Ranger Class

Northeast High School

Philadelphia, PA, United States

ROV – *N.E.M.O.* (North East Marine Operations)

Prem Patel – 11th grade - President

Cuong Tran – 11th grade – Vice President

Evan Carey – 9th grade – engineering design

John Thekkumthala – 11th grade – technical report

Andy Huang – 11th grade – engineering design

Jessica Hattina – 12th grade – spokesperson/community affairs officer

Shaun Sebastian – 10th grade – Chief Financial Officer

Carole Niemiec – Coach

Ashleigh Niemiec - Mentor

John Kamal – Mentor

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ABSTRACT

N.E.M.O is one of the finest ROV companies in the state. Our company is from Philadelphia, PA, representing Northeast High School. After months of our rigorous design process, we are ready to present the capabilities of our ROV, N.E.M.O. We took all of these possible activities into account during the design process. With this capability, NEMO's versatility allows Northeast Robotics to finish all tasks laid out in front of it The two cameras on NEMO allow the operator to see all of the activities of the ROV and its surrounding environment, which ensures the safety of the robot and of the environment. These are just some of the range of processes that NEMO was designed to conduct; its modularity allows it to do virtually anything required of its mission.

By designing NEMO within the tools first perspective, we were able to ensure stability, agility, and effectiveness during ROV operations. We had to conduct research, and make many corrections throughout the process to make the robot work to its fullest potential.

Purpose of the ROV is to explore and identify shipwrecks, collect samples and remove trash and debris from the shipwreck and its surroundings areas. We plan to complete these using our ROV, a claw and collective canister to take the sample.

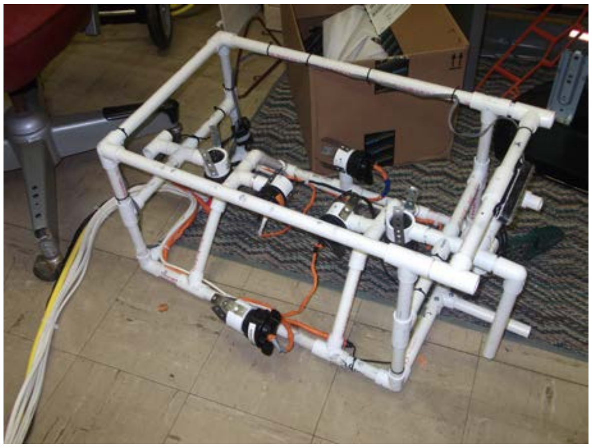

Figure #1 - N.E.M.O.

DESIGN RATIONALE:

Our first thing that the team did this year was to decide our budget for building the ROV. We based our design on the successes and failures of our ROV last year. The ROV was first designed on paper before we made a prototype and then the final design for each competition. We decided that weight is a very important factor in the operation of the robot, because it allows for maximum maneuverability. To reduce the weight of our ROV, we used a lighter base, and drilled holes in the motor shrouds. Our motors have twice the power that they did last year, ensuring that our ROV has no issues while surfacing. The floats on N.E.M.O. are much larger and more structurally sound than our previous ROV. The cameras were positioned in a way that allows for greater visibility of claw operations, and of the ROV's surroundings. In order to be economical, we reused a variety of parts from previous years, or purchased recycled materials. In using recycled parts, we kept to our budget as well as built an environmentally friendly machine. The students learned a new type of electrical control box featuring joysticks vs. switches. We also switched to color monitor and cameras that were smaller and lighter weight. Claw we decided to use is capable to pick up this year tasks effectively.

After the regional competition, the team reviewed all of conflicts that the robot had and redesigned the robot to overcome those problems at International competition, example would be the claw we decide to step away from a plexiglass claw and use a Vex claw as it is more versatile for the tasks that we have to complete.

Our team also decided to go with a hardware only approach instead of using computer programs. We have problems in the past with the programming, so we decided to take a different approach.

