainstorming, design, and fabrication, we did not have the required expertise in order to create a computer and software based system for our vehicle. Instead, we chose to fabricate our electrical system using analog methods. A hardware-only approach was much more reasonable and cost effective for our company; our budget and skill set were both factors behind this decision. The system and fluid diagrams are shown below.

SID

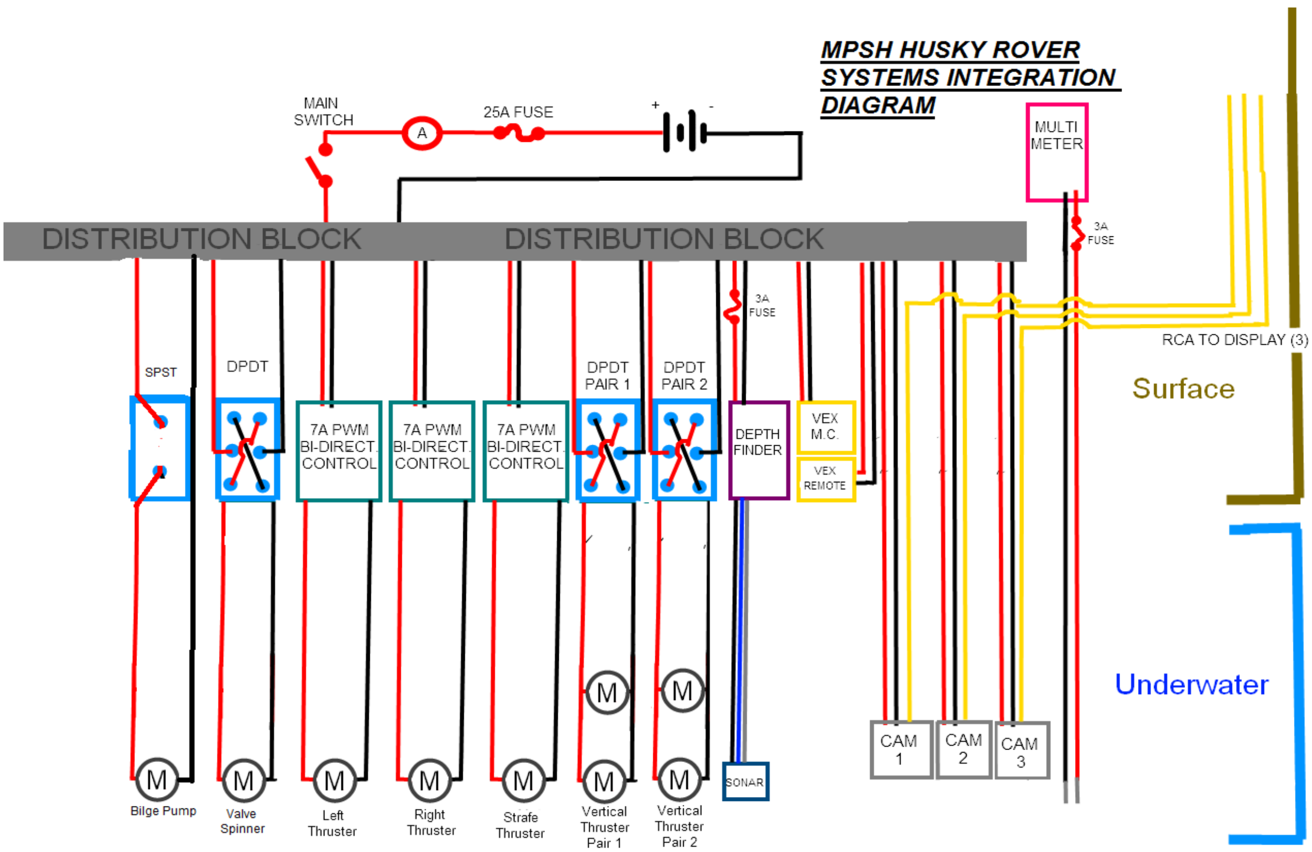

Figure 25: SID for TMR 1.(Credit: Sean Purchase)

