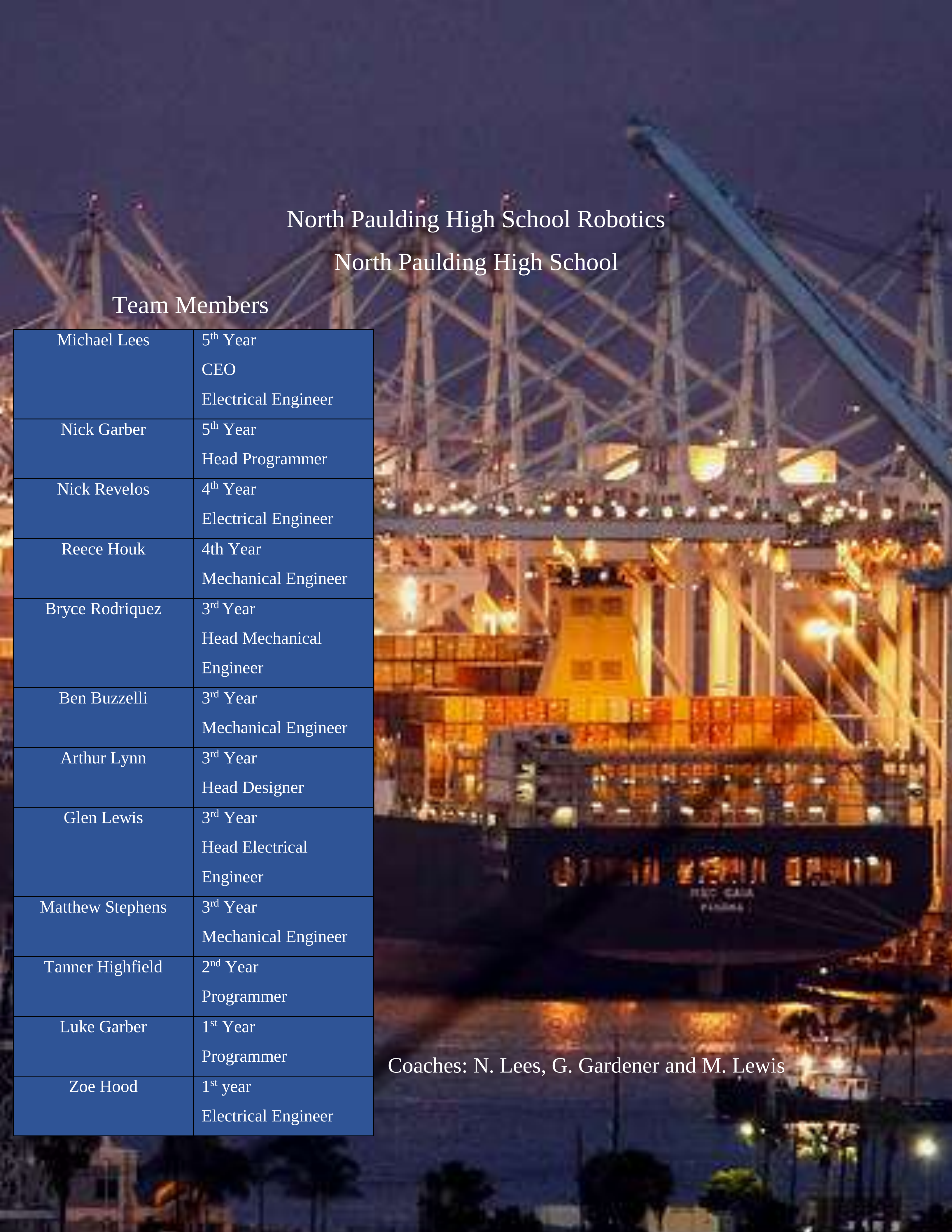

North Paulding High School Robotics

North Paulding High School

Team Members

Michael Lees	5th Year CEO Electrical Engineer
Nick Garber	5th Year Head Programmer
Nick Revelos	4th Year Electrical Engineer
Reece Houk	4th Year Mechanical Engineer
Bryce Rodriquez	3rd Year Head Mechanical Engineer
Ben Buzzelli	3rd Year Mechanical Engineer
Arthur Lynn	3rd Year Head Designer
Glen Lewis	3rd Year Head Electrical Engineer
Matthew Stephens	3rd Year Mechanical Engineer
Tanner Highfield	2nd Year Programmer
Luke Garber	1st Year Programmer
Zoe Hood	1st year Electrical Engineer

Coaches: N. Lees, G. Gardener and M. Lewis

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Abstract

North Paulding High School Robotics specializes in building high quality remotely operated vehicles (ROV) that are durable and meet the highest standards of safety. In response to the Request for Proposal released by the Port of Long Beach, one of the busiest seaports in the world, the team designed and constructed an ROV that is small and lightweight in size. The ROV has a sturdy external frame made from lightweight aluminum metal to protect the motors, wiring and cameras to operate in confined conditions along the port and waterfront. The team's focus this year was the maneuverability of the ROV. As a result, four high-powered Seabotix thrusters and two Blue Robotics T200 thrusters were purchased to ensure fast motion and efficient thrust. The team also implemented a new control system by adding a joystick to help control the ROV and the manipulator so that the team could complete each task in a timely manner. In addition, the ROV was equipped with a rotating manipulator, an upgraded camera system, a valve rotator and a specimen collector to allow the ROV to recover contaminated specimens. Our team upholds the highest level of professionalism and guarantees quality work in a timely manner.

Company Profile

North Paulding High School Robotics was established in 2012 and currently has 12 members. To meet the individual needs of our clients, the company maintains a wide range of qualifications that allow them to be creative in their build of ROVs. The team strives to expand upon their knowledge and expertise, which allows them to continue to develop high quality and reliable ROVs. The team demonstrated exceptional teamwork and management skills as they completed this year's build.