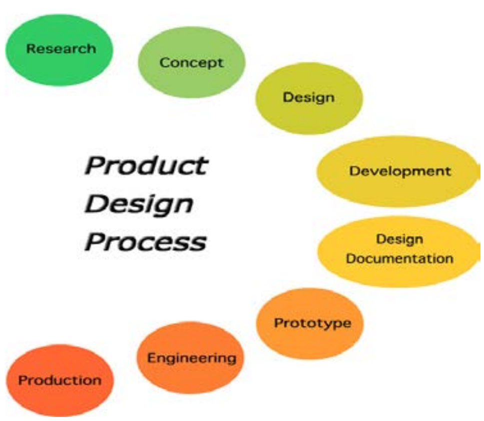

Figure #2: DESIGN PROCESS

STRUCTURE:

The ROV frame of *N.E.M.O.* is constructed out of 1.27 cm PVC pipe. Northeast Marine Operations used this material because it is readily available at a low cost and can be cut into different shapes and sizes. PVC pipe is lightweight and can be connected with a variety of connectors such as elbows and T's. The frame is screwed together to prevent the ROV from coming apart during the competition. Measurements are 55.88cm x 31.75cm x 64.77cm. PVC pipe allows for impressive modularity. A design can be changed easily within just a few minutes if necessary. We have also figured out a way to bend the PVC without the PVC collapsing at the bend. The approximate weight in air is approximately 4.53 kg. PVC pipe that we are using is negatively buoyant.

Figure #3: STRUCTURE

CONTROL SYSTEM:

The control systems we used is a plastic box with three locking sides (Figure #4) with two function joysticks, kill switch, four K166 bi-directional DC motor controllers and control for the servo. The joysticks are connected to all six of the thrusters. The control for the claw's servo is a separate control. The controller was designed and sized so the driver could easily access the switches; to do this properly we measured the driver's hand and placed the switches in places that were convenient for the driver. This is new type of control box compared to last years design.

Figure #4: CONTROL BOX

TETHER:

For our tether, we used six 12.8 meter segments of 16 GA UL 1426 marine cable with 2 conductor jacketed wire from Waytek. Each segment sends messages from the control box to the switches that control one motor we are using, one 12.8 meter segment of neutral buoyancy cable to power the two cameras and one 12.8 meter segment of 18 GU wire with 5 conductors to power the light and servo. The second segment is connected to our two cameras and the claw. The tethers are bundled together with multiple zip ties and foam as means of preventing potential damage and tangles. This is done to keep the tether in one manageable section that will not interfere with the ROV's operations or the surrounding environment with floats attached to keep the tether buoyant.

Figure #5: TETHER

CLAW:

To construct our claw mechanism, we used a VEX claw that we attached to a waterproof servo (Traxss digital waterproof #2075). The claw is attached to a PVC pipe. The purpose of the claw is to pick up the items and other tasks needed for this years' competition.

Figure #6: CLAW

CAMERAS:

Our ROV has two waterproof cameras, in the front and back, so we can have a 180 degree view on the robot. Our cameras will improve our versatility and give us better angles to accomplish tasks more efficiently. The camera has a 170 degree viewing angle macro lens with 'mirror' image, these are the same type that are used as backup cameras on vehicles. We made sure we not only watched our bottom line but also have good and efficient cameras. Our cameras are built in with an acceptable voltage level so they will not burn out. They are connected to our tether to avoid addition cables reducing our neutral buoyancy.

Figure #7: Car backup camera

PROPULSION:

Our motor system consists of four Johnson bilge pump model #2851: 1000 GPH motor cartridges with a max amp draw of 3.2, 12 volt ignition protected and two 500 GPH bilge pump motor cartridges. (Figure #8) We attached a two blade plastic propeller to each thruster. One motor was placed on each side of our ROV to provide thrust, while the remaining motor was positioned in the center to provide up and down and crab movement. A series of tests and comparisons were performed to determine the optimal number of thrusters. We relocated the motors to the inside of the frame to protect the propellers, our fingers, and underwater organisms from damage and marked all of them with safety tape.

Figure #8: Johnson Bilge Pump Motor

FUSE:

Our fuses are a 20A inline fuse (Figure #9) which is incorporated into our ROV as a primary safety feature; it prevents fire and damage to our electrical components when the current becomes too high. The fuse is located between the control box and the battery terminal.