Fluid Diagram

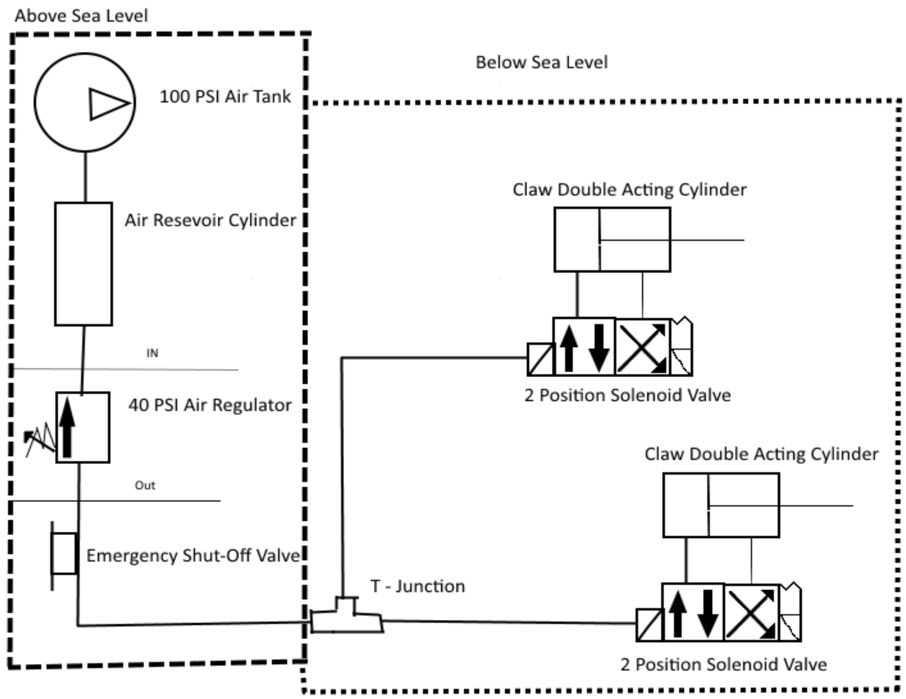

Figure 26: Pneumatic schematic for TMR 1. (Credit: Sean Purchase)

Safety

The safety of our company's members is our number one priority. At the beginning of the year, our safety team developed a safety checklist (see appendix #1) that we regularly reviewed with our members before each meeting to ensure safety while at work on the ROV.

During the construction of the ROV, each member received instruction on the use of new equipment. To prevent accidents while using tools that were a potential hazard, long hair was always pulled back and tied up, long sleeves were rolled up and safety glasses were worn. Supervision was always a priority. No members were permitted to operate equipment without a mentor present. As well, members were encouraged to ask questions and practice a safe workplace.

Figure 27 above: Soldered and shrink wrapped wiring. (Credit: Maria Halleran)

While working on electrical components of the ROV, we ensured that each connecting wire was soldered and shrink wrapped to prevent damage to electrical items. Furthermore, a 25 amp fuse was added on the positive side of the circuit to prevent damage to the electrical components of the ROV and to protect our teammates from any injuries which may be sustained from working with the electrical items. Electrical safety is of utmost importance, especially when practicing with the ROV at the pool and during competition.

Figure 28: Soldered and shrink wrapped wiring. (Credit: Maria Halleran)

From the beginning, we made sure to be incredibly safe while working with electrical equipment and components by wearing safety glasses and incorporating a safety protocol into each aspect of our work on the vehicle. Each time we powered up the vehicle, we completed a checklist; we ensured all connections were reliable and no wires were crossed, we made sure to check fuses, and we requested that all technicians near the ROV kept their bodies, extremities, hair, and clothes, far away from the ROV while under operation and maintenance of the electrical system.

Moreover, to further protect against injury, the thrusters were labeled with warning labels and plastic wire was attached to shroud the motors.


Figure 30: Protective covering around motors. (Credit: Maria Halleran)

The tether was also secured to the frame using a double strain relief to prevent damage to the electrical system.


Figure 29: Double strain relief of tether. (Credit: Laura Johnson)

Finally, when we visited the pool to practice the missions, all teammates on deck were wearing their personal floatation devices (PFDs) under the supervision of a lifeguard present. As well, we ensured that the tether was kept neat to prevent tripping and that our teammates were wearing gloves to protect them from any sharp edges that could potentially harm them.

Our safety department worked with all team members to ensure that the procedures required for the design, the building, and the use of the ROV followed all safety protocols.

