Technical Report

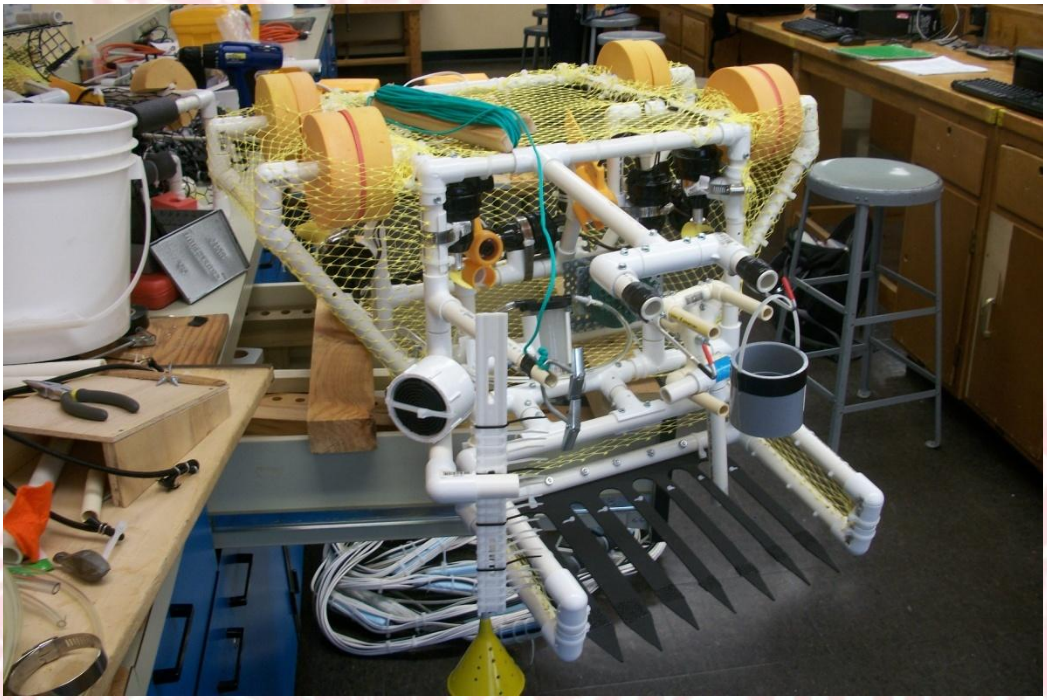
Submitted by:

NB Whalers 2

New Bedford High School

New Bedford, Massachusetts 02740

Free Willy



NB Whalers 2, Members:

Kenny Chan (VPO) YOG 2012, Brandon Medeiros (Design Engineer) YOG 2011, Dwayne Farias (Pilot) YOG 2011, Mason St.Jacques (Design Engineer) YOG 2013

Company Instructors:

Chris Parker (CEO)
Bill Ferreira (Mentor)

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Abstract

Our company, NB Whalers 2, is staffed by two seniors, one junior, and one sophomore enrolled in a high school technology class. Our company was tasked to design an ROV to combat an oil spill like the one that occurred in the Gulf of Mexico. Free Willy, our ROV was designed around balance and efficiency. In our voyage to create an ideal ROV for the competition, we contemplated several ways in which we could have an ROV that was practical and functional. PVC pipe was the material of choice for our project. It met our requirements for weight, durability, versatility and cost. The robot had to be competitively price and transportable. The frame's symmetric box shaped design is augmented by "wings" from the side for additional stability. We wanted to stay as simple as we could and as innovative as possible. We designed most our tools to multi-task, minimizing the number of tools we had to design. The claw, for example, is designed to complete the first two missions without surfacing. In order to complete these tasks we decided to have each person specialize in a part of the construction of our ROV. While all of the tasks were done as a team, one person was designated to focus his attention more onto key tasks. Our company used standard engineering practices such as, inquiry based design and concurrent engineering.

Company Information

Kenny Chan: (Vice President of Operations) Junior at New Bedford High School.
Team Role: I served as the team captain. I worked primarily on the technical report and wiring our ROV. On the side I would jump in and out of the ROV body and tools.

Dwayne Farias: (Pilot) Senior at New Bedford High School.
Team Role: I helped out with the construction of the R.O.V, also the making of the tools and the Gear Box.

Brandon Medeiros: (Design Engineer) Senior at New Bedford High School, also an Intern at UMASS Dartmouth learning about electrical engineering.
Team Role: I had constructed some of the tools and the R.O.V. with Dwayne. I also helped with the electrical for the control box.

Mason St. Jacques :(Design Engineer) Sophomore at New Bedford High School.
Team Role: I did the wiring of the electrical box as well as the construction of the ROV's frame. I also served in sorting out our tether.

Chris Parker: (CEO) Technology Education Instructor, 22 years.
Team Role: I assisted the students in their day to day operations, involving the engineering design process of their ROV.

Mr. Ferreira: Retired Navy Civil Service Manager. 40+ years experience in submarine Combat Systems design and development.
Team role: Mentor, guide and cheerleader.