Figure #9: 20A Fuse

BOUYANCY:

Our company attached two completely sealed 2 inch PVC tubes that are 48.26cm long to the top of the robot for flotation. We completely sealed it using rubber waterproof silicone glue. We are trying to use less metal and more PVC pipes and zip ties to reduce and manage weight. Also we drilled holes in all of the PVC pipes so the water can flow through. This will make our robot neutrally buoyant.

Buoyancy is defined as upward force exerted by a fluid on anything immersed in it. Buoyant force can be explained in terms of Archimedes' principle. The buoyancy force is the mass of an object out of the fluid minus the mass in the fluid, which is equal to the weight of liquid displaced by the object. (Buoyancy = P x V). Negative buoyancy results in sinking, positive buoyancy results in floating. Thus, it is vital to find the proper balance and nearly perfect neutral buoyancy.

In the deep sea environment of most ocean observing systems, buoyancy takes on central importance. An ROV with a low center of gravity- which makes for reliable stability- has the capability to maneuver around complex structures on the ocean floor. In the condensed and complicated layout of a typical ship, the ROV operator must maintain complete control over the robot's activity. It is imperative to keep balance under water, for there are ever changing currents, and other variables to account for. Therefore, we made sure the center of buoyancy was placed slightly above the center of gravity to sustain balance and stability.

Buoyant Mass

m(b) = m(object) x (1- (p(fluid)/ p(object)))

- m(object): True mass of object

- p(object) : Average density of object

- p(fluid) : Average density of the surrounding fluid

Fluid density: Greater fluid density than the average density of the object = float

Less fluid density than the average density of the object = sink

Buoyant Force

F(buoyant) = -pVg

p: Density of fluid

V: Volume of the object being submerged

G: Standard gravity on Earth (9.81 N/kg)

Archimedes Principle

Relative Density = Weight / (Weight – Apparent Immersed Weight)

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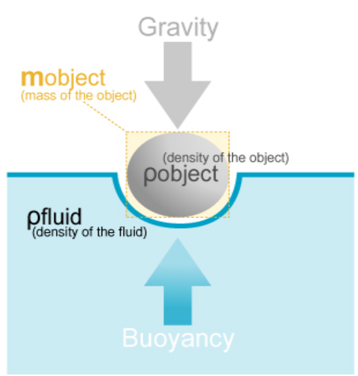


Buoyancy: Figure #10

MISSIONS:

MISSION OVERVIEW -

RANGER class companies will compete in ONE mission that consists of the following three tasks:

Task #1: SHIPWRECKS

Explore, document, and identify an unknown shipwreck recently discovered in sanctuary waters. This will be competed using our cameras.

