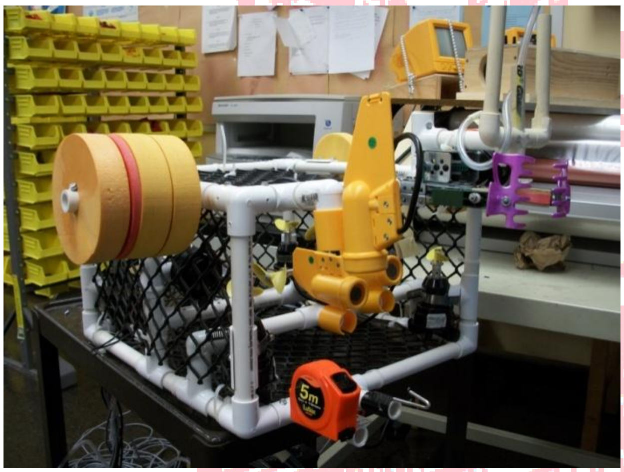
Technical Report

Submitted by:

NB Whalers Salvage Company

New Bedford High School

New Bedford, Massachusetts USA 02740



ROV

Control Box

NB Whalers, Members:

Thaison Le (Chief Executive Officer/Pilot) YOG 2013

Michael Rapoza (Electrical Engineer) YOG 2013

Jose Vargas (Vice President of Operation) YOG 2013

Alexis Almeida (Chief Financial Officer) YOG 2013

Mason St. Jacques (Design Engineer) YOG 2013

Company Instructors:

Mr. Chris Parker (Mentor)

Mr. William Ferreira (Mentor)

Dr. John DiCecco (Mentor)

Mr. Michael DeSousa (Mentor)

Table of Contents

Contents

Abstract

Our firm, New Bedford Salvage Co, is competing this year in the 2012 MATE ROV International Competition. Five high school juniors who are taking an underwater robotics class formed the company to respond to the challenge. This year's competition revolves around sunken World War ll shipwrecks, found all over the world, slowly leaching poisons into our waters. Our first goal was to lay out the tasks and objectives of the competition, and discuss how we could design our ROV to accomplish the missions.

Continuing previous year's traditions, we used PVC pipe for the overall shape of our ROV. It is cheap, easy to work with and very versatile. We based the shape of our ROV's frame on a rectangular prism. To maintain balance and maximize stability, we placed the buoyancy on the top and the motors on the bottom.

We designed our tools to multitask. For example the claw; we have multiple purposes from inflating the lift bag, to removing and transporting the coral, to patching the drill hole. Our company worked side by side with the Naval Undersea Warfare Center Newport to design, fabricate, and test a controller that would give us more manipulative control of the ROV and also reduce tether mass.

The most stressful part for our company was trouble shooting; we had to address all of the problems and create improvements. The company worked as a team designing and fabricating a workable ROV that could accomplish all the missions and achieve the maximum points possible.

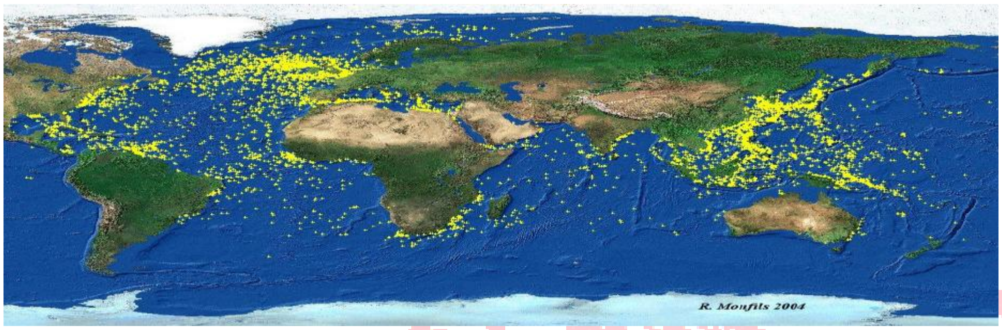
Information about World War II Sunken Ships

There were 105,127 warships participating in World War II, 36,387 of these ships were destroyed by the end of the war. The big problem now is that these sunken ships are still leaking hazardous fluid into the ocean. This causes pollution and massive fires.

As early as 1942, 287 ships were sunk in the U.S and in Canadian waters. Without our awareness, 548,884,740.00 liters of oil spilled within 80 kilometers of the coast. To put this in perspective the Exxon Valdez, a supertanker spilled 41,639,532.00 liters of oil. That's an estimated 227,124.72 liters of oil spilled per day every day for six months, creating pollution and harming sea life.

During World War II the largest disaster overtook British naval forces in English Channel which took place on October 1943. Two warships were sunk in combat HMS Charybdis and HMS Limbourne, between them they took over 500 men with them. 58 years later, on June 2001 British trimix divers set out from Weymouth England to bring this story to the public. HMS Loridan based diver Keith Morris led the expedition, and it was a success HMS Charybdis was found lying in a depth of 80m/ 270 feet.

On December 25, 1942 the MS Gardner was hit and sunk by a German U-Boat during World War II. Our company has accepted the MATE request for proposal to design and build a remotely operated vehicle to locate the ship wreck, map the wreck site and surrounding area, survey the ship and recover a fuel sample.



Locations of World War II shipwrecks

Oil Tanker Disaster

Budget/Expense Sheet

Parts	Quantity	Unit Price ($)	Total Price	Vendor
Underwater Camera & Monitor set	**3**	**139.95**	**419.85**	**Harbor Freight**
2-Axis Joystick (#27800)	**2**	**6.99**	**13.98**	**NAVAL Undersea Warfare Center Newport (NUWC)**
PIC 18F452 Microcontroller	**1**	**4.00**	**4.00**	**NUWC**
L298N H-Bridge	**16**	**2.00**	**32.00**	**NUWC**
LM323 5- Volt Regulator	**1**	**0.65**	**0.65**	**NUWC**
NBHS Secret Aquatic Drive Motor	**8**	**17.99**	**143.92**	**Cabela's**
MISC Electronic Components			**25.00**	**NUWC**
5x2.5x1.5" Project Enclosure	**1**	**2.00**	**2.00**	**NBHS**
Heat Sink	**1**	**4.80**	**4.80**	**Den Mar Corp.**