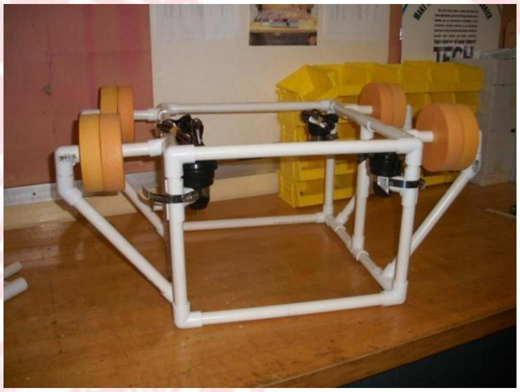
Design Rationale

Brain Storming

1. Our process all started with pencil and paper. We had our member draw out 4 schematics based off of the idea of balance and efficiency. From this we voted on the best design

Frame

2. From our “blueprints” we constructed a frame out of ½ inch PVC pipes
    - PVC was then chosen material because of its versatility and its low weight.



(Above: The frame of our ROV)

- In designing our frame we were looking for something with stability when placed in water.
- Our logic in using the wings is the fact that, the further away our floats are from our main frame, the more stability we will have; so we added wings in which we would place our floats on, giving us more stability.
- We were also able to tuck our thrusters inside the frame for safety purposes when handling.
- The versatility of PVC allowed us to create tools from PVC and attach them to the ROV, with ease.

3. After determining our ROV’s dimensions and specification, we proceeded to piece together the ROV

Motor Placement

4. After the ROV's body was constructed, we proceeded onto deciding where our motors would be place. As shown above we have four motors for horizontal thrust, one in each corner. This was done for four main reasons:
    a. Due to past experience, we figured that we needed more lift and more speed, leading us to use four motors instead of two.
    b. The motors would be more productive, when placed further away from the center 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 all of the motors inside the ROV for safety reasons when handling.
5. The vertical motors were also placed with the same idea as the horizontal motors, far from the center ideal for balance. The further out the motors were, the easier it would be for the ROV to rotate.
6. Our last movement oriented motor is our motor placed in the center of the ROV. This motor serves the task of shifting the ROV either right or left, instead of turning and reorienting the ROV with the vertical motors.