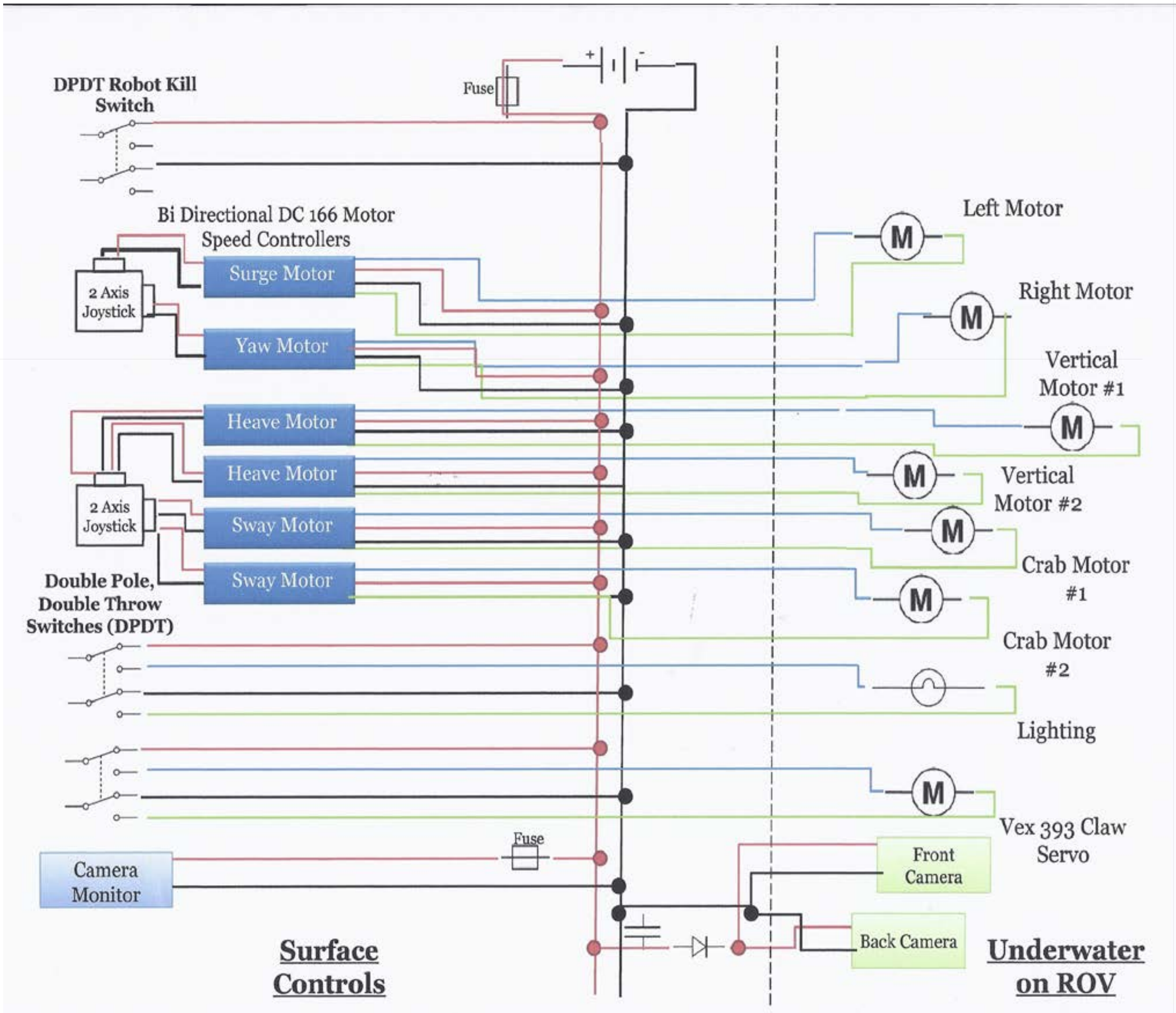
Task #2: SCIENCE

Collect microbial samples, measure the conductivity of the groundwater emerging from a sinkhole, deploy a sensor, and estimate the number of zebra mussels found on the wreck. This task our ROV will use the cameras and a medicine bottle to pick up the microbial sample.