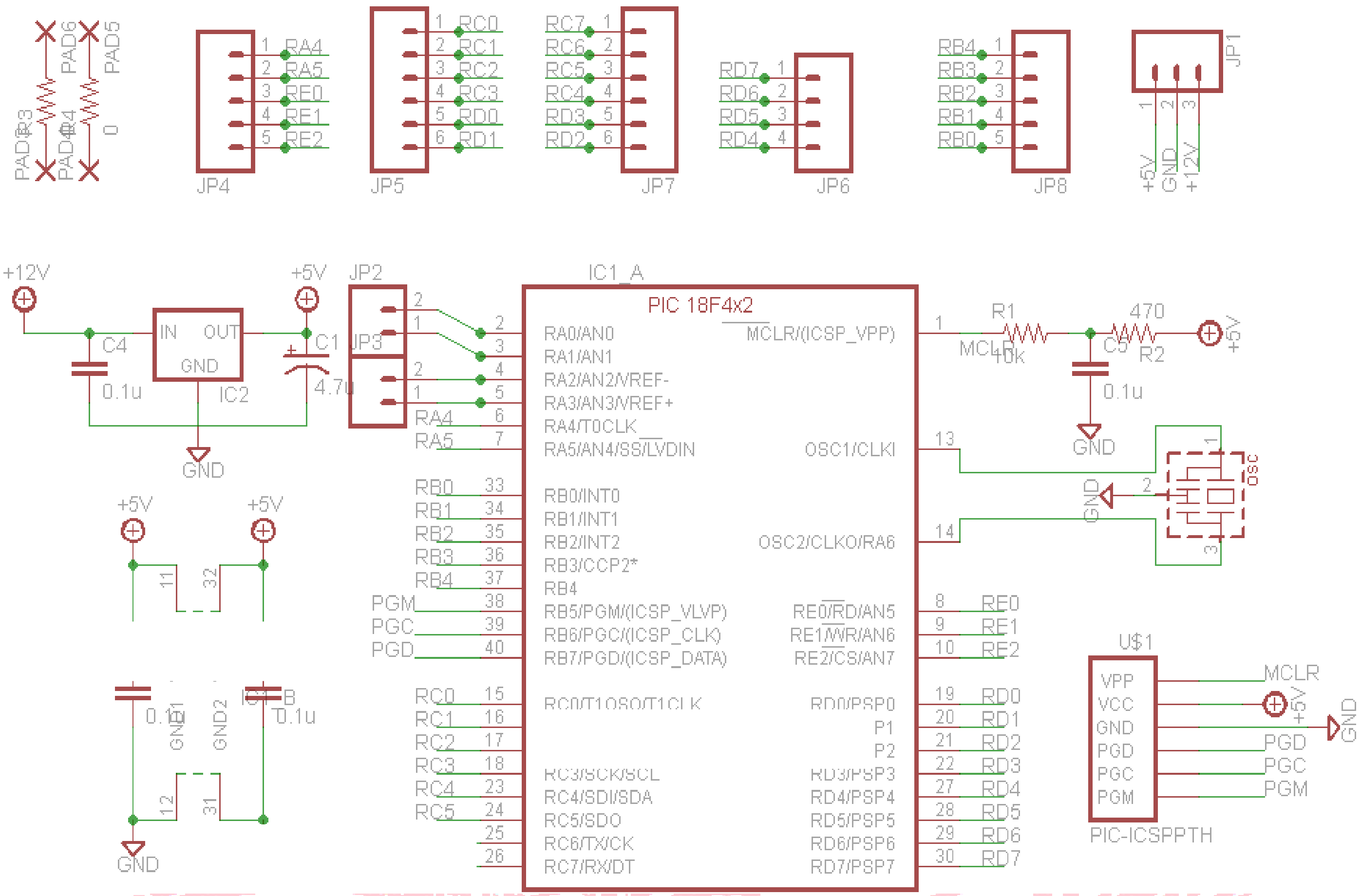
Boards	**9**	**4.00**	**36.00**	**NUWC**
CAT 5E Cable	**½ 500 ft.**	**75.00**	**37.50**	**Home Depot**
Plastic Funnel	**1**	**1.00**	**1.00**	**Home Depot**
Circular Magnet	**2**	**0.50**	**1.00**	**Home Depot**
#12 SS Hose Clamps 11/16" – 1 ¼ "	**1 Pkg.**	**12.50**	**12.50**	**Mahoney's**
20.32cm Zip Ties	**1Pkg.**	**29.95**	**29.95**	**Mahoney's**
Lufkin 8m Tape	**1**	**18.99**	**18.99**	**Home Depot**
Octura Plastic Prop (R)	**7**	**1.25**	**8.75**	**Happy Hobby**
VEX Gear Kit	**1**	**12.99**	**12.99**	**VEX Robotics**
VEX Worm Gearbox Bracket (2-pack)	**1**	**12.99**	**12.99**	**VEX Robotics**
Multicolor Heat Shrink Tubing (12 Pack)	**1 Pkg.**	**3.99**	**3.99**	**Radio Shack**
½" PVC 90° Ell Soc Fitting	**2**	**0.30**	**0.60**	**Mahoney's**
½" PVC Te Soc Fitting	**2**	**0.35**	**0.70**	**Mahoney's**
½" PVC Pipe, 3.048m length	**5**	**2.25**	**11.25**	**Mahoney's**
¼" PVC Pipe, 3.048m length	**2**	**2.00**	**4.00**	**Mahoney's**
½" PVC Snap-On Saddle IPS O.D x Soc Fit	**14**	**0.64**	**8.96**	**Mahoney's**
½" PVC Side Outlet Ell Soc Fitting	**4**	**1.56**	**6.24**	**Mahoney's**
6x4x2" Project Enclosure	**1**	**4.99**	**4.99**	**Radio Shack**
25 Amp Blade – Type Automatic Fuse	**1**	**1.49**	**1.49**	**Radio Shack**
LCD readout display	**1**	**9.95**	**9.95**	**The Robson Co., INC**
Electrical Tape	**2 Rolls**	**5.00**	**10.00**	**Ketcham Traps**
Plastic Net	**1**	**3.00**	**3.00**	**Ketcham Traps**
Dinsmore Analog Heading Sensor	**1**	**39.00**	**39.00**	**Dinsmore Company**
9 Volt Battery	**1**	**0.88**	**0.88**	**Mahoney's**