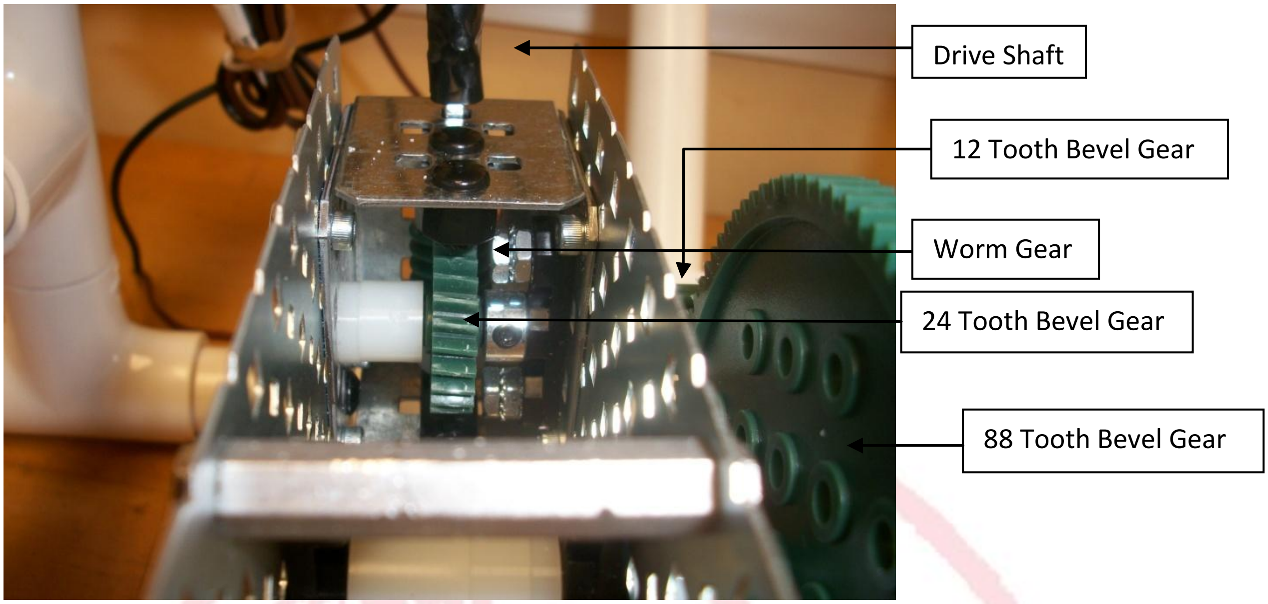
Safety Features of Vehicle

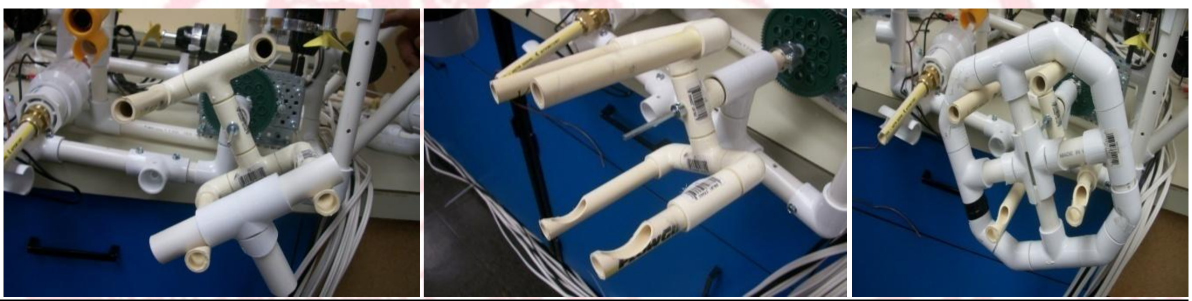
When our company took on the task of building the ROV, we all agreed that safety would come first. Our main safety feature on our ROV was a plastic mesh, which encased the entire ROV for protection from the propellers; by doing this we were able to handle the ROV freely without fear of cutting our hands on moving propellers. Another feature that we had, our motors are all individually fused with a 5-amp, slow-burn fuse. We chose to stick an LED in-line to let us know which fuse has blown. Lastly we have a 25-amp primary fuse which attaches to the MATES power system.

Tools

7. After we constructed the body of our ROV, we then started to design and construct our tools necessary to complete each task.
   * Pictures and description of tools are listed below.

Rotating Claw





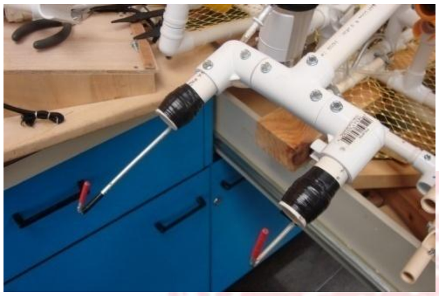
(Top: top/side view of the gearbox; bottom left: front view of our rotating claw; bottom middle: side view of rotating claw; bottom right: rotating claw with shut off valve wheel)

Specifications

- The claw is constructed out of ¼ in PVC pipe and has four prongs, which can be used for carrying, gripping, spinning, and grasping.
- Our claw started as our primary tool that would serve in all four tasks, but after consideration, we decided for it to conduct tasks one and two.
- The claw's purposes will be to spin the wheel 1080˚ and to remove, carry, and insert the hose line from the top kill manifold to the port of the weld head.
- There is a small metal rod, in the center of our four prongs to stop the claw from hitting and catching onto the pipe behind the valve.
- The claw is powered by a gearbox run by one of our motors. This gearbox reduces the motor's RPM by a ratio of 176:1

- This allows us to come up to the valve wheel and spin it at a manageable speed.
- The gearbox was placed inside the ROV and enclosed for safety reasons.

PVC Hook

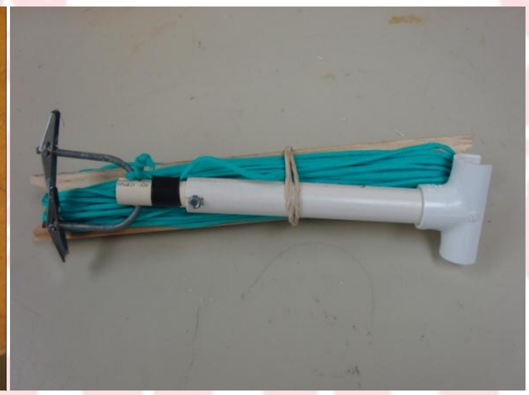


(PVC Hooks, used to grab the PVC ring and carry the well-cap)

Specifications

- This tool was constructed out of about 20cm of ½ in PVC and two aluminum hooks. We locked the hook into the PVC by bending one end by 90˚ and putting the end of the aluminum into a hole in the PVC.
- The hook's purpose is to grab the PVC loop at the end of the Velcro, separate the two pieces of Velcro and carry the well cap to the well head.
- It is removable, via connection to saddle Tee, which allows easier maneuverability and allows more room to work.
- The ends of the hooks were shrink-wrapped for safety reason.

PVC+U-Bolt catcher

(Above Left: Tether Tool; Above Right; Our tool with the PVC extension and detachable U-Bolt with toggles.

Specifications

- The purpose of this tool is to clasp onto the U-Bolt on top of the riser pipe and disengage from the ROV once it has attached.
- While thinking about this tool we knew we needed something that would allow the U-Bolt in, and then lock it in place.
- Our thinking result in the idea of using a bended metal rod, and putting two toggle bolts on the open end, allowing the U-Bolt in, and locking it in.
- We modified the tool in order for it to easily slide off of the PVC.