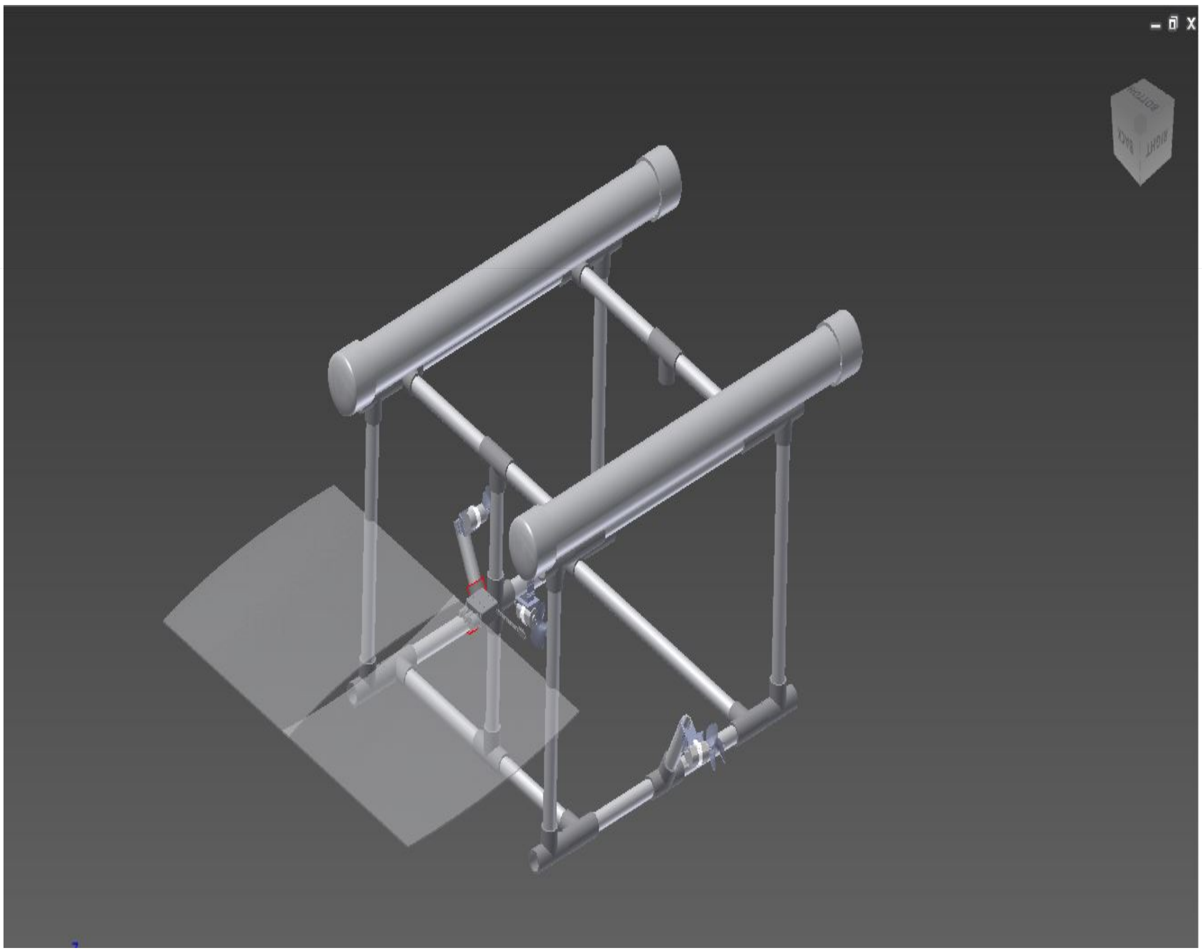
Task #3: CONSERVATION

Remove trash and debris from the shipwreck and surrounding area. Our ROV will complete this task by using our claw to pick up the trash and debris from the shipwreck and surrounding areas.

SYSTEM INTERCONNECTION DIAGRAM (SID)



CAD (Computer Aided Drawing):

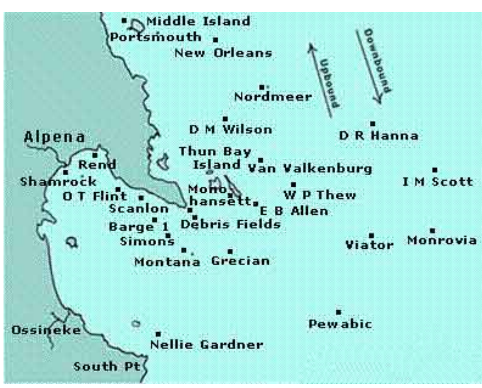


SHIPWRECKS:

Collecting chemical, biological, and physical conditions underwater may help scientists and detectives identify the cause of shipwrecks, natural disasters, and unidentified organisms. The TBNMS (Thunder Bay National Marine Sanctuary) is a dangerous area with unpredictable weather that sank more than 50 ships to date. There are sinkholes on the ground level that are depleted with oxygen, are 10 times more conductive, and contain 100 times more sulfate than the surrounding water.

The TBNMS staff and scientists are in need of a remote vehicle that can explore, document, and identify an unknown shipwreck in sanctuary water; collect microbial samples and measure the conductivity of the groundwater emerging from a sinkhole; and remove trash from the surrounding area..