Cost: $922.92

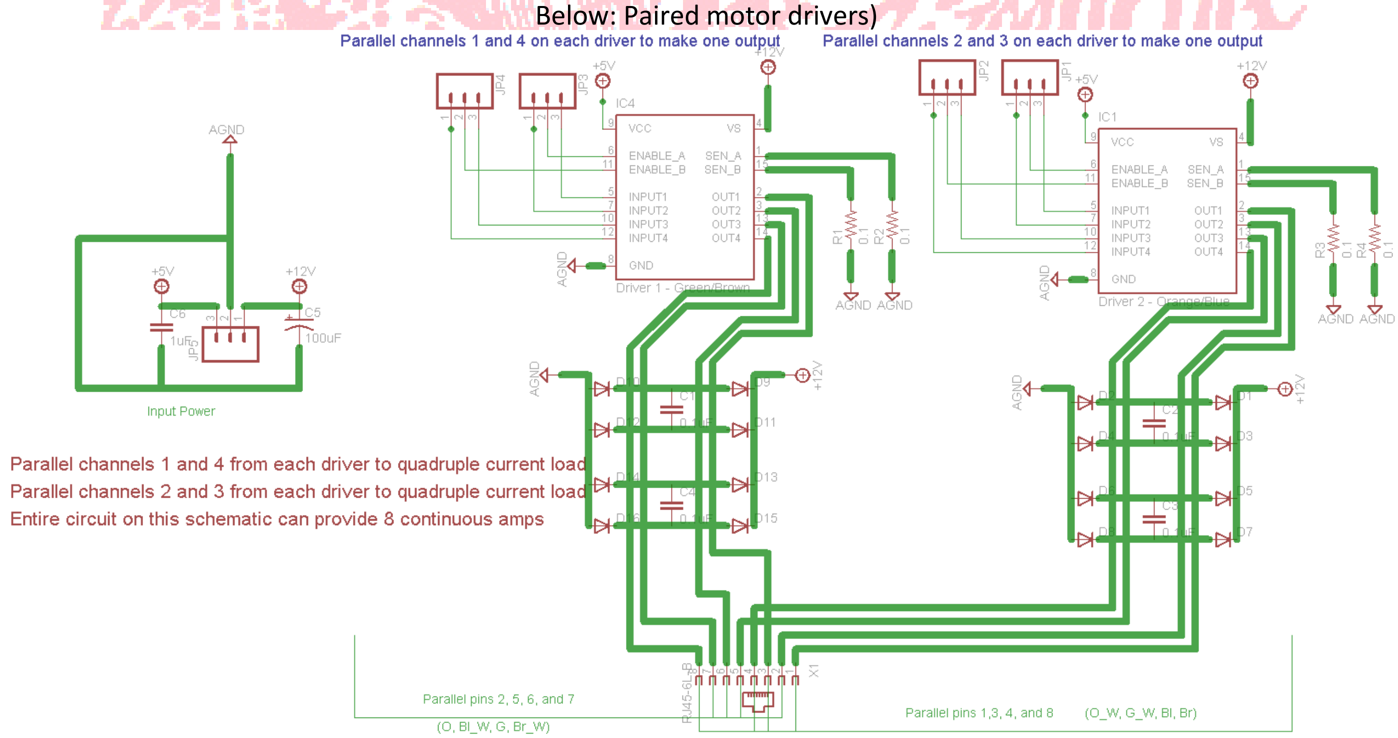
Donation: $275.35

Total Cost of ROV: $647.53

Electrical Schematic

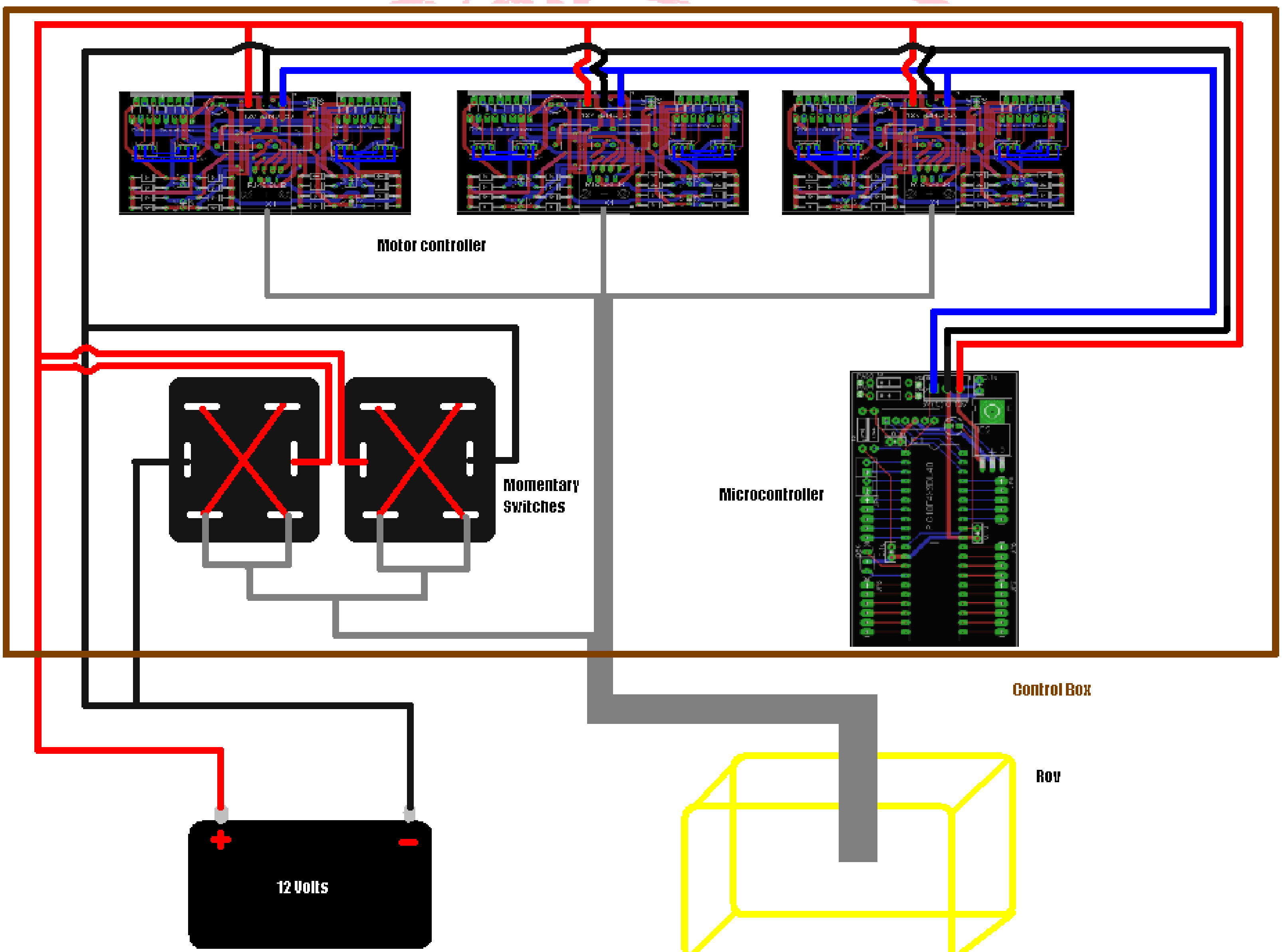


(Above: Microcontroller
Below: Paired motor drivers)



Control Box

Our control box consists of a microcontroller which uses a PIC18f452 microprocessor. The microcontroller connects to the motor controllers. Each motor controller board has two motor controller drivers and each motor controller driver has 2 motor ports. We jumped together the motor controller driver outputs to drive 1 motor. Since each motor controller board can drive 2 motors, we have a total of 3 driver boards. That allows us to control 6 motors using PWM (pulse width modulation.) Our two forward and backwards motors are independent from the microcontroller because we wanted more power when driving. We used momentary switches which are connected straight to the battery. The motor controllers and momentary switches are all connected to the motors through RJ45 cables. We connected the eight wires in each RJ45 cable in pairs and wired the pairs in to drives 2 motors. This allowed us to significantly reduce our tether mass.