NPHS Wolfpack Robotics Team

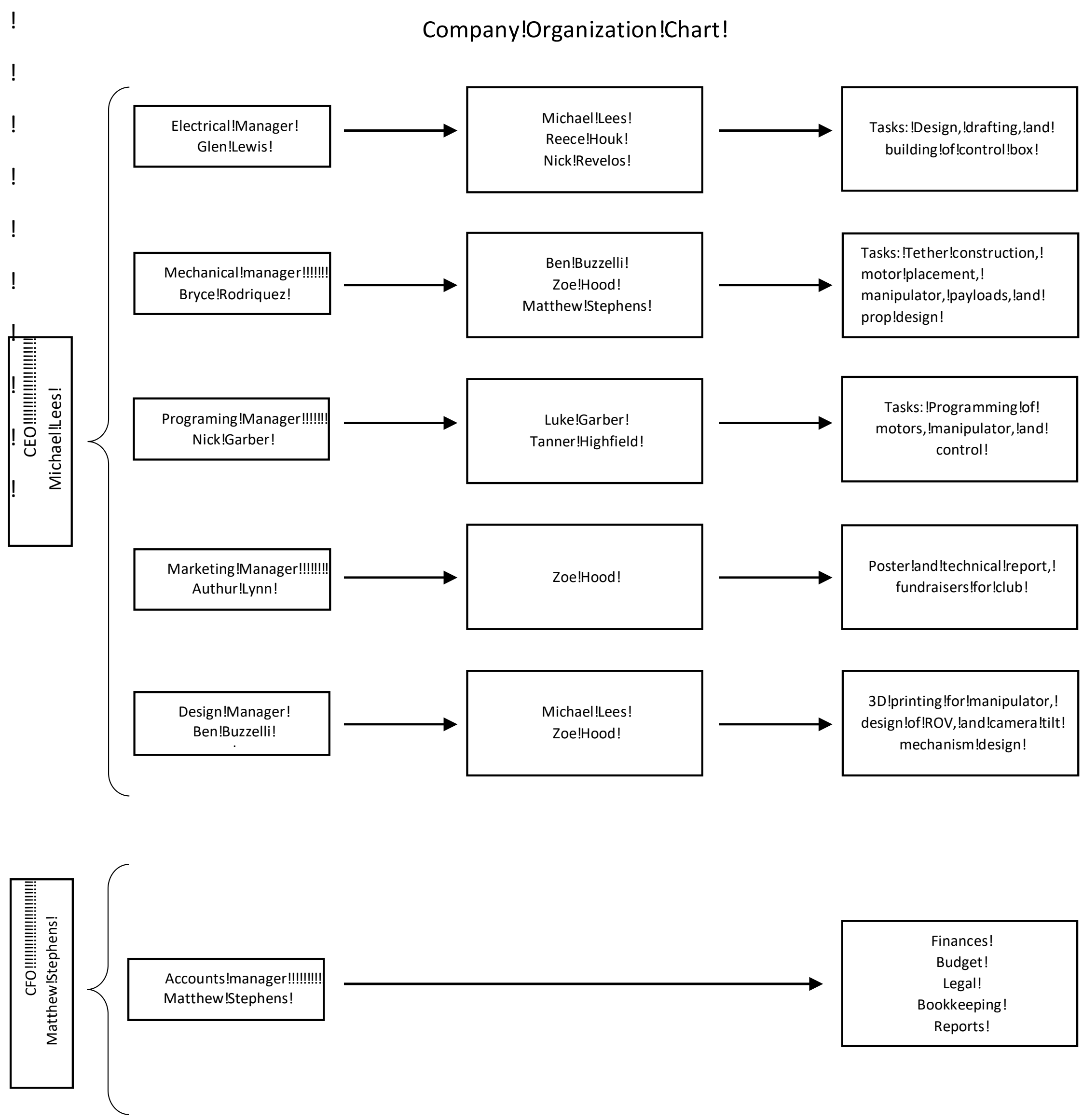
Project Management

Project Plan

The team developed a comprehensive plan that outlined the initiation, planning and build of this year's ROV. In previous years, the team was challenged with achieving the goals within the given constraints of the MATE regional competition. To address this, the team developed a time frame for each part of the ROV build as well as completion of each task, allowing for adjustments to be made as the build progressed. The process was documented and checked off as the team made progress.

Company Structure

Team members were assigned roles based on their understanding of the tasks, as well as the strengths, skill-level, experience and interests of each team member. The team leaders collaborated with the CEO and their individual teams, keeping the team on track and aware of any potential delays or changes in the build to ensure a successful build of the ROV. The company's organizational structure is outlined below.



Mission Theme

The Port of Long Beach, one of the busiest ports in the United States, has undertaken a project to develop and improve the port and waterfront. To accomplish this clean up, the port will install a Hyperloop system, which will transport cargo underwater to the port, from 10 miles offshore. Removing the docking ports and high traffic areas within the port will provide the opportunity for Long Beach to beautify its port, decrease the pollution, increase marketable real estate for homes and restaurants, and increase the tourism flow to the waterfront and port area. This year's mission is to design and build an ROV that can operate in the confined spaces and high-risk areas within the port. The safe construction and operation of commercial and entertainment projects in ports and harbors is vital to the economic and environmental health of many cities. The innovative use of ROVs can play an important role in maximizing these opportunities while maintaining the safety of workers and ocean life. The mission demands are represented by the following tasks:

First Task: **Commerce:** Hyperloop Construction
Second Task: **Entertainment:** Light and Water Show Maintenance
Third Task: **Health:** Environmental Cleanup
Fourth Task: **Safety:** Risk Mitigation

Task One – Commerce: Hyperloop Construction (60 points possible)

The team must insert rebar reinforcement rods into the center of a steel baseplate found on the sea floor. The ROV must place a frame on the concrete baseplate and remove a pin to release the chains that hold the frame to the surface. The team is also tasked with maneuvering a hose to pour concrete into the center of the frame. Lastly, the team must retrieve the positioning beacons and return them to the surface. This new Hyperloop transportation system will streamline the process of transporting cargo by eliminating the need for docking cargo. Because underwater construction can be dangerous, using an ROV is the best option to build the Hyperloop.