In order to assist the TBNMS and its scientists, we have carefully built and programmed an ROV that has capability to perform tasks such as exploring, documenting, identifying shipwrecks, and scanning the wreck. This will help them recover the many shipwrecks they have yet to find, protect the vulnerable shipwrecks, achieve better aspects of the environmental and natural aspects, and gather information that divers are not able to get at Lake Huron. With this, not only will they be able to get a better understanding of sinkholes and create progress in their continuing investigation, but also preserve the marine heritage that Thunder Bay Sanctuary was meant to protect.



Shipwrecks of Thunder Bay

http://thunderbay.noaa.gov/images/TbayMap4.jpg

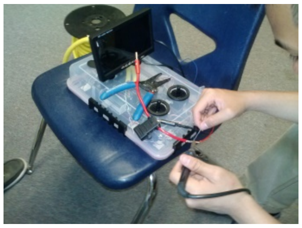
ROV investigating Thunder Bay Shipwreck

https://pbs.twimg.com/profile_images/2385495057/byrfib2awmmdb3j3abi3.jpeg

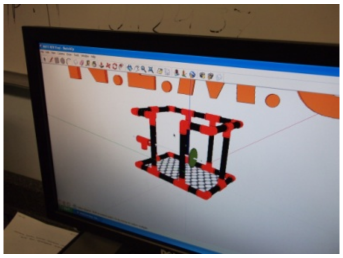
LESSONS LEARNED:

While building the ROV, we learned things in a level of technicality and the importance of operating as a team. In an individual sense, we learned to leave no one behind. Everyone gave equal amounts to the ROV, regardless of experience. We learned to group each other according to what we can provide, such as assets, planning, and structure of the machine. From this, we also learned that we can produce much more effectively since everyone is giving from the areas of their greatest capabilities.

We did not just learn to work as a team though; we also learned how the ROV works. We gained knowledge of the use of tools and electrical equipment such as motors, cameras, and claws. We even gained a greater knowledge of the CAD software so we can more effectively build the robot. With the greater knowledge of what we were dealing with, our efficiency is much better. We learned enough to give each other ideas and insight during the development, such as improvements, or even overhauls just so the robot can perform the way we want it to.



Electrical: Figure #11



Learning CAD: Figure #12

SAFETY:

Some of the steps our company has taken for our safety procedures are:

SAFETY HANDLING/OPERATING ROV

- Only use power tools under adult supervision
- Turn off the ROV while working on it
- Remove any clothing accessories that could be caught in the ROV
- Make sure any team members' long hair is tied

SAFETY FEATURES OF THE ROV

- Announce when the ROV is turned on or off
- Turn off the ROV while working on it
- We have no exposed wiring, make sure all necessary parts are waterproof
- Make sure tether is generally straight and has no tears
- Ensure all parts are tightened, check the ROV for foreign materials
- Remain clear of motors when they are on and check for any damage to ROV after each testing session.

We have to teach proper usage and safety procedures as this our company's safety philosophy: wear closed toed shoes, protective eye wear. Along with these policies there are also safety features on the ROV including shrouds and hazard labels on the motor to prevent injury, sanded edges to prevent injury and cuts in the tether, and a 25-amp fuse attached to the electrical box to protect our electrical in case of a short circuit. Our whole ROV was designed to maximize safe operating features for the environment and operators. We had a few incidents of minor cuts this year that need Band-Aids only.

CHALLENGES FACED:

Technical Challenges - We faced a variety of challenges this year during the design and construction of N.E.M.O. for the competition. Buoyancy was one of our main concerns in building the perfect ROV. We had to determine the best structure for neutral buoyancy. This was imperative; buoyancy is what allows a ROV to float and sink. Soldering was a large concern for our team; most of our team is very inexperienced when it comes to soldering. The various wiring tasks that had to be completed were made more challenging by the inexperience in soldering. With the help of our coach and the older team members, the problems were alleviated through experience.