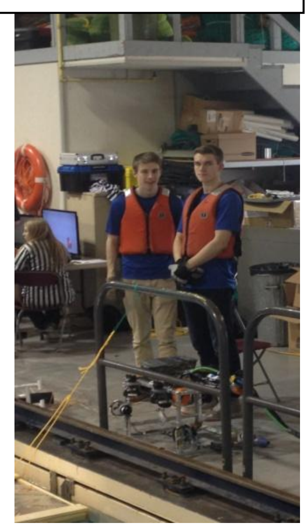
Figure 31: On-deck safety - All team members wear PFDs. (Credit: Laura Johnson)

Troubleshooting Techniques

Throughout the completion of the ROV, the team faced many challenges and encountered many problems. The troubleshooting process often involves the process of elimination, where a technician will follow a set of steps in order to determine the problem or resolve the problem. Our team used a simple three-step approach to troubleshooting:

1. Isolate the cause by eliminating possible problems.
2. Correct the cause of the problem.
3. Verify that the problem has been corrected.

Figure 32: ROV testing - Summit Centre.(Credit: Laura Johnson)

This process proved to be very effective during the construction and development of the ROV. Once the ROV was completed it was tested in our indoor testing facility and then several practice sessions were held at the local pool, the Mount Pearl Summit Centre. It was through vigorous testing and troubleshooting that our ROV became as effective as possible.

Challenges

Technical

While working on the ROV we faced many challenges, but the largest technical problem was the size of our ROV. This year we opted for a larger frame design to allow for better placement of tools and cameras. Initially, we designed and built a frame with the dimensions 60 cm x 50 cm x 40 cm which was large enough to allow more space for attachments, but still small enough to fit through the hole in the ice for the science under the sea mission (75 cm x 75 cm). After attaching our claw and motors, we realized that we had not taken into account the extra length that these components would add to the overall size of the ROV. Once attached, the pneumatic claw extended over the steel frame by approximately 5 to 10 cm. The motors were approximately 10 cm beyond the frame. With this increase in size, the ROV would be too big to fit through the hole in the ice. To overcome this challenge we had to brain storm alternate positions or attachments methods for the claw and motors. Finally, we resolved the problem by attaching two steel bars approximately 10 cm into the frame and moving the motors back onto these bars, minimizing the ROV length by 10 cm. With this solution, our ROV dimensions were shortened and we were able to fit it through the hole in the ice.

Non-Technical

Husky R.O.V.E.R. is composed of 16 members and this played an important role in the process of building our ROV this year. Having such a large team has many benefits, but it can also create the need for additional management and conflict resolution. With so many members, we faced difficulty with having multiple people working on the same task at the same time and sometimes this resulted in little to no progress. To resolve this problem, the CEO assisted in dividing the team into smaller groups, based on each individual member's interests and strengths. Each group was assigned a specific role to play for the fabrication of the ROV or the management of the company. We made sure to keep all written documents, including brain storming, design proposals, and modifications in the team's Google drive to allow the inclusion of all team members. Moreover, we kept a large checklist hung on the whiteboard, helping to ensure that all tasks were completed, eliminating the possibility that a team member would begin a task that had already been done by someone else.

Lessons Learned

Technical

One technical lesson that we have learned is the importance of planning the size of our vehicle in advance with all our equipment attached to the ROV. Initially, when we began planning the size of the ROV, we knew it had to fit through a 75 cm x 75 cm ice hole. Considering the difficulty we had with the small frame last year, we decided to build one much larger, 60 cm x 50 cm x 40 cm. However, we quickly realized that when the tools such as our claw and bilge pump were mounted to the front it extended the length of the ROV. Through this error, we learned the importance of planning and thinking through thoroughly each facet of the ROV design before making any final decisions. Fortunately, we were able to adjust the thrusters and claw to fit through the ice-hole without too much difficulty.

Interpersonal

One interpersonal lesson we have learned throughout this process was how difficult it is to maintain a large company with 16 members. From the very beginning, it was clear that with so many people each person would need to fulfil a different role and responsibility within the group. However, even with assigned roles, not all members were as committed and dedicated as was required. Many original members missed too much time. Therefore, as time progressed, several members resigned their positions and then other members had to assume new roles. Luckily, the remaining team members were reliable and willing to learn new skills to help complete the ROV. Due to this issue, it was decided that in future attendance will be taken at meetings and if members miss too much time, then they be required to withdraw from the team.

Future Improvements

Although we chose to use modified bilge pumps for propulsion this year and they were effective, we feel as though new thrusters may be better suited for future missions. The modified bilge pumps we used draw more current than other models, have been used for several years, and therefore are not as powerful are before. Propulsion is an important aspect for the operation as it is what makes our vehicle move and is the most used device on the vehicle. As such, if they are operating inefficiently, much more of our limited current must be allocated to their operation. We feel that a more advanced computer operated thruster system may be better suited for vehicles we plan on making in the future.