Task Two – Entertainment: Light and water show maintenance (60 points possible)

The team must pilot the ROV to the platform and disconnect the power cable and turn a valve to stop the water flow. The ROV must then be maneuvered underneath the platform to disengage the locking mechanism at the base of the fountain. Once completed, the ROV must go topside of the platform to remove the old platform and install the new one, then re-engage the locking mechanism under the platform, reconnect the power cable and turn the valve to allow the flow of water. The ROV must then return the old fountain to the surface. This complex task will involve the ROV replacing an old fountain with a newer one. Tourism and entertainment, of course, is vital to the economy of any city, and safely undergoing routine maintenance on the entertainment components is very important.

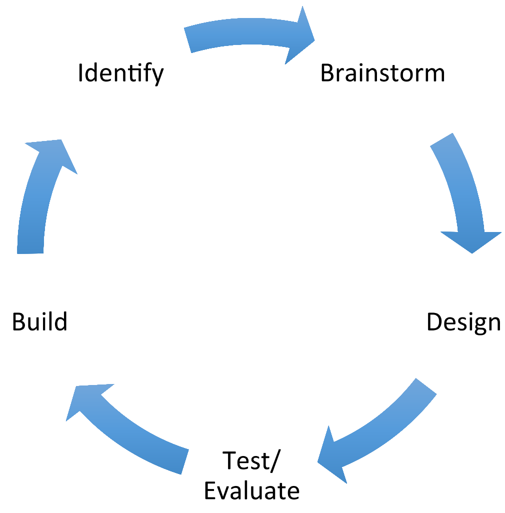
Task Three – Health: Environmental Cleanup (60 possible points)

The team is tasked with simulating a Raman spectrometer using either a laser or light to illuminate two areas of sediment to determine if they are contaminated or not. The team will be given a simulated Raman spectra to analyze, and after determining which area is contaminated they will collect sediment samples and two crabs/clams from the contaminated area. The ROV must then place a cap over the area to remediate it. The cleanup process requires the company to inspect multiple elements that were contaminated in the Port of Long Beach by the U.S. Navy. By using a Raman Spectrometer, the ROV can carefully inspect and identify these contaminants and then precisely collect affected samples of sediment and bring them to the surface. This inspection technology can be used anywhere on the planet and can provide important chemical data for scientists and environmentalists to examine.

Task Four – Safety: Risk Mitigation (60 possible points)

The team is tasked with searching a given area to locate four cargo containers buried in the silt on the sea floor and activating the Radio-frequency identification (RFID) tags to determine each container's identification number. The team will then match their identification numbers to the manifest of cargo containers to determine if the contents are at high risk. The team must then have the ROV attach a buoy marker to the containers they find to be at high risk and map the site of the high-risk container from the other three. RFID can be used to transfer multiple pieces of information about cargo without opening anything. RFID is an incredibly efficient method of collecting data and identifying cargo. It can be used anywhere from logistics to cargo containers.

The Design Cycle



Design Cycle

The ROV was developed and constructed by following set guidelines established by the team in the first month of the design. Every task, purchase or strategy needed to complete the build, was thoughtfully planned before any action was taken. Team members developed a clear description of the task, timeframe for completion, and cost by researching what was needed and assigning the most qualified team member to tackle the challenge. The team designed the ROV frame on Sketch-up and then consulted with their team leaders and decided the best way to proceed based on time and cost constraints. The team then developed a detailed design plan that outlined the steps needed during each stage of the ROV build. The team followed a five-step design process, and every component of the ROV followed the same design process. During the first step, the team brainstormed what was required and researched what was needed to complete each mission of the competition. This included material, cost and responsibility for each task.

Prototypes were built, tested and if necessary re-designed until the final prototype was developed. The prototype then went into production, was tested, evaluated, and then added to the ROV frame.

In addition, the team followed a detailed timeline and protocols during each production stage to facilitate the completion of each component in a timely manner. If delays were encountered due to ordering of parts or components not working, the timeline was adjusted and team leaders were informed. The team reused parts and components from last year's build to help improve the overall success of this year's build and to minimize the cost for the ROV build.

TASK	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Fundraisers									
3D Design of frame									
Design of manipulator									
3D Printing of manipulator frame									
Frame Build									
Manipulator build and attachment									
Attach motors									
Attach cameras									
Attach lights									
Programming motors/ arm									
Control box assembly									
Tether Construction									
Payload Design									
Payload Build									
Attach Payloads									
Pool Test									
Technical Report									
Printing Technical Report									
Poster Design									
Printing of Poster									
Engineering Presentation									
Engineering Presentation Props									

Key:

	Mechanical Team
	Electrical Team
	Programming Team
	Marketing Team
	Design Team Frame
	All Teams
	Design Team Manipulator

Team matrix for 2017 ROV Build

Design Rationale

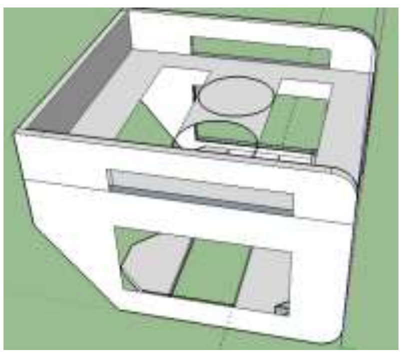
North Paulding High Robotics built the ROV in response to the Request for Proposal (RFP) issued by the MATE center in 2017 and The Port of Long Beach. The request specified that the ROV must be able to navigate in the confined spaces of the port and waterfront of Long Beach. The requirements set by MATE Center were:

- The vehicle must fit through a 48cm diameter hole.
- The vehicle and tether must weigh less that 11Kg.