Design Rationale and Payload Description

We read MATE's Request for Proposal (RFP) and developed a matrix of mission tasks, the work needed to accomplish the tasks, possible tools and the points for the task. We thought about the minimum types of tools that would be needed on our ROV. Based on the ideas that our company came up with, we started designing our ROV. Our designing took us about a week or so because we sketched out a lot of the parts, and we also talked about the pros and cons of the ideas that each and every one of us came up with. We based the design of our ROV on having something small with a lot of stability and maneuverability, as well as complete motor control for our several calibrations that we will be taking. After all of our brainstorming was done we started to implement our ideas into the construction of the ROV. We built, tested and reworked our design until we were satisfied with the results.

Control of the ROV was an important design feature; simple switches didn't give us the motor control we needed. We partnered with the Naval Undersea Warfare Center in Newport Rhode Island to help us design and test a PIC microcontroller driven ROV motor control system from parts and circuit boards. We then designed the box and wiring and also programmed the PIC microcontroller. We then modified the programming based on what we learned after a series of in water trials and test runs. What follows is a **Payload Description** of our company's ROV.

Motor placement

Once the ROV frame was constructed, our company's first task was the placement of the motors. We placed four up/down motors in the corners for stability purposes. This was done for four main reasons:

A. Due to past experience, we figured that we needed more lift and motor control leading us to use four motors instead of two.
B. We would have better motion control with the motors placed further away from the center of rotation of the ROV.
C. By placing the motors on the corners, we achieved both balance on the ROV and productivity from the motors.
D. We decided to place all of our motors inside the ROV for safety reasons and handling.

On the port and starboard side we placed two forward and backward motors. We centered the motors evenly on both sides for balance. In the absolute center of the ROV we position our side to side motors. Our motor placement made our ROV symmetrical as far as weight and thrust goes.

Tools

After we constructed the body of our ROV, we then used MATE's mission matrix and started to design and construct the tools necessary to complete each and every task given. These are the following tools that were constructed:

A: Claw

B: Pitchfork /air bag holder/ air line guide

C: Calibration probe/ fuel intake

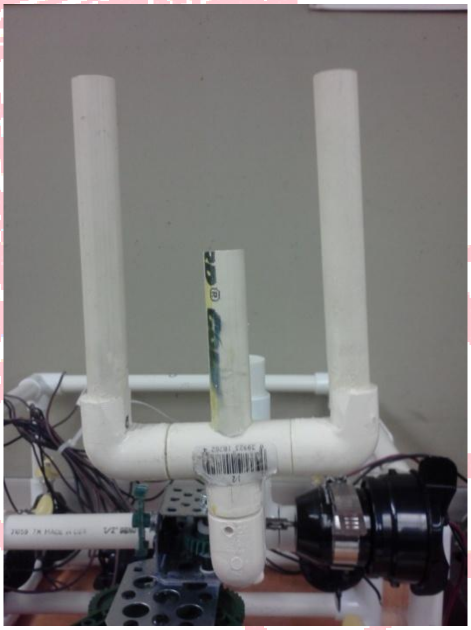
D: Dinsmore Analog heading sensor - orientation device

E: Tape measure - linear measurement device

F: Magnet - magnetic detection device

G: Water proof camera used for calibration tank/ neutron backscatter

H: Operator control cameras



(Above: the pitch fork/ air bag holder/ air line guide)

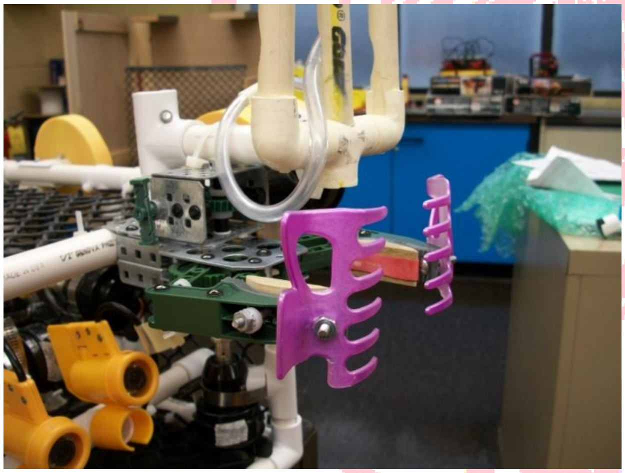
Specification:

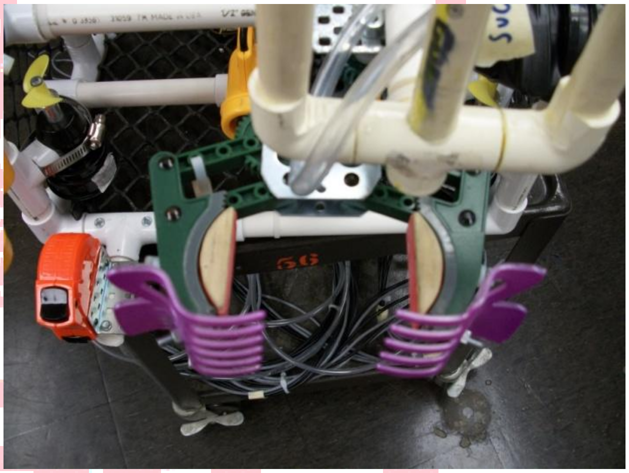
This tool is made up of ½ inch PVC pipe it is used to hold the air bag and as center the air line under the air bag. This tool allows us to deliver the airbag to the site and insert air to fill the bag.

(Left: linear measurement device)

Specifications:

This is our linear measurement device. This consists of a METRIC tape measure and a 2” PVC pipe loop. We wanted something that was effective and simple; this tool is going to be used to measure the boat’s length from bow to stern. We will use an onboard camera to observe the measurement reading.