Modified Ruler

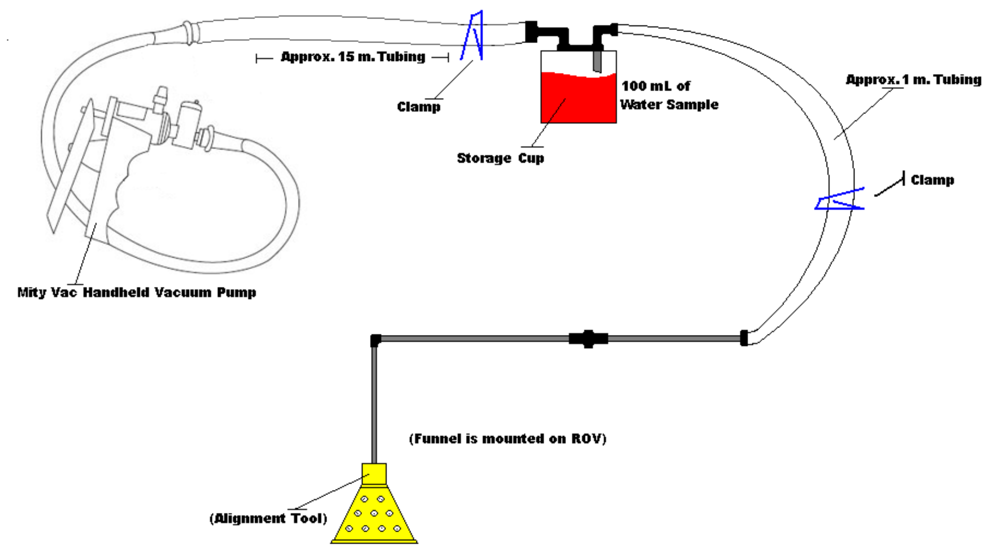
Modified Ruler for depth measurements

←

- Task three was by far our most challenging task. We did most of our thinking around how to complete this task.
- Our first goal in this task was to determine how to interpret the graph given to us.
- After that was complete we continued to measuring the depth of the water.
  - After our thinking we thought we would go and use a depth gauge to find out the majority of the depth measurement.
  - To measure the tape on the bucket, we determined that we were going to place a ruler with zip-ties sticking off of it to make our measurements. Each centimeter, we placed a white zip-tie. At every five centimeters, we placed a black zip-tie.

Vacuum Pump


Sub-System Schematic of Vacuum Pump



- Our system is installed with a self aligning pipette.
- The clamps are on to stop any flow of water to enter the system, by apply a constant pressure.
- If any water does get in, we can expel the water by using the pump to blow air into the tube.
- The pipette will be inserted into the bucket with the sample and the vacuum pump will be switched to suck in air, creating a vacuum, sucking in our sample into the containment vessel.

Scoop

(Above: Crustacean Scoop)

Specifications

- The whole intent of this tool is to complete task 4
- In the beginning we had intended on using a fork-like scoop, but later figured that the crustacean would fall through.
- We then look into cages and found a design from a cage that may come to our advantage
- After cutting out of teeth for the scoop, we added aluminum rods under them to reinforce them, while leaving enough up front to allow some spring effect to scoop up crustaceans.
- We made the scoop so that one side had thinner more free teeth to allow the crab and sea cucumber to simply slide in and stay, while the other side had thicker, more restricting holes in order to keep the glass sponge under control.

Control Box

8. Next up, was the ROV control box. The control box was probably our biggest challenge overall. Our control box was designed for safety and efficiency. Due to experience from last year's members, we built our control box more cautiously and safer than last year's. The controller contains 5 momentary switches and 2 push buttons.

(Above-Left: Top View, ROV controller; Right: Left side Control Box, note fuse holders)

- The controller has extras that can help save the team a bunch of time.
- Inside the controller we have placed LED's connected to every fuse, which accounts for every battery powered piece on the ROV. If a fuse were to blow, the LED would shut off and we would take the steps required to fix the issue.
- We have placed the top of our fuse holders to the exterior of the ROV. If a fuse were to break, we would simply unscrew the cap and place a new fuse and continue.

Tether

9. With the body of the ROV completed and with the controller finished, we continued onto connecting the two together. Our tether was made out of about 9 cables for the motors and pump, and another two for the cameras. We were looking for these cables to be about 15.24m.

(Above: Tether restraint, located on the rear of the ROV)

- One end of the cable went into the control box, which we soldered accordingly and completed all connections.
- We ran our vacuum tube through our tether to maintain organization and zip-tied it to our tether to avoid any further entanglement of the tube.
- The other end of the tether went to the ROV where we then systematically soldered, shrink-wrapped, silicone, and taped the exposed wires.