Frame

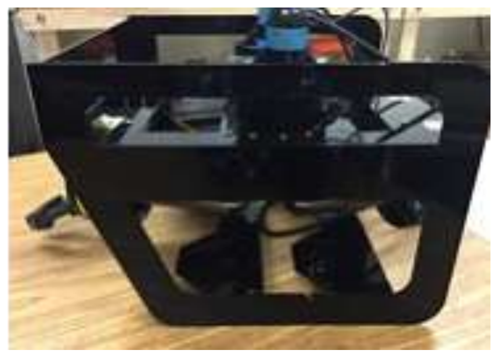
The team built a ROV that meets the size and weight specification. The motors and wire connections are housed inside the frame to prevent the ROV from being damaged if it bumps into cargo containers during the missions. The prototype for the ROV frame was developed using the Sketch Up program. The design was analyzed and changes were made to incorporate placement for the payloads, thrusters and cameras. The team then built a prototype from cardboard, again made final adjustments if needed. The final ROV was built from aluminum metal to create a rigid, stable, and lightweight overall structure that would allow the team to attach multiple payloads required for completing each mission.

The team decided to reuse the ROV frame from the build from last year, as the frame was sturdy and met the MATE specifications for the size requirements for the 2017 competition. Reusing the frame minimized build time and the overall cost for the 2016- 2017 build year and allowed the team to focus on other aspects needed to complete the missions. The frame's dimensions measured 36.5 cm in length, 33.5 cm in width and 25.3 cm in height with a weight of 6.4 kg without tether and payloads. The frame was coated with black enamel paint.



Sketch-Up design of ROV frame

Prototype of ROV frame



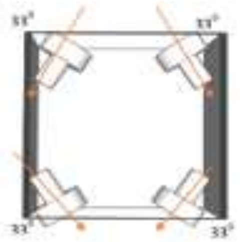
Final ROV frame

Thrusters

The proposal requested that the ROV must be capable of maneuvering in confined spaces quickly and effectively. The team built an ROV equipped with six motors. Four motors were placed on the inside corners of the frame of the ROV. They were securely mounted to the frame using stainless steel machine screws and lock nuts that achieved balance for the ROV frame and prevented the thrusters from being loosened during the missions. To meet the specifications of the MATE competition, the motors are enclosed inside the frame for safety. The two up/down motors are placed on the top surface of the frame, towards the center, keeping the frame evenly balanced. The team took into consideration that the water had to flow freely in and out of the ROV frame as the motors were placed to minimize obstruction of water flow.

The four Seabotix thrusters BTD150 have a depth range of 150 meters. The continual thrust is an impressive 2.2 kg at only 4.25 amps. Each thruster draws 4 amps of power and provides approximately 28.4 Newton's of thrust. The propellers on the ROV consist of 76 mm - 3" blades. The dimension for each thruster is 6.8"x 3.7"x 3.5", with each weighing 350 g in water and operates with a depth rating of 150 meters. They use anti-corroding steel and allow water to flow freely throughout its compact design up to a depth of 3000m (4500 psi). The ROV draws 8 amps of electrical power when all thrusters are in use. The team positioned the thrusters to allow the ROV to move forward, back, up and down. The motors were strategically placed to utilize all the degrees of motion. Two thrusters were installed facing forward to the front of the ROV, and two were placed towards the back of the ROV frame. When these thrusters are powered in the same direction at the same time the ROV will move forward, reversing the direction allow the ROV to maneuver backwards. These thrusters were positioned at an angle 33 ^{0}, allowing the team to move the ROV in a motion around a pivot point.

Additionally, the team used two T200 Blue robotics thrusters, with ESC for vertical motion of the ROV. These thrusters draw 4 amps of power and provide 23.1 Newton's of thrust. They are only capable up to a depth of 150m (213 psi). The top two Blue Robotics thrusters control the up/down motion of the ROV. When power is applied to the down direction, the thrusters will cause the ROV to dive. When power is applied to the thruster in the up direction, the thrusters will cause the ROV to return to the surface.



Motion position- arrows indicating flow of water when thrusters are moving forward

Seabotix BTD 150 Forward and Reverse Thrusters Side

Blue Robotics T200 Vertical Thrusters

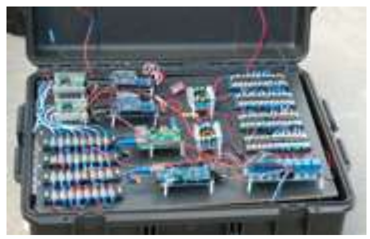
Cameras and Mounting

For the 2016 RFP, the team used security cameras that were liquid dipped as a precaution against leakage. However, after testing the cameras the team found that the feedback to the monitor started to turn yellow on the screen, making it difficult to complete the tasks effectively. This year the specifications require that the ROV must retrieve a sediment sample from the ocean floor, measure the distance between cargo containers, and turn a locking mechanism at the base of the fountain. To accommodate the proposal and complete the tasks effectively, the team decided that the ROV needed to be equipped with four underwater waterproof fish finder color cameras with built in lights. The camera extension cable length is 15 m long. The camera incorporated a light source of 12 high-power brightly white led lights. The cameras offer a field of view angle of 92 degrees. The company selected the best cameras that will provide the best image to the pilot when completing the individual tasks. The camera's dimensions are 2.17"D x 3.18"W x 2.95"H. They work at a viewing angle of 92 degrees. The operating temperature of the cameras is 20°C -60°C, allowing the cameras to operate in cold temperatures. One camera was mounted to a DDT500 Tilt system with a built-in HS 5646WP Hitec waterproof servo. The tilt mechanism allows the camera to move up and down rotation of 150 degrees to optimize the front view of the ROV during the missions. The remaining cameras were mounted by using hose clamps in specific spots on the frame to help monitor the payloads and to assist in completion of each task. The cameras were liquid dipped to prevent any future water damage.