Non-technical challenges - Another major concern was funding for the robotics club. Our school district has gone through serious budget cuts which have affected our chances to achieve our full potential. Without sufficient funding, we could not acquire certain equipment to correctly assemble the ROV. It took us many student bake sales and fundraisers over the course of the year to obtain the necessary funding of the robot. We were able to pay for our transportation to the competition as well as the entrance fee through our lollipop sales.

With the technical and nontechnical struggles faced throughout the year, we completely finished N.E.M.O. within a few weeks of the competition. We are proud to have achieved our goals after going through so many issues.

REFLECTIONS:

From the members of N.E.M.O, (Northeast Marine Operations) it is believed we can all agree that this has been a great experience for us. Through these experiences, it is not only the R.O.V that has been built and developed but also skills within the members themselves. From hydrostatic pressure to soldering, or simple communication skills and patience, this event has certainly given us more than we had thought it would. In addition to tangible abilities, we have also gained considerable awareness and a greater understanding towards the complex work done for such purposes.

After the meticulous processes and hardships we have faced, we as a team feel accomplished towards the work we have done to deliver what we believe as the best possible ROV we could make. We believe we have become the better engineers we have hoped to be compared to before. With greater knowledge and pride in our accomplishments, N.E.M.O comes away from this competition with the satisfaction of being able to work together to create something new.

Here are the thoughts of some of our members:

John Thekkumthala- “The competition was a good experience. I learned the various strategies we have as a team and how to bring everything together as a team effort. This is my first year in robotics and I am already looking forward to my coming three years.”

Cuong Tran- “MATE has inspired my future plans and ambitions. Because of this competition, I am now looking forward to studying engineering in college.”

Prem Patel- “As this is my third year working in the MATE competitions, I realize the magnitude of what I have learned. The technical aspects I have learned are great of course, but my experience of working as a team to accomplish a greater goal is something indispensable to my future studies in aerospace engineering.”

TROUBLESHOOTING:

Troubleshooting was an area we believed to have improved on substantially from years prior. If a part was observed to be underperforming or not functioning properly, we fixed it through analyses, and much trial. We researched possible solutions to each problem, and decided the best way to apply them to our ROV. Once each major component of N.E.M.O. was completed, it was tested out of water, then in water. Each sensor was tested independently as well. Once the individual components were functioning, they were tested together to ensure proper overall operations. Our company tried to test components at least once a week. We made sure to allow one week for testing the completely finished ROV. When we tested our robot there were only a few major problems. One main one was short circuits. This made our camera not work. We solved this problem by identifying the short circuit by going through the camera wiring of the robot and fixing it. After that we repeatedly checked the wiring everyday just to make sure that our robot is in perfect condition.

We faced a huge problem on our circuit board when our motors would not respond properly. We had to take each wire out and do individual unit tests. We took apart all the circuit boards and tried all the motor with the joysticks. Our joysticks are apparently wrongly formatted from the manufacturer but we still have to use the joysticks due to lack of time. After regional competition, these joysticks were replaced with new ones. Also we realized that one of the resistors was loose causing many of our problems. Once we soldered everything down again, it worked to the fullest potential.

FUTURE IMPROVEMENTS:

This year, we have already set our minds to changing our methods next year; some will be more substantial than others. There will be improvements on non-technical aspects, and technical aspects, such as increasing the modularity of the design. We have to remember that there is always room for improvement, even if we think we have reached perfection.

One of the areas that we believe we could improve upon is materials. We have used PVC pipe for our ROV's for many years, including this year. Perhaps next year we could experiment with other lightweight materials to create a better, faster, more maneuverable robot. Carbon fiber or another composite may be something we will consider implementing in our design next year. The cost may prohibit how much we could use, however. If our company uses lighter materials, we would have less need for flotation, thereby reducing the overall size of the ROV.