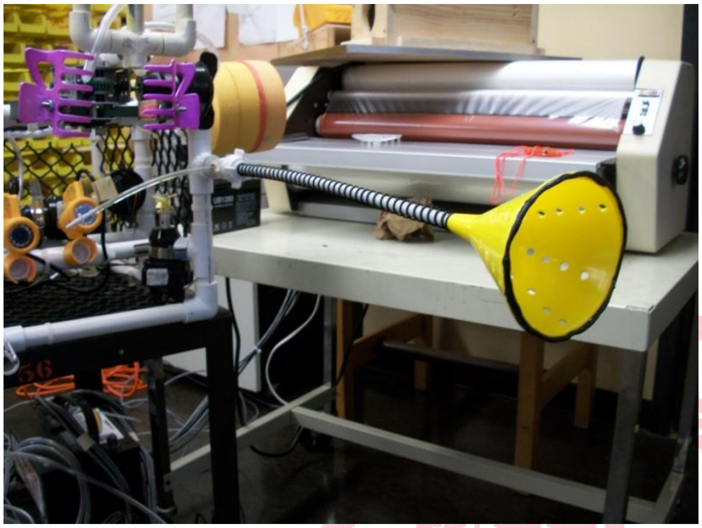


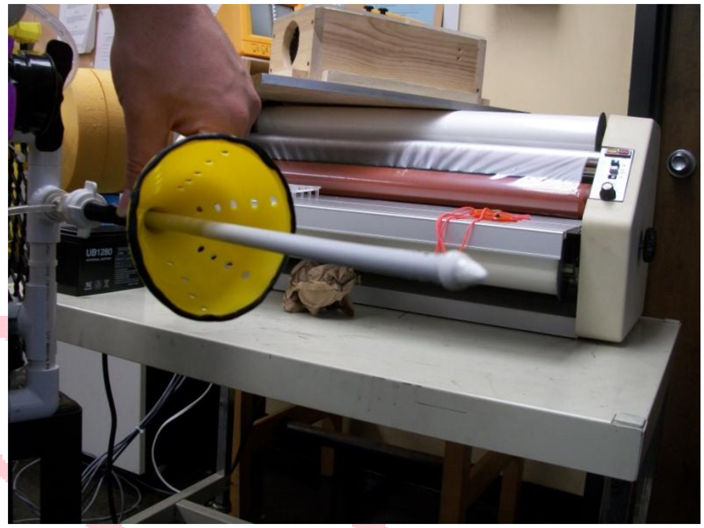
(Above: The Vex Claw)

Specifications:

This is our vex claw. It is made out of plastic and stamped sheet metal. We had to make a coupling to interface the 2839.06 LPH bilge pump motor we use to activate the claw to the gear-box. This is worm gear driven gear-box used to reduce the speed and hold the claw in position when the motor is stopped. There are teeth at the end of the claw to make extracting the coral more secure. One of the problems that our company ran into was that when the worm gear opened the claw too wide it locked the gear train in place and the motor wasn’t powerful enough to move it back into its original place. Our company built a butterfly handle and added it to the worm gear drive to help us unlock the gear box just in case it gets locked.

We have also programming the PIC to order this motor driver to slow the rotational speed of the gear box motor.

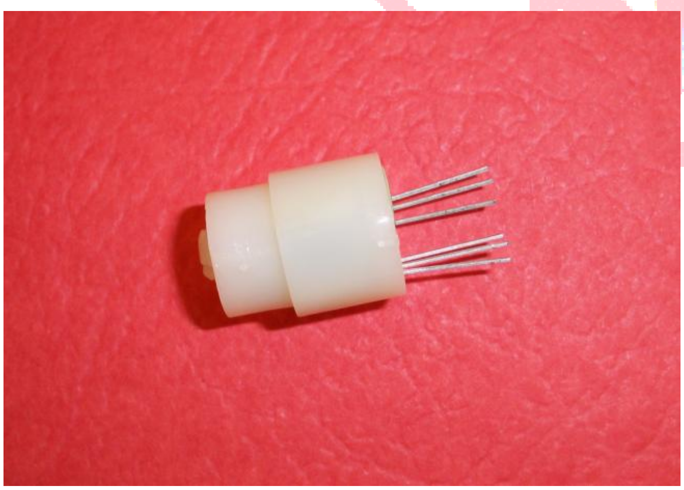




(Above: the calibration/fuel intake tool)

Specifications:

This is our calibration/fuel intake system. This is a spring-loaded system that is designed so that the funnel can guide the probe to the oil sample port and will move up the probe as the probe is inserted. The spring will push the funnel back to its original position when the probe is removed from the oil sample port. It is a dual-purpose tool, used to take the oil sample and also used as our calibration and measurement probe. This tool consists of a regular funnel, a length of quarter inch PVC and a plastic spring. We decided to have the funnel spring loaded and drilled with holes to help guide the probe to the calibration tank while letting water flow through the holes to minimize drag.



(Above: Heading C3 Monitor screen)

(Left: Orientation Device)

Specifications:

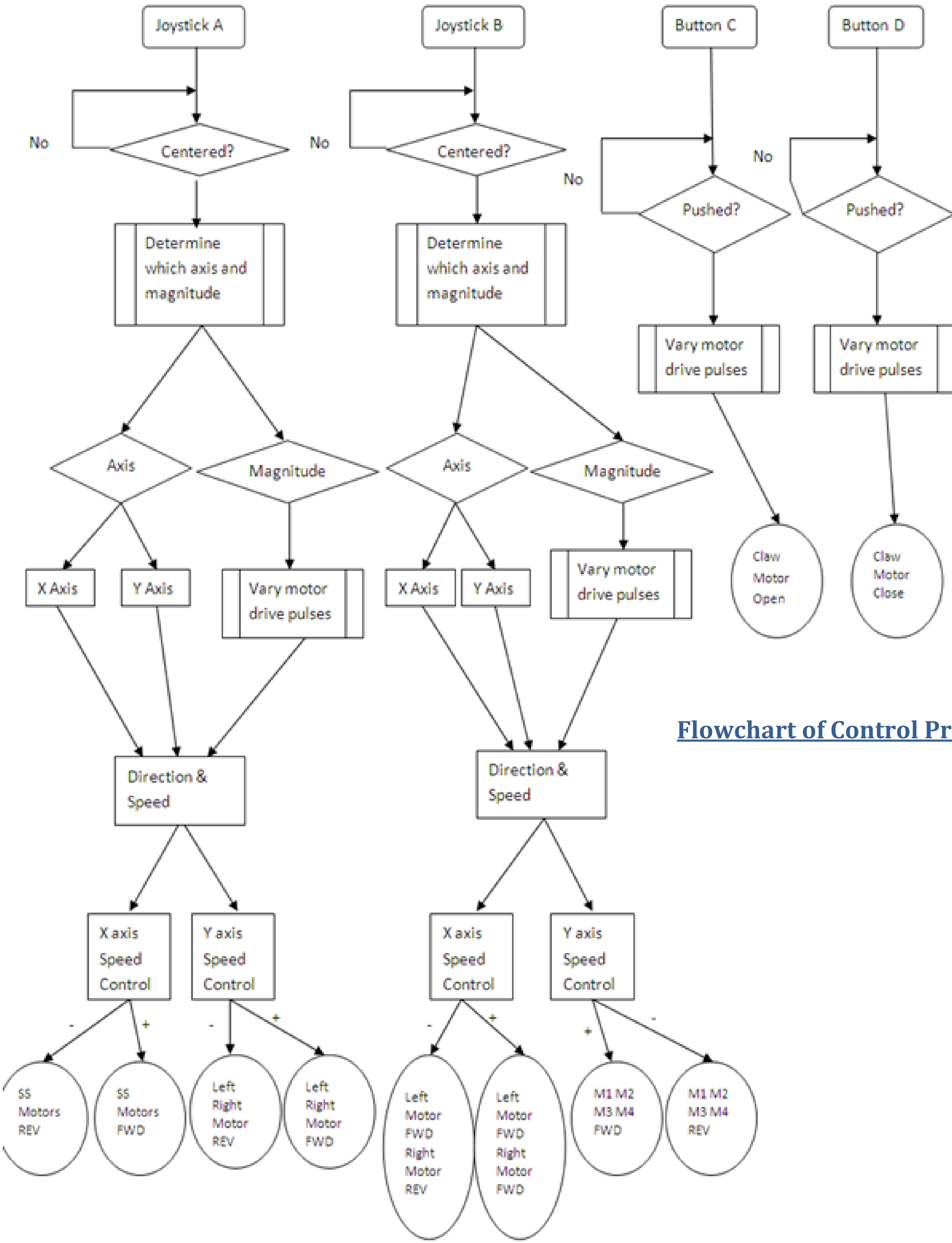
The orientation device is an analog heading sensor that interfaces with the microcontroller to help us determine the orientation of the ship. At first we tried a regular magnetic compass but we had troubles because the motors interfered with the compass. We tried many methods but none worked until we went on a forum and asked professionals. We were recommended to investigate a Dinsmore analog compass sensor which is designed to be unaffected by our brush motors. The orientation device has small sensors that detect the robot's magnetic fields and compensates for these to allow us to sense the earth's magnetic field. The Dinsmore analog heading sensor is connected to an another separate PIC Microprocessor which we then programmed it to display on a LCD display which shows our magnetic heading.

(Above: The Quicker Picker Upper)

(Above: The Capper)

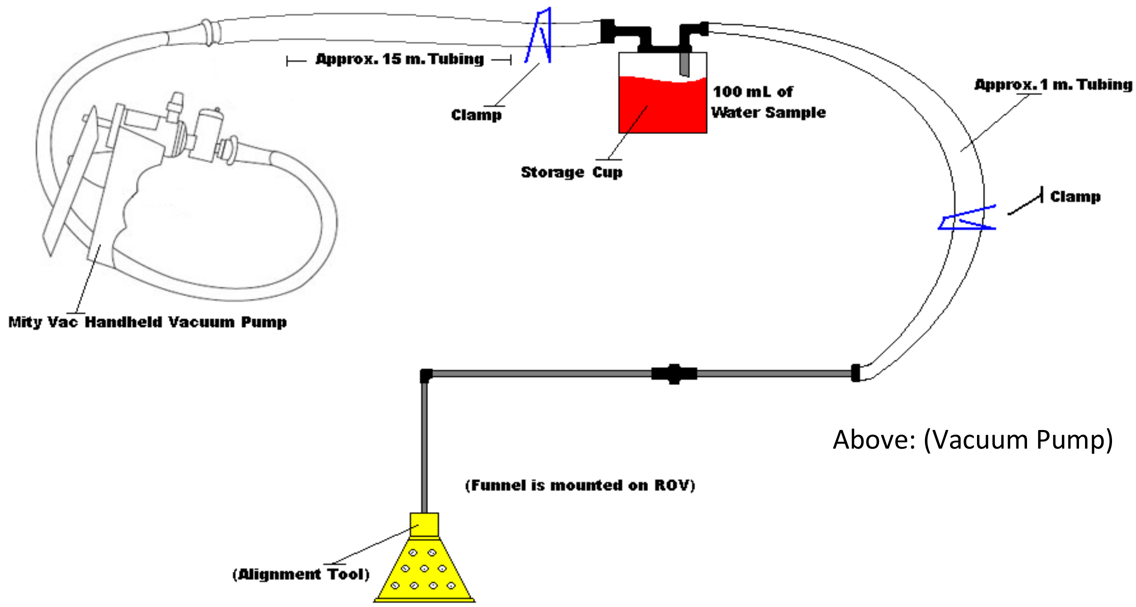
Specifications:

"The Quicker Picker Upper" This device is used for retrieving fallen mission props. It consists of aluminum and PVC pipe. It is 7 cm long. The hook was designed to be able to retrieve any fallen mission props. "The Capper". This tool was specially designed to cap the fuel tank .It consists of two 8 cm long aluminum rods, and a piece of 5 ½ cm long PVC pipe.



Flowchart of Control Program

Vehicle Sub-System



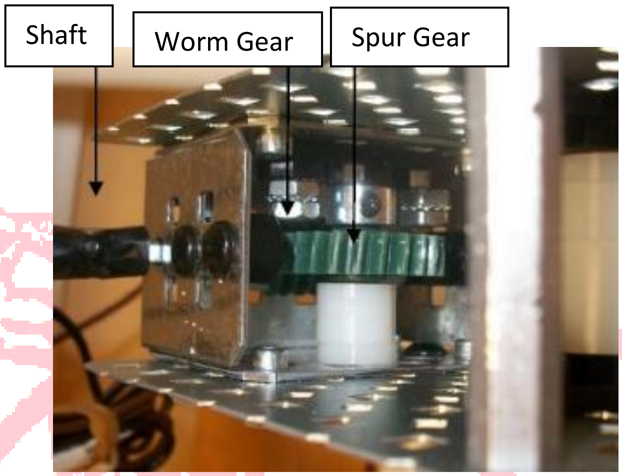
Above: (Vacuum Pump)

- Our vacuum pump is installed with a self- aligning pipette.
- The clamps that we put on will stop any back flow of water entering the system.
- If any water gets in we can reverse the pumping system and expel the water by blowing air into the tube.
- The pipette will be inserted in the fuel tank and the vacuum pump will be activated to suck air, creating a vacuum, sucking in the fuel from the vessel into the storage cup.