Reflections

As a team we have accomplished a great deal throughout the process of designing and manufacturing our ROV. We began with nothing but a mission and our minds, and finished with a product that brings us great pride. As soon as the competition manual was released, we began brainstorming our ideas. With these ideas in our heads, we split off into smaller groups where we able to accomplish the construction of each of our tools and ROV components. By working separately in teams and cohesively together, we were able to build and modify all the necessary components of the ROV. This allows for a team sense of accomplishment when the project came together, with each team member seeing their portion having aided in the completion of the mission tasks on competition day.

The MATE competition has given us an opportunity to learn and accomplish tasks like no other experience in our time in high school. You can learn so much in the classroom but this competition allows for hands on experience approaching a variety of real world problems that allow us to use our own ideas and designs to solve them. This gives us a real sense of accomplishment when we can all watch our own ROV in action.

Acknowledgements

We are extremely grateful to all our sponsors. Without their support this project would not have been possible. We thank our teacher mentors, Mr. King, Mr. Power, and Mr. Williams as well as our alumni member Catherine Ducey for their guidance. This project would not have been possible without donations from businesses within our community. We would like to extend our gratitude to Sea-Force and High Point Industries for their equipment donations; to Triware Technologies and Rutter Inc. for their financial support; to the city of Mount Pearl who allowed us to use the Summit Center pool for testing our ROV; and to The Print and Sign Shop who printed our poster board using their large format printers. We'd like to give special thanks to the MATE center and Marine Institute for giving us the opportunity to compete with our ROV.

MARINE INSTITUTE

MATE
MARINE ADVANCED TECHNOLOGY EDUCATION CENTER

THE PRINT & SIGN SHOP
Graphic Arts & Sign Shop Ltd.

CITY OF Mount Pearl

RUTTER

Triware Technologies Inc.

HI-POINT INDUSTRIES

SEA-FORCE

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Appendix A: Safety Checklist

Safety Procedures during construction include:

- ❑ Safety a priority in discussions, displays and actions.
- ❑ No loose clothing.
- ❑ Long hair tied up.
- ❑ Closed toe footwear.
- ❑ Safety glasses at all times since multiple activities occurring in shop.
- ❑ Appropriate behavior: no running or horsing around.
- ❑ Safe materials handling: long or heavy stock moved by 2+ people; use trolleys.
- ❑ Instruction and apprenticing for all shop equipment usage (power tools, heating, etc.)
- ❑ Hazardous or toxic chemicals removed from lab permanently.

Pre-Mission Checklist:

- ❑ Deck Crew put on PFDs.
- ❑ Wear Safety Glasses.
- ❑ Remove loose clothing.
- ❑ Tie up long hair.
- ❑ Place ROV in secure location on deck.
- ❑ Unwrap tether and extend along the pool deck.
- ❑ Prepare to launch ROV.
- ❑ Place small TVs control box and panel in suitable location.
- ❑ Use Banana Plugs to connect to main power supply.
- ❑ Connect Video cameras to Control Panel power supply.
- ❑ Connect video cameras to TVs.
- ❑ Turn on Main Power switch.
- ❑ Commence pre-mission check on systems: Cameras, Tools and Thrusters.

Appendix B: Budget

During the initial meetings on Dec. 12, 2014, a budget of $750 provided by the Marine Institute and Mate was discussed. This budget was to cover all new materials to build an new frame, props, tool development, hardware and a poster display. It was decided that some of the equipment (tether, control box and thrusters) from last year be reused. Fortunately, we came under budget by approximately $120. It was noted that a fund raising effort was needed to purchase new equipment, including thrusters and computer related equipment. This will be a major focus for next year.

Appendix C: Husky R.O.V.E.R. Team

Front row: Mary Pike, Erin Fitzgerald, Julie Bennett, Laura Johnston, Maria Halleran, Connor Hynes, Back Row: Mr. Paul King (Teacher Mentor), Catherine Ducey (Alumni Mentor), Mr. Aaron Power (Teacher Mentor), Aloysius Ducey, Mr. Cameron Williams (Teacher Mentor), Mitchell Sparkes, Ryan Hayes, Khafre Pike, Sean Purchase, Adam House, Colin Hunt, Andrew Pye, Brad O'Leary, Josh Hapgood. (Photo Credit: Sean Purchase)