BUDGET:

Budget/Expense Sheet

School Name:		Northeast High School	From:	1/14/2014
Instructor/Sponsor:		Carole Niemiec	To:	6/26/2014
Funds				
Date	**Deposit or Expense**	**Description**	**Amount**	**Balance**
1/14/2014	balance	Membership Dues	$ 400.00	$ 400.00
1/14/2014	recycled parts	Parts reused from last year - motors, …FMV	$ 213.96	$ 400.00
1/26/2010	expense	Lowe's PVC connectors	$ 32.43	$ 367.57
2/10/2014	expense	Lowe's misc. parts	$ 34.50	$ 333.07
2/20/2014	donation	Donation of Pufferfish kit - FMV	$ 600.00	$ 333.07
3/18/2014	deposit	Fundraising - lollipop sales	$ 360.00	$ 693.07
4/1/2014	expense	PVC, rope, other misc. Lowe's	$ 66.89	$ 626.18
4/17/2014	reg. fee	MATE ROV competition reg. fee	$ 75.00	$ 551.18
5/10/2014	travel expense	Bridge toll for 3 vehicles $5.00 x 3 for Regional	$ 15.00	$ 536.18
5/14/2014	expense	Vex robotics claw kit	$ 19.99	$ 516.19
5/14/2014	expense	Waytek 152.4 m of 16 GU UL cable	$ 122.20	$ 393.99
5/28/2014	deposit/donation	NE Alumni Foundation/trip expense to Intl	$ 10,000.00	$ 10,393.99
5/28/2014	travel expense	Hotel for 10 people in Alpena, MI	$ 1,456.32	$ 8,937.67
5/28/2014	travel expense	Wertz Coach Company	$ 7,995.00	$ 942.67
6/1/2014	expense	Cost of Poster printing	$ 100.00	$ 842.67
6/24/2014	deposit	$100 per person for food & misc. expense	$ 1,000.00	$ 1,842.67

balance	$ 400.00	Building ROV	$ 276.01	Net Budget
deposit	$ 11,360.00	Registration Fee	$ 75.00	
		Printing Costs	$ 100.00	
total deposits	$ 11,760.00	Travel Expense	$ 9,466.32	
		Total Expenses	$ 9,917.33	$ 1,842.67
		no time & services paid or donated		

- FMV = Fair Market Value

ACKNOWLEDGMENTS:

Jill Zande

Velda V. Morris – Regional coordinator

Principal and Teachers of Northeast High School

Robotic Team members and parents

And our sponsors –

Northeast HS Alumni Foundation

Philadelphia Chapter

Mr. Charles Lumpkin

JPM, INC.

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APPENDIX #1

N.E.M.O. Schedule for 2014

N.E.M.O. Mate Project Schedule 2014

		Jan 21- 28	Feb 4 -11	Feb 18-Mar 11	Mar 18 - Apr 22	Apr 29 - May 9	10-May	May 13- May 27	June 3 - June 24
1	Teach new members tools								
2	Mate 2014 Mission Review								
3	Overview Goals and Competition								
4	MATE Rules								
5	Budget								
6	Build mission Props								
7	Initate designs & start research								
8	Frame designs								
9	Electronics								
10	Build ROV								
11	Finalize ROV								
12	Finish Engineering Notebook								
13	Finish Poster								
14	ROV testing & practice								
15	Regional Competition								
16	Redesign robot								
17	Build new ROV								
18	Modify the Engineering Notebook								
19	Re-do the Poster for Intl								
20	Practice, Practice, ...								

APPENDIX #2

SAFETY CHECKLIST

NORTHEAST HIGH SCHOOL – N.E.M.O. (NORTHEAST MARINE OPERATIONS

SAFETY CHECKLIST

Construction safety checklist

- All personnel working on the ROV have proper qualifications for tools
- Personnel use safety glasses / other appropriate safety equipment
- Secure long hair and jewelry near power tools
- Check for sharp objects and edges to reduce injury
- Have a First Aid kit available
- ROV is disconnected from power source
- Propeller guards are securely fastened
- No exposed wiring
- Secure safety warnings on robot and control box

Operational Safety Checklist

- ROV is disconnected from power source
- Wearing proper safety equipment at all times
- Fuse is in place
- Check ROV for hazards
- Tether is neatly laid out
- Beware of tripping hazards
- No running near edge of pool
- Ensure guards are securely fastened

Remember Safety First !!!!

APPENDIX #3

SPEC SHEET