Challenges Faced

A major challenge that the company faced was opening and closing the gripper claw. When the claw was opened or closed it went too fast at first. It seemed to only spring into the opened or closed position at speeds that were too fast to accomplish our tasks, even with the use of the pulse signals from the microcontroller. Additionally, the claw motor would constantly spin and run the risk of damaging either the motor itself or the claw because there was no locking mechanism. We solved the problem by adding a gearbox and programmed the microcontroller to slow the claw motor.

A non-technical challenge that we faced was the position in which to place our cameras. The goal was to have the least number of cameras as possible and still be able to have a wide range of vision. The claw was at first going to be placed on the bottom of the frame of the ROV. One task for the claw was to hold the hook that is attached to the lift bag. We realized with the claw on the bottom of the ROV, we were not able to see the hook at all. We then placed the claw on the top of the ROV which gave us a better view of the hook.



Trouble Shooting Techniques

To solve the challenge of the gripper claw, our initial idea was to add a gear box that would include a worm gear. This would slow down the speed of the gripper claw and the worm gear would assure the locking of the gears. We subsequently implemented the idea and found the results were not quite what we intended. The worm gear locked, but the motor had too much force behind it and could still jam if not opened or closed properly. Fortunately by changing the duty cycles (pulse signals) from our microcontroller, we solved the problem by slowing the motor down with programming.

A simple solution to the challenge of the camera position was to move the placement of the claw to the top of the frame, along with angling the camera up-wards. Cutting the "wing" off the back of the camera would insure that it fits within the ROV. When testing, we drove the ROV with our two main cameras for a couple of test runs realized we had to add a third camera at the top of the frame that is angled down and to the left. This third camera was specifically intended for use with the linear device tool, but it also helped with the “quicker picker upper” tool as well as helping to determining the water depth beneath the ROV.

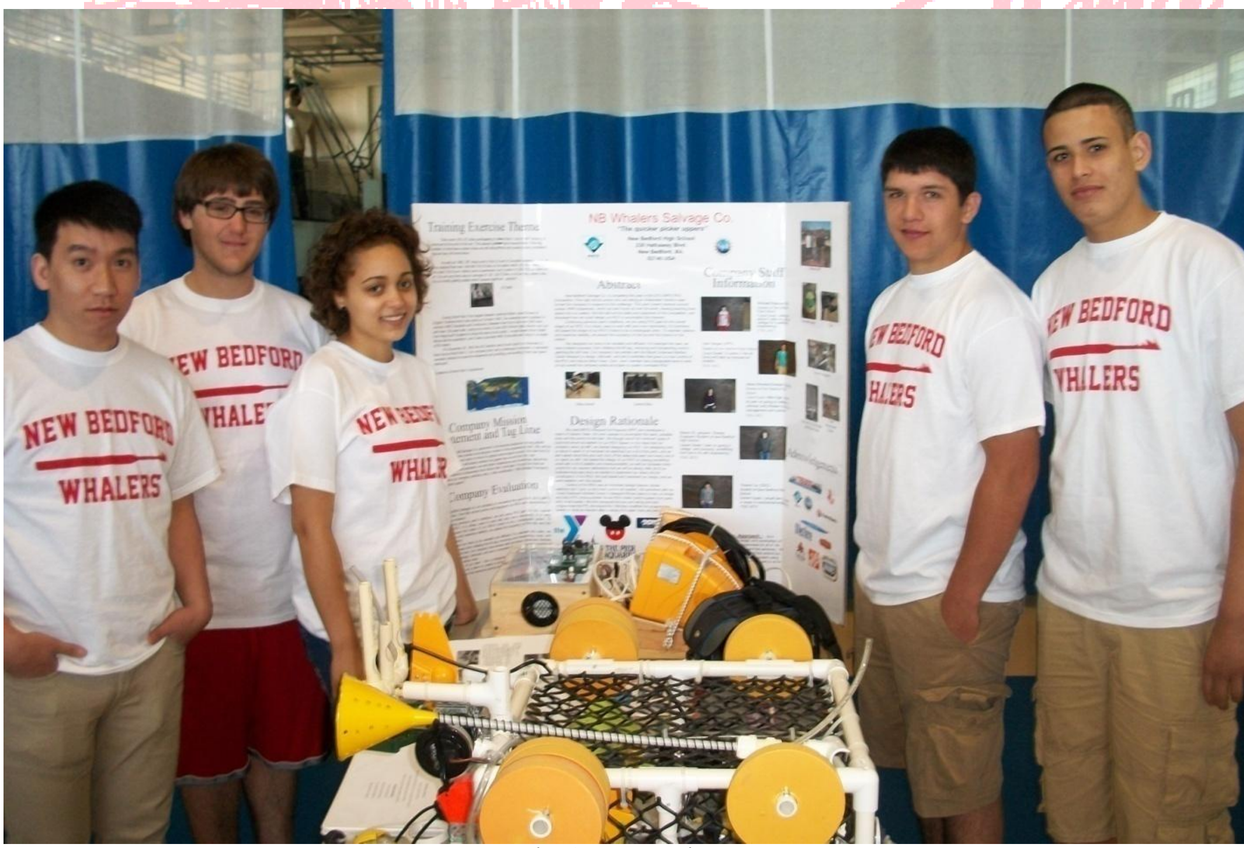
Future Improvements

For future improvements, we would get rid of the worm gear within the gearbox completely. It would be much more convenient to use only the pulse signals from our microcontroller to open and close the gripper claw. Now with a better understanding of a microcontroller, we feel using that knowledge will help us to get rid of unnecessary parts or features and would most likely result in better outcomes. Also we would encourage future companies to focus on reasonable goals; not to disregard anything that might seem impossible, but to set primary goals and try their best to think of creative ideas to get a job done.

Lessons and Skills Learned

Over the course of these past months our company has had many positive and negative experiences and has developed a good insight into problem solving and critical thinking. We have learned how to implement ideas to solve a problem and how to compensate for the shortfalls in outcomes that every solution has. From an electrical standpoint we have gained many skills that came about when we were given the task of helping to design and more importantly understanding the microcontroller, as it is a huge part to our project. From an engineering standpoint we all got a better understanding of neutral buoyancy, propulsion, electrical engineering and gear reduction. We have learned how to cooperate and coordinate in a company as a whole, not as individuals. To conclude, this project was all about keeping the skills and lessons learned so that we could take on the MATE challenge and possibly pursue a career in engineering or to overall arm ourselves with proper knowledge that can help us out in the future.

Personal Reflections



(Left to Right)
Thaison Le, Mason St. Jacques, Alexis Almeida, Mike Rapoza, José Vargas

Alexis Almeida

“My name is Alexis Almeida; I am a junior at New Bedford High School and I am the Chief Financial Officer”. Before I got into Mr. Parker’s MATE ROV robotics class I had no experience with engineering. After weeks went by and our company got more into making the ROV, I started to realize engineering is something good to have some knowledge of. After high school I do plan on going to college at Johnson and Wales to take up management and culinary, but because of this class I can say I know a whole lot more about engineering and how things work. I appreciate the fact I got to work with NB Salvage Co. From taking this class I learned nothing works the first time and because of that you have to take some notes as you go so you can go back and see what you have done wrong. All engineers know it takes more than a hand full of times to get their machine working well.”