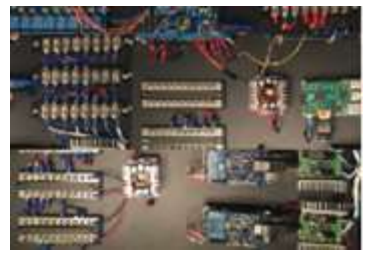
Side view of tilt camera

Control Box

Relay board in control box



Control box pool side



Top view of control box

The control system for the ROV consists of two major components to help with steady control during missions and testing. An Arduino system allows the pilots to control the ROV with helicopter simulator joysticks. The Arduino system consists of 2 standard Arduino Mega 2560's which all run separately and control different aspects of the ROV. The Arduino's run a series of C++ commands repeatedly (for more information about the Arduinos and their C++ commands see Programming). The Raspberry Pi system allows the use of digital switches instead of the standard toggle switch. The Pi system consists of a standard Raspberry Pi Model 2 B+, one Arduino Mega 2560, and an 8-bar Relay Module. The Raspberry Pi system allows the pilots to control different aspects of the ROV while not having to focus on anything other than the mission. Our control box is housed in a 22 by 12 by 9-inch Pelican Waterproof casing. All components of the ROV are enclosed inside of the casing, and the casing does not need to be opened during a mission. The team decided to mount to layers into the control box, the bottom layer hid the wires and the top layer housed the components. The team installed a hinge bracket, so that the platform holding Arduino boards and Sabertooths speed controllers can be easily accessible for maintenance and repairs. The connection points into the box from the tether were permanently mounted to the side of the box. All wires from the tether could be disconnected and make transport of the ROV easier to manage.

Programming

The control box takes advantage of three ATmega2560 microcontrollers, each of which is dedicated to controlling one of the ROV's systems. The code used on the microcontrollers is primarily written in C or C++, but uses Assembly in certain cases in-order to increase the efficiency of the code. Watchdog timers are present in all microcontrollers and allow the controllers to restart if an error is encountered. The Raspberry Pi, a single board computer running a Linux environment, is present in the control box to create a simple user interface, which is used for both toggling values used by the microcontrollers and debugging errors that may be encountered. The GUI used on the Pi is built in Python, an extremely flexible interpreted language, which allows for modification of the program without the consumption of time. The program takes advantage of the pyserial module, which allows the Arduino and Raspberry Pi to communicate efficiently via USB.

The programming code used to control the four motors that move the ROV in various directions is written in C++ for an Arduino micro controller. This allows up to 54 I/O pins to be utilized for both control inputs and outputs to speed controllers. First, input is gathered from the control input. A loop determines the direction of the robot. The speed is accounted and the variables are given a value of 1000 (full reverse) to 2000 (full forward). Finally, the data is sent out through the corresponding line to the speed controller where it is converted into the correct analog value (+12v to – 12v).

Pilot Control System

A Logitech Extreme 3D Pro flight stick allows the pilot to control the movability of the 6 motors on the ROV. The manipulator is controlled using a servo joystick. The second Logitech Extreme 3D Pro flight stick allowed the teams to control the movement of the manipulator.

3 D Pro Joystick

Buoyancy

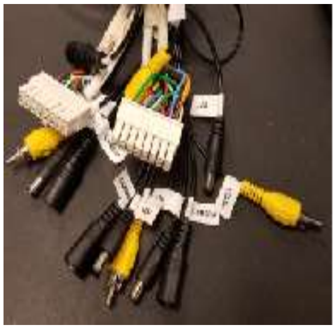
The control and maneuverability of the ROV depends on the neutral buoyancy of the ROV. Last year the team used high-density foam, which was difficult to shape to the needed specifications. This year the team constructed a two-part liquid of polyurethane pourable foam (commonly known as A-B foam). The team mixed equal parts of Part A and Part B, into a premade acrylic mold measuring 14 inches by 11 inches by 3 inches. The resultant compound expanded to form a rigid mass of foam. The team calculated how much floatation the ROV needed to obtain a neutral buoyancy, by first determining the volume of the ROV using the displacement method. The ROV was submerged into a container with a known volume of water. The difference in the displaced volume and the original volume determined the volume of the ROV.

Fabricated floatation

Using Archimedes Principle, the team calculated the mass of floatation needed.

The lightweight floatation was then machined, glued, painted, and coated to fit the size required. The total dry weight of the finished foam is 307 g. The float was mounted to the top of the ROV frame to maximize stability of the ROV, which played a vital part during the mission, as the ROV had to maneuver between cargo containers and retrieve samples from the ocean floor. The wires of the tether, camera and manipulator are enclosed on the underside of the float protecting the wires from getting tangled up in any props during the missions.

Tether



Detachable tether

The tether is one of the most important features of our ROV as it is the link between the ROV and the control box. The tether is made up of four strands of 18 AWG/16 cable, four camera cables and tubing for the sediment vacuum payload. The weight of the tether 4.6 Kg, diameter 6.7 cm is and measures 35 meters in length. The tether is encased in black Tech Flex covering allowing easy maneuverability and minimizing tether management both in and out of the water. The tether is neutrally buoyant as floats were added to the tether. The team decided to make the tether detachable by using three connectors that house sixteen pins each that stay inside with two flaps. The pins connect male to female allowing the ROV and tether to detach, making packing more effective. The tether was secured to the ROV frame using a U-bolt bracket, minimizing tugging on attached wires. Tether protocol was implemented when the ROV was in use and stored to minimize damage by adding hooks to the inside of the storage tote for transportation. In addition, one team member is responsible for connecting the tether to the box to prevent pins from being damaged.