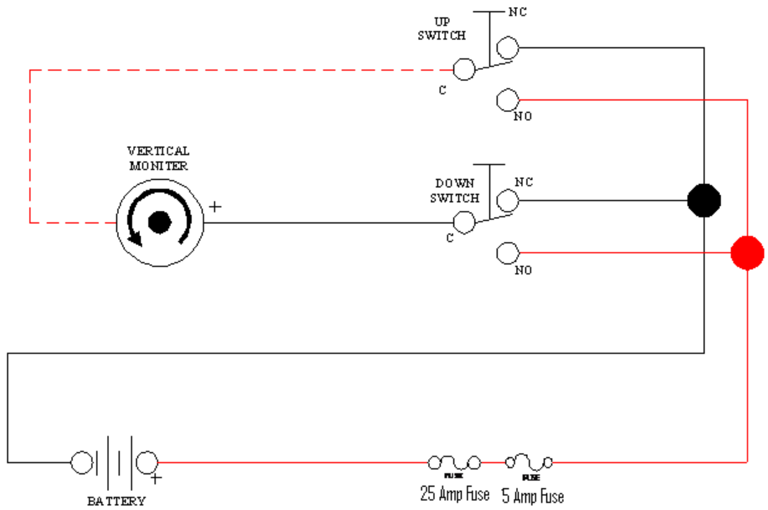
Parts Log

Parts	Quantity	Unit Price ($)	Total Price	Vendor
-Underwater Camera & Monitor set	2	139.95	279.90	Harbor Freight
-DPDT Momentary Flip Switch	5	4.49	22.45	Radio Shack
- Momentary Push Buttons	2	3.29	6.58	Radio Shack
-Slow-Blow 1 1/4″x1/4″ Glass Fuse-8.0A 250V	9	2.39	21.51	Radio Shack
- Fuse Holders	9	1.19	10.71	
-25 Amp Blade- Type Automatic Fuse	1	1.49	1.49	Radio Shack
-6x4x2″ Project Enclosure	1	4.99	4.99	Radio Shack
-Mayfair Cartridge Replacement Motors, 750 GPH	8	17.99	143.92	Cabela's
- 1/2″ PVC Side Outlet Ell Soc Fitting	4	1.56	6.24	Mahoney's
- 1/2′′ PVC Snap-On Saddle IPS O.D x Soc Fit	18	0.64	11.52	Mahoney's
- 1/4″ PVC Pipe, 3.048m length	2	2.00	4.00	Mahoney's
- 1/2″ PVC Pipe, 3.048m length	5	2.25	11.25	Mahoney's
- 1/2″ PVC Te Soc Fitting	2	0.35	.70	Mahoney's
- 1/2″ PVC 90° Ell Soc Fitting	4	0.30	1.20	Mahoney's
- #12 SS Hose Clamps 11/16″ – 1 ¼″	1 Pkg.	12.50	12.50	Mahoney's
- 20.32cm Zip Ties	1 Pkg.	29.95	29.95	Mahoney's
- 76.2m Roll SPT 2, 24 Gauge, Lamp Cord White	2 Roll	60.00	120.00	Mahoney's
- Multicolor Heat Shrink Tubing (12 Pack)	3 Pkgs.	3.99	11.97	Radio Shack
- Octura Plastic Prop (R)	4	1.25	5.00	Happy Hobby
- Octura Plastic Prop (L)	3	1.25	3.75	Happy Hobby
- VEX Gear Kit	1	12.99	12.99	VEX Robotics
- VEX Advanced Gear Kit	1	19.99	19.99	VEX Robotics
- VEX Worm Gearbox Bracket (2-pack)	1	12.99	12.99	VEX Robotics

- VEX Shaft Coupler (5-pack)	1	4.99	4.99	VEX Robotics
- VEX Booster Kit	1	179.99	179.99	VEX Robotics
- 3/16” Aluminum Rods, Length 6”	10	.25	2.50	Happy Hobby
- Plastic Sheathing	1	2.00	2.00	Ketcham Traps
- Fishing Net	1	3.00	3.00	Ketcham Traps
-152m Roll, 8 Gauge Wire (Red)	1 Roll	0.00	0.00	NBHS
-152m Roll, 8 Gauge Wire (Black)	1 Roll	0.00	0.00	NBHS
- Onset Depth Gauge	1	113.00	113.00	Onset
- Poly Floats	20	1.00	20.00	Ketcham Traps
- Electrical Tape	2 Rolls	5.00	10.00	Ketcham Traps
- Rule Bilge Pump, 360 GPH	1	19.99	19.99	West Marine
- LED	9	1.19	10.71	Radio Shack
-Totals			1119.71	
-Donations			-179.99	
			-19.99	
Final Total				
			$919.73	

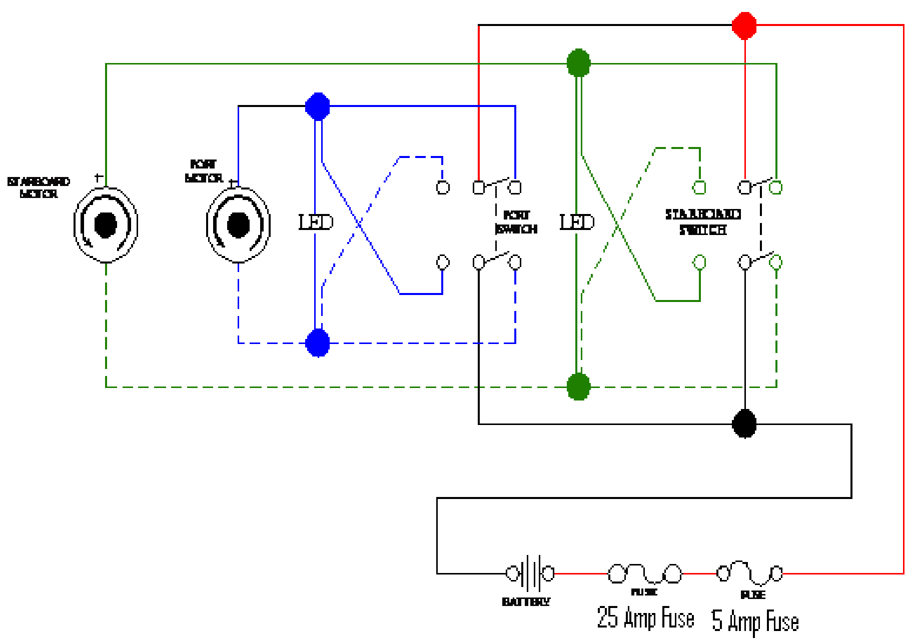
Red Text indicates a donation or that the material was readily available and free