Mason St. Jacques

"My name is Mason St. Jacques; I am a junior at New Bedford high school, in the company I’m the design engineer. I am currently enrolled in Mr. Parker’s MATE ROV robotics class. Technology and engineering have always been an interest of mine so this class was a great opportunity for me to further implement my skills. At the beginning of the project I had minimum knowledge of the engineering of an ROV. Working with the NB Salvage Co gave me an insight on how to get better acquainted with the engineering process and teamwork. I Think engineering is something I would like to pursue after high school thanks to my experience on this project."

José Vargas

“My name is José Vargas; I am a junior at New Bedford high school and I am the VPO. I am currently enrolled in Mr. Parkers MATE ROV robotics class. My plans for the future are to enlist in the Air Force and take up Mechanical Aviation. I had the privilege to work with Mr. Parker (mentor), Mr. DeSousa (mentor) Mr. Ferreira (mentor) and Dr. DiCecco (mentor). I have learned a lot of information that helped me in the building of the ROV. This class really gave me a good lesson on what it takes to be an engineer that will stay with me for the rest of my life. Designing this ROV really defined what engineering means. One of the things that I learned about engineering was that no matter how good one can be at their job there are still going to be complications. Real engineers find the answer to most problems. I also learned that if we didn’t draw out our ideas, or take notes on the ROV, we lessened the chances of having a good working machine.”

Michael Rapoza

“My name is Michael Rapoza; I am a junior at New Bedford High School I am the Electrical Engineer. Before I took Mr. Parker’s class I didn’t have any engineering experience. As weeks went on our company got closer and more into the ROV, and I started to realize all of the steps of the engineering design process. After high school I plan on going to college for business or engineering, this class has helped me get more on the engineering side. From taking this class I have noticed you have to make mistakes in order to get the best results. Thanks to Mr. Parker (mentor), Mr. DeSousa (mentor), Mr. Ferreira (mentor), and Dr. DiCecco (mentor), this experience has been a blast."

Thaison Le

"My name is Thaison Le. I am a junior at New Bedford High School and I am the CEO/Pilot of this company. I enrolled in the Navy's Naval Underwater Research program for the summer of 2011. I worked with engineers to design and create an ROV similar to what we are doing in MATE. I really like this subject so when I was offered to be in a robotics class by Mr. Parker, I was onboard right away. The 1st semester we competed in FTC and Seapearch; which we did really well. Now we are competing in The Mate Competition. I really like this class, I get to work with real engineers and we get to design and create a workable ROV. This has been a great experience, and the knowledge that I have obtained will help me pursue my engineering career."

Teamwork

Teamwork and cooperation was key in completing the ROV. Nobody slacked off, everyone gave 110%. The company worked together as a group to brainstorm and discuss the tasks and ideas of creating the ROV with the help of our mentors. We then assigned the work to each person according to their specialty. Thai is the pilot and CEO of the company. Jose is the Vice President of Operation. Michael Rapoza is the Electrical Engineer. Alexis is the Chief Financial Officer and Mason is the Design Engineer. With that said, everyone in the company had a chance to work in another's "department". Everyone soldered, did electrical, helped design and construct the tools, learned to program the PIC processor and had chances to drive our ROV.

We each wrote a section of the technical report and poster board. We then compiled our sections into a working, logical technical report and poster board. All members participated in every aspect of the ROV, from designing, fabricating to soldering and programming the ROV. Everyone had a part in the building of the ROV; each person had a specific role in the engineering design process. This increased the productivity in designing and completing the ROV. For example while Mike and Jose were working on the control box, Mason was working on the tether, Thai was writing the technical report and Alexis was designing the poster.

This is a schedule of time that we spent working on this project.

Schedule

Jan 23 2012	The company discussed the competition, rules, tasks, points and strategy
Jan 30 2012	We brainstormed and researched ways to build and designed the ROV
Feb 6 2012	Built the frame and placed the cameras
Feb 27 2012	Put on the motors, built the tools and started on the technical report
Mar 12 2012	Started to design and build the control box, work on tether and finish technical report
Apr 16 2012	This week we tested the ROV, trouble shoot the problems and worked on buoyancy
Apr 23 2012	We worked on safety and wrote the safety procedure. We prepared for the competition in the pool, finished the poster board and technical report and got in some driving practice in the pool
April 28 2012	New England regional competition at Mass Maritime academy
April 30 2012	Reviewed the competition and brainstormed improvements
May 1 2012	We made adjustments and improved the ROV

References

http://www.homebuiltrovs.com/rovforum/

Underwater Robotics: Science, Design & Fabrication by Moore, Bohm, Jensen

Safety Procedure

This company takes safety very seriously. Competing in the competition is our goal, but our main priority is the safe being of not only our team but every participant in the MATE program. We dealt with specific safety issues for example we enclosed the ROV in a plastic mesh that prevents contact with the motors. We designed a safety checklist to go over before the mission. Safety Checklist

- Safety Glasses
- No open toed shoes
- No jewelry
- Long hair secured
- No loose clothing
- No sharp edges
- All motors functioning properly
- Monitors work
- Pressure gauge works
- ROV covered and secured
- Check tether for cuts
- Gripper claw works
- Extra fuses
- Tool box
- Check for all ROV tools
- Propellers are all tight
- Plastic mesh secured
- Flotation Modules secured
- Tape measure is retracted
- Magnet is in place

Acknowledgments

MATE: The MATE provided our company with all of the information and aid that we needed for the competition.

New Bedford High School: New Bedford High School provided us with a facility to work in and with the school that we needed to work.

Naval Undersea Warfare Center (NUWC): NUWC donated us all the components for the control box. ($275.35)

Radio Shack: Radio Shack provided us with our wires.

Happy Hobby: Happy Hobby provided us with our propellers and the adaptor kits.

Harbor Freight: We acquired our underwater camera and monitor set from Harbor Freight.

West Marine: The bilge pumps we used are from West Marine.

Home Depot: Home Depot provided us with our CAT 5E cable, plastic funnel, circular magnet and the Lufkin 8m tape.

Mahoney's Building Supply: Mahoney's supplied us with most of our PVC pipe, hose clamps, and zip ties.

Den Mar Corp.: Den Mar Corp. provided our company with our heat sink.

Mr. and Mrs. William Ferreira: Donated funds for our trip.

The Robson Co. INC: They supplied us with the heading sensor.

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