Fuse

25 Amp fuse connected in main power line.

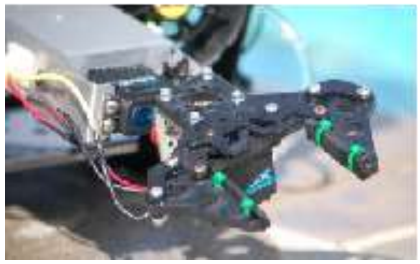
To meet the safety requirements for the MATE competition the team incorporated a 25 amperes circuit breaker into the main power line. This small safety device will stop working if the electric current exceeds the required amount, preventing fires, electrical shock, and damage to the main control box.

Payloads to Accomplish Missions

The team researched what payloads would be needed to reliably complete specific tasks during each mission. These payloads would allow the team to complete the following missions: install a hyper loop system to expedite shipment deliveries; maintain the waterfront light show equipment; collect contaminated sediment samples; and identify cargo containers that have fallen off ships prior to delivery. The ROV can perform these missions by implementing special features that will help improve the mobility, offer multiple mounting options for payloads, and improve the electronics and programming. The payloads and their tasks are:

Manipulator

Gripper test



Front view of gripper

Testing tilt mechanism of manipulator

The ROV is equipped with a custom-built manipulator, which is comprised of three servos, a tilt mechanism, a claw, and a chassis to increase length and hold the twisting servo. The servos can rotate 100° to allow for maximum movement opportunities. The claw has strips of rubber along its interior to assist in keeping the object being held in the control of the pilots. The chassis was 3D printed to meet our specific needs and size. Tilting is controlled via a set of two gears and a mechanism controlled by a servo. The servo is set so that it will never go fully up or down to protect the manipulator and the rest of the ROV from harm. Our manipulator is controlled via a joystick that is connected to a dedicated Arduino. The manipulator is attached to the ROV with two screws. This allows the manipulator to be detached and reattached further inside the ROV to meet the size restrictions. The manipulator draws a maximum current of four amps and runs off twelve volts of power. The manipulator will be used to retrieve contaminated samples and coral from the ocean floor, construct the Hyperloop.

A.G.A.R Suction cup

The ROV is equipped with an Accessible Gatherer of Artificial Remnants, or A.G.A.R. Our team added this payload to our Robot to collect the contaminate substance in the water. This substance is simulating a jelly-like bacterial substance that needs to be retrieved within the pool. The payload has a long ½ inch tube attached to it to pull in the sediment off the floor's surface. The tube was constructed out of a baby bottle that was cut in half to expand the diameter of the area to use. The baby bottle can hold approximately 250 mL of substance. A valve is attached to the end of the tube which, when closed creates a whirlwind that vacuums up any sediment that is underneath it. The material will remain in the tube until the ROV returns to the surface and the valve will then be turned to the open position and the material will be released into the sample cup for testing.

A.G.A.R

Raman Simulator

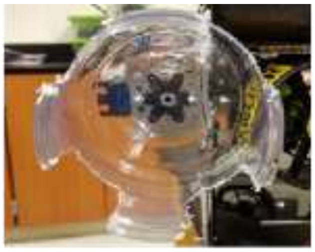
The ROV is equipped with a 6-LED; 9W drain light with waterproof connector. The light is waterproof and is powered from a 12V battery source. The team selected a red LED to illuminate the two sediment samples. The illumination of the sediment samples simulates a Raman laser, which will be used to determine if contaminants are present in the samples.

Boat light to simulator Raman

Valve Rotator

The mission requires that the ROV turns a valve to shut off the water supply during maintenance checks. The ROV features a custom-built rotor that was fabricated with the sole purpose of turning a valve. The rotor uses a simple yet functional method to extend and turn. The part that moves has two nuts connected to it. These have a threaded rod going through which in turn is connected to a rotating servo, when the servo turns the rod extends outward. At the end of the rod a cup with slots was attached and the slots slide in over the valve arms. When the rotor turns, it turns the valve with it. A continuous servo also powers this part. These servos are different from the regular servos. The team removed the potentiometer, leaving only the motor which allows the rotator to turn continuously when needed. The rotor itself is 49 inches long including the cup at the end. When the mission is completed, the rotor can be fully retracted and back.

Back mounting bracket of valve rotator



Front view of valve rotator

Side view of valve rotator

Collection basket

The team decided to modify a basket so that it could be deployed to the bottom of the pool as the mission starts. The old fountain and clams need collected will be returned to the surface via the basket. The basket has a 15ft rope attached to it. One team member will pull the basket to the surface at the end of the mission. The basket dimensions are 10 inches in diameter and it weighs 450g.

Collection basket

Measuring Device

The mission requires the ROV to measure the distance and direction of the high-risk containers. To accomplish this the ROV is equipped with a fabricated measuring device. The team mounted a metal bracket to a small, lightweight tape measure. The tape measure will allow the team to hook the metal bracket onto the container and once attached, the ROV will reverse extending the tape measure until it can measure the distance of the one container to the other. A camera is mounted to allow the team to see the measurement on the tape measure. A team member will then be able to read the measurement and use the information to calculate the distance and direction of the high-risk container to the other containers to make a survey map of the incident site.