Electrical Schematics



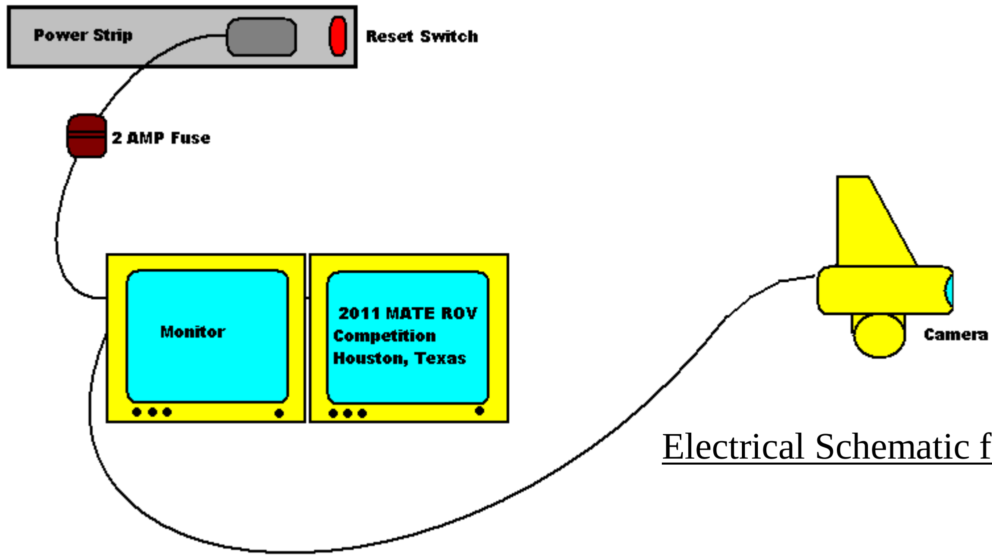
VERTICAL THRUSTER CONTROL CIRCUIT DIAGRAM

NB WHALERS 2



HORIZONTAL THRUSTER CONTROL CIRCUIT DIAGRAM

ALL MOMENTARY SWICHES WIRED AS PER DIAGRAM



Electrical Schematic for Cameras and Monitors

Challenges Faced

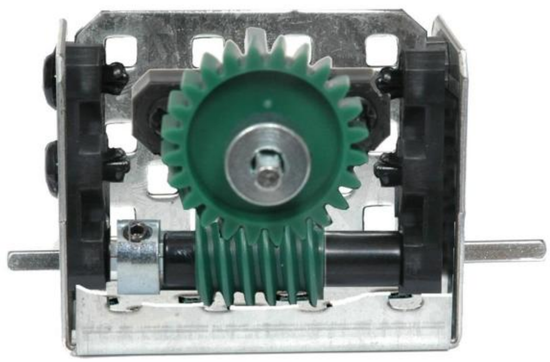
A major challenge that the group faced, was the construction of the control box. The control box was made up of so many wire and components, that working around all of it is near impossible. Soldering the connections to each other was a constant chore of having two people watch the wires, watch the iron, and watching themselves, to prevent anything from being burnt or melted. When we discovered that our problem was that we had too much excess wire between each connection, we promptly got onto fixing this issue.

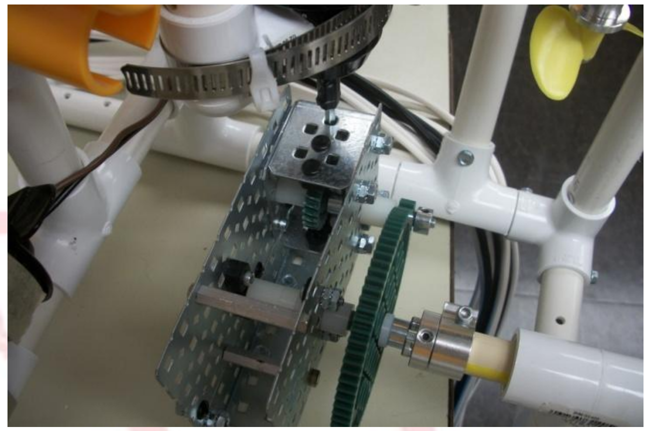
The installation of the LED's was also a major challenge we faced. The LEDs were very delicate and were prone to easily snapping. We needed to work slowly and as a team to not break anything. In the end the LEDs were successful and were operating and they will serve as an important tool in our competition.

As we made our control box, we constantly had to restart and redo this or redo that. As we added new ideas and better things, the box grew more complex. The electrical schematic became more difficult to understand as we added new things to it. After several nights of some research, in the members all have at least a basic understanding of what s going on with the ROV altogether. Due to the fact that the control box took so long to design and construct, it now created a new challenge for us. We realized that time was going to be a factor and we would not have as much practice as we would have liked. As a company we decided to give our weekend before the competition as well as afterschool hours to prepare ourselves for the New England Regional.

Troubleshooting Techniques

Before **After**





One issue that we faced was the completion of our gear box. We had intended on using a much smaller gear box in order to reduce our speed, but we were drastically wrong in how much this little gearbox can slow the motor. After we discovered that this gearbox was too small, we ordered more parts to increase gear reduction. We used the knowledge of gears and their ratios to determine which would fit our needs. After we constructed a better gearbox, we discovered that it needed to be reinforced, just in case. We then out two nuts on each exposed screw and we still shot lose one of the set screws. We ended up taping that screw down and it is now settled. Small mechanical errors have been an issue we have learned to deal with and we try to take every precaution to everything we do.

Why We Chose a Hardware Only Approach

We chose a hardware only approach for many reasons. We wanted to work off of the idea of simplicity. An ROV built from PVC pipe would be easily adaptable and durable. Only using hardware also helped us keep a low budget and avoid a need to search for exotic items. A hardware only approach allowed us to obtain more hands-on experience, instead of buying a tool off the shelf. We as a company made this decision before we ordered parts for our ROV.

Lessons and Skills Gained

During the design and building process, we learned several things. From the technical aspect we acquired skills in several different fields in the engineering design process. The electrical control box seemed to be the toughest part. Aside from electrical we also learned skills in plumbing, HVAC, propulsion, maintaining neutral buoyancy, and gear reduction. On the interpersonal aspect we obtained priceless life lessons, vital for future success in the engineering field. We learned how to work as a team, problem solve, improve organizational skills, and more importantly complete the task that we started. Overall, this has been the best project of our high school career and we have all obtained important skills needed to survive in the real world.

Future Improvements

For future reference, we would change our control box. In the future we would remind others to try and keep things simple, but still presentable. Our installation of LEDs to indicate a fuse failure was a great idea, but when working it out, it proved to be impractical. Build your ROV toward a goal, not for aesthetics or for showing off. In addition, it is a good thing to keep in mind that sometimes, you should focus on what you can score on, and turn your attention to the secondary goals, once you've completed what you know you can. Lastly, you do not need a boatload of expensive equipment to build a quality ROV. Sometimes being over-complicated can backfire and blow up right in your face.

Personal Reflection on the Experience

Kenny Chan
"I have learned an abundance of information from this experience. During these past few months, I've gotten plenty of experience that should help me in the future and my goal of becoming a Robotics Engineer. I see this opportunity as a once in a lifetime opportunity. Teamwork and remaining positive were also traits that have come to me in these past few months. After my years in New Bedford High School, I would like to aspire to one day go to MIT"

Dwayne Farias
"In these past months I learned a lot more then when I first started out, and I believe it will help me down the road because I plan on becoming an electrical engineer. We faced plenty of challenges that we over came as a team. I am glad that I had this opportunity to work on a project like this and to work as a team. After graduation I plan on attending BCC then switching to UMass Dartmouth to study engineering."

Brandon Medeiros
"My time with the NB Whalers 2 team has been a very good experience and has helped my understanding in troubles of engineering. I plan to go to college at UMASS Dartmouth and study to be a mechanical engineer. This experience with the team has taught me about teamwork and how to overcome problems as a team along with making key team decisions. I very much appreciate being a part of this team and I am sure that this experience will help me in the future."

Mason St. Jacques
"At the start of the project I had no experience with engineering other than a Tech Ed class. Working with the NB Whalers 2 team gave me an insight on how to perform simple engineering tasks, as well as to work as a team. I think that engineering is something that I would like to pursue after high school, thanks to my experience on this project."

Time Management

At the beginning of the semester before we started, we broke the construction of the ROV into different stages. We set a time-line for each stage and when that time expired, if it was complete we moved on, if not we stayed after school to continue work. We found this to be extremely effective to complete the ROV in our limited amount of time.

Information about the Deepwater Horizon

The *Deepwater Horizon* was an ultra-deepwater, offshore drilling rig located in the Gulf of Mexico. Commissioned on March 21, 2000, it quickly became known as one of the world's most powerful oil rigs, at one time holding the record for the deepest oil well ever drilled.

On April 20, 2010, a series of mechanical failures and poor monitoring allowed high pressure methane and other natural gases to shoot toward the surface. This gas then ignited, causing an explosion, and creating a fire that proved to be inextinguishable. After about 36 hours of burning, on April 22, 2010 the oil rig sank.

It was not until April 24th did BP officially declare that there was a leak on from the rig. The sunken oil rig broke the riser pipe, which had to be removed in order to continue attempts on stopping the flow of oil. In connection, we will be simulating this by removing the Velcro and moving the riser pipe from the work area.