Measuring tool

Safety Measures

Company Safety Philosophy

North Paulding High School Robotics is a company committed to the highest standards of safety performance. The company has developed an organized and effective safety program for every phase of the build. We continuously evaluate risks inherent in every activity performed on a daily basis. Creating a safe working environment is every employee's responsibility and the company's priority. Adherence to safety policies is a requirement for participation in the club. Our safety procedures consist of two areas:

Procedural Safety:

During the build and design of the ROV team members are required to wear appropriate clothing when working in the lab area, including no open toed shoes and no loose-fitting attire. While working with chemicals such as adhesives, team members are required to wear gloves and safety goggles. In addition, safe working practice dictates that personnel should not work alone when dealing with power tools. Team members are required to have an adult present when working with the electric saw. Lastly, team members are expected to conduct themselves in a professional manner, so no horseplay is permitted in the ROV work area.

Electrical Safety:

When team members are working with electrical wiring, batteries, or power tools, safety protocol measures are in place for their protection. In case of electrical shock, team members are trained to help the team member in distress. A separate soldering station is distanced from the main work area and all electrical wiring and equipment are packed away at the end of each workday.

The ROV is designed to meet the safety guidelines provided by the MATE competition manual. This included three major criteria:

1. Mechanical features: The ROV frame has no sharp edges that could cause injury during the deployment and transportation of the ROV. The ROV thrusters are housed within the aluminum frame. This prevents objects from contacting the propellers, ensuring the safety of the thrusters and the surrounding marine environment. Safety labels are placed on the surrounding casing of the thrusters, indicating that the moving propellers could cause harm. The control box is clearly labeled to prevent wires from being switched or connected incorrectly.

2. Electrical features: All cables inside the frame are secured away from the moving propellers. An inline circuit breaker (fuse) is attached to prevent the ROV from exceeding the maximum operating value of 25 Amps. All connections are waterproofed with liquid tape. The control box is constructed from a strong black toolbox, providing protection to the team member handling the box. All Sabertooth and Arduino boards are placed on plastic mounting stands to prevent contact with the mounting board, since the electrical boards get warm with extended use. Circulating fans were installed into the box to keep all electrical components from overheating when the box is operational.

3. Environmental concerns: The ROV is free from any chemical substances or pollutants that may mix with and harm the marine environment.

All team members operating the ROV follow the safety checklist thoroughly before operating the ROV. A visual inspection before the operation of the ROV would indicate any potential issues that may need to be addressed before the operation of the ROV in the water. (See Appendix A - Safety Checklist). In addition, team members follow a deck command list when testing the ROV in the pool, to ensure both the safety of the team members and to minimize damage to the ROV.

The team has numerous opportunities this year to test the ROV in the pool. At the beginning of each pool session, the main pilot follows the checklist below to ensure the safety of each team member. The following commands were given:

Going Hot – The pilot connected the ROV control box to the power source
Hands Clear – The pilot turned on the control box and all team members remove their hands from the area of the moving propellers.
Going Cold – ROV powered off and wires removed from power source
Tether – Team members are to start rolling up the tether before team members leave the pool area to avoid team members from falling in.

Budget

Estimated Expenditures

One of the primary objectives for the 2016 - 2017 build year was to build an ROV within the budget in a timely manner. To meet this objective the team brainstormed what parts would be needed and included extra costs for replacement servos and cameras. The approved budget was $3500.00.

ROV Estimated Budget 2016-2017		
Items	Notes	Amount
Thrusters	Vertical and up/down movement 2 T200 Blue Robotics Thrusters with ESC controllers. Reused Seabotix motors from last year	$650.00
Control Box and Tether	Pelican box, easier mounting, more space to work. Tech flex covering, boards for mounting, controllers	$1000.00
Payloads	Waterproof servos, measuring device, cameras, custom manipulator, 3 D printing, balance bracket	$1000.00
Frame	**Reused** frame from last year	0
Buoyancy	Custom built light weight float, acrylic frame	$100.00
General	Fees, posters, registration, shirts	$450.00
Total estimated expenditures		$3200.00

Actual Expenditures:

The team managed to keep the total cost of the ROV build to $6441.48. This included three new servos to replace those damaged in the build before the ROV was even tested in the pool due to team error. Careful planning from our team leaders, recording purchases at weekly meeting, tracking purchases, orders, deliveries, donations and fundraisers helped the team meet this goal. For a detailed expenditure for 2016-2017 ROV build See Appendix D- Budget).

ROV Project Costing 2016-2017		
Items	Notes	Amount
Thrusters	Vertical and up/down movement 2 T200 Blue Robotics Thrusters with ESC controllers. Reused Seabotix motors from last year.	456.00
Control Box and Tether	Pelican box, easier mounting, more space to work. Tech flex covering, boards for mounting, controllers	1174.59
Payloads	Waterproof servos, measuring device, cameras, custom manipulator, 3 D printing, balance bracket	809.89
Frame	**Reused** frame from last year	15.00
Buoyancy	Custom built light weight float, acrylic frame	70.00
General	Fees, posters, registration, shirts	670.00
Total		3195.48
Reused item	Motors, frame	3253.00
Total ROV costs included reused items		6448.48

Challenges

The ROV team has performed very well this year and has been generally better prepared than in previous years. A complex ROV build will nevertheless have challenges.

Technical Challenge

At the beginning of the year we had a radical idea to use a detachable tether. We decided to purchase a tether that what would essentially be three small tether ropes, but it was all put into one giant protective casing for 1 tether. We spent a considerable amount of time setting up and constructing the tether. We spent roughly three months working on the tether, only to find out that the tether was heavier than the weight limit for the ROV and tether combined. This was a major setback as we had to completely re-design our tether and many afternoons getting the tether soldered and connected to the control box.

Non-Technical Challenge

The team had no shortage of ideas and solutions but struggled initially with choosing which ideas work the best. To address this, our team commonly held votes in which all our members' opinions were equally represented. This year, we also decided to organize the team into three separate engineering groups: electrical, mechanical, and programming. Each group has approximately 4 people in it, and then we always came together at the end of each meeting and discussed our progress and goals.

Lessons Learned

Over the last three years, the team has learned to work together to design and build an ROV capable of successfully competing in the MATE Regional competition.

First ROV test in pool

Interpersonal Lessons Learned

One goal of the North Paulding School Robotics is to create a positive working relationship while taking the product to the next level. The team learned to work with minimal mentor assistance while independently solving problems with programming, buoyancy, and the manipulator.

Technical Lessons Learned

The ROV build was strategically planned throughout the year to avoid delays. The team members learned to program the six motors and controller. We also improved the control box layout this year to increase accessibility to the wires, which eliminated the need to disassemble the box if a problem occurred. Additionally, a new program to design the ROV frame was mastered, improving the frame design process.

Future Improvements

North Paulding Robotics built an ROV capable of completing the missions required by the MATE Regional competition. The team is continually learning and discovering ways to improve the build. Next year's team will have rising 9th graders joining; the club needs to ensure that all team members are actively involved in the planning, design and build of the next ROV. The club has decided that splitting the team into two departments and allowing two teams to compete which will allow all team members to be actively involved and be able to contribute effectively to the build.

Reflections

This year North Paulding High School Robotics has managed to work effectively as a team, ensuring that all team members play a valuable role in the fabrication of the ROV. Competing in the MATE Regional competition has not only allowed the team to develop skills in the build of the ROV, but also in the planning, technical, and presentation aspects involved when operating as a company. The team has learned how to problem solve, budget, and order parts needed in the ROV build. Although the management of the club is at a school level, the skills learned and gained through the experience will be utilized by each member when seeking higher education and entering the work force. This year our reflections are written by a new, a returning, and a senior team member.

Michael Lees – senior member

This year in ROV I learned how to be a leader of a group of high schoolers. The club has been an enjoyable experience for me and has allowed me to interact with others from my school, as well as, other schools across the state during competition. ROV club has influenced me to be more outspoken with my ideas and comments and has developed my leadership skills through additional responsibilities as the CEO.

Bryce Rodrigues- returning member

ROV this year has been amazing. I've learned about new ways of solving problems. I've learned to work better as a team and to help people. It has helped me to become a stronger speaker and to make my voice heard. It has also showed me how fun it is to be a part of something and to work for a common goal and see it succeed.

Zoe Hood- new member

This is my first year in ROV and I enjoyed it. My team included me in many ways. I helped build, solder and fix the robotic arm. I built the tape-measuring tool for the ROV. I was taught how to solder this year in ROV. I had a fun year and I plan to join ROV again next year.

Team member completing Buoyancy test

Team members salvaging parts from old ROV

Representing NPHS Robotics at Allgood Elementary School STEM night.

Acknowledgements

- North Pauling High School would like to recognize several sponsors and individuals for their continuous support and help throughout the year.
- MATE Center and Grays Reef National Sanctuary for creating the 2017 missions and organizing the competitions
- Governors Town Club for allowing us the use of their pool to practice for the event
- Longhorn Steakhouse for allowing us to host two fundraisers throughout the year
- Interstate All State Batteries for donating batteries for our pool practices and sponsoring our T-shirts.
- Sammy McClure School Staff, with a special thanks to Mrs. Hayes for supporting and believing in the ROV club and providing us with a meeting place.
- Parents of team members for transporting us to meetings and pool practices and for the wonderful snacks and treats during our meetings.
- Mrs. Lees, Mr. Gardner, Mr. Lewis and Mr. Lees for the continuous help and support throughout the year.
- MATE sponsors (Marine Technology Society, Marine Technology Society ROV Committee, National Oceanic and Atmospheric Administration (NOAA), National Science Foundation (NSF), Oceaneering, Long Beach College).

- Special thanks to our surrounding businesses for supporting our trip to the international competition.

References

About the Port. (n.d). Retrieved February 3, 2017, from http://polb.com/about/default.asp.

World of Color. (n.d.). Retrieved February 19, 2017, from https://disneyland.disney.go.com/entertainment/disney-california-adventure/world-of-color/

Marine Advanced Technology Education: RANGER_2017. (n.d) Retrieved February 3, 2017, from https://marienetech.org/ranger_2017/

REQUEST FOR PROPOSALS (RFP) TO ... - Port of Long Beach. (n.d.). Retrieved February 19, 2017, from http://www.bing.com/cr?IG=2C32AB549603413D92DB9F3626167FDC&CID

The ROV Manual. A User Guide for Observations Class ROV/ Robert D. Christ. L. Wernli Sr. 2007, ISBN- 97800750681483.

Datasheets:

Seabotix BTD 150 Thrusters
http://www.seabotix.com/products/pdf_files/BTD150_Data_Sheet.pdf

Blue Robotics T200 Thrusters "Thrusters & Motors." T200 Thruster Documentation. Web. 29 Feb. 2016.

Thrusters. (n.d). Retrieved December 12, 2016, from http://www.bluerobotics.com/thruster/

Appendix A: Safety Checklist

Workplace

- Eye and ear protection worn when working with power tools
- Appropriate clothing worn when working with machinery or moving parts of ROV
- No dangling jewelry
- Long hair tied back
- No loose clothing
- No open toed shoes
- All work with power tools performed under proper adult supervision

Mechanical

- All cables are fastened
- Ensure all cable connections are good
- All screws, nuts and bolts are fastened tightly
- All thrusters are secure
- No sharp edges are present on the ROV
- Hazardous areas of the ROV have warning labels
- All parts of the ROV are securely attached to the base
- Propellers are enclosed inside the frame of the ROV
- Tether is secularly attached to ROV
- Tether is secularly attached to control box with clamp
- Tether is neatly bundled and protected to prevent injury