BP attempted several methods of stopping the flow of oil into the gulf. Methods such as placing a large dome over the well-head, capping it with a tight fitting cap, pumping cement into the wellhead, and closing a shut-off valve proved to be difficult to do under the depths. We will be shutting off a valve and placing a cap over the wellhead, to stop the flow of water. In the end with the help of the U.S Coast Guard, scientists, and experts from around the world, the oil was finally capped and the free flowing oil stopped on July 15th, 2010.

Approximately 779 037.745 kiloliters of oil was spilled from the beginning of the spill to the day it was capped. This disaster is about 20 times worse than the Exxon Valdez oil spill in 1989. The BP oil spill left around 665 miles of coastline contaminated, endangering hundreds of wildlife species. Species ranging from coral to pelicans were all hurt by the oil. Scientists were required to do testing in the affected waters to see the damage done by the spill and how far it has spread. This links back to task three, which requires us to take samples of the water and determine the depth it has affected. Acquiring and saving these species were an important part in the wildlife relief effort. We will be recovering species endangered by the oil spill, by acquiring three crustaceans from the bottom of our seafloor. Vital species that the locals harvest for money such as fish and shrimp were contaminated by the oil. This hurt the economy of Louisiana and much of the American southeast.

<u>Aftermath of the Spill</u>

Microbes used to remove oil, depleted oxygen from the sea and created "Dead Zones" for marine life.

Breeding grounds of several bird species are left compromised from the oil.

Birds and otter are all affected negatively by the oil coating their bodies, causing them to lose body heat and buoyancy and die from drowning or hypothermia.

Marine food chain was ravaged by the oil and killed off thousands of local species.

Prolonged exposure to the oil and dispersants pose a large danger to public health.

April 20$^{th:}$ Deepwater Horizon Fire →

Area affected by the oil spill ←

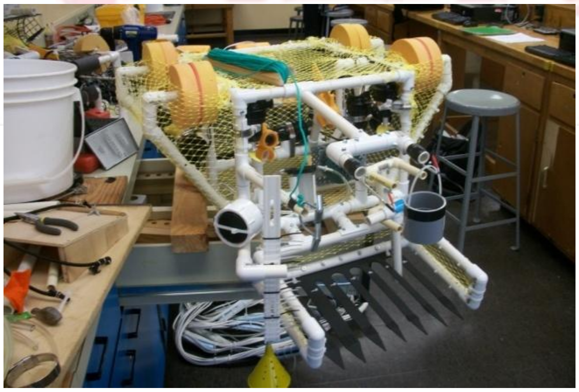
Company Spec Sheet

- Company Name: NB Whalers 2, New Bedford High School
- Home State: Massachusetts
- Distance Traveled: Flight 2,560 km / Driving 2,974 km
- This is New Bedford High School's second time competing in the Regional MATE ROV Competition, as well as the second time competing in the International MATE ROV Competition. This is the first time for our company.

From left to right:
CEO- Chris Parker- Tech-Ed Instructor, 22 years
Pilot- Dwayne Farias- Senior
Design Engineer- Brandon Medeiros-Senior
Vice President of Operations: Kenny Chan-Junior
Design Engineer- Mason St. Jacques-Sophomore

ROV Specs

- Name: Free Willy
- Total Cost: $1119.71
  - Donations: $199.98
  - Company Expenditures: $919.73
- Primary Building Materials: Commercial PVC pipe, wiring, and mesh
- Approximate Dimensions:
  - Robot Frame: Length: 73 cm, Width: 44 cm, Height: 37 cm
  - With Tools: Length 96 cm, Width: 44 cm, Height: 71 cm
- Total Weight in air: 8.5 kg (With Tools)
- Safety Features: Plastic mesh propeller guards; Motors are individually fused, with an LED alert; and a 25 amp primary fuse.
- Special Features: Rotating Claw with a 1:176 gear reduction; Tether attaching grapple; Hand-operated vacuum pump with self aligning suction tube; Digital depth gauge; Side-to-side motor for precise control; LED alert system; Outboard struts to improve stability.



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1. “Underwater Robotics: Science, Design & Fabrication”
2. http://www.teamdavinci.com/understanding_gear_reduction.htm
3. MATE Center
4. http://www.vexforum.com/wiki/index.php/Main_Page

Acknowledgments

MATE: The MATE center provided us 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 provided us with funds for our gearboxes and bilge pump.
Ketcham Traps: Ketcham Traps supplied us with several of our parts, such as the floats and mesh.
Mahoney’s Building Supply: Mahoney’s supplied us with the lamp cord, most of our PVC pipe, hose clamps, and zip ties.
Radio Shack: Radio Shack provided us with our fuses, switches, LED control box, and shrink tubing.
Happy Hobby: Happy Hobby provided us with our propellers and the propeller adaptor kits
Harbor Freight: We acquired our underwater camera and monitor set from Harbor Freight.
Cabela’s: We acquired our Mayfair Cartridge Replacement Motors from Cabela’s.
West Marine: The bilge pump we used is from West Marine.
United Waste Systems: UWS gave our company a $200 donation.
Mr. and Mrs. William Ferreira: The Ferreira’s gave us a $200 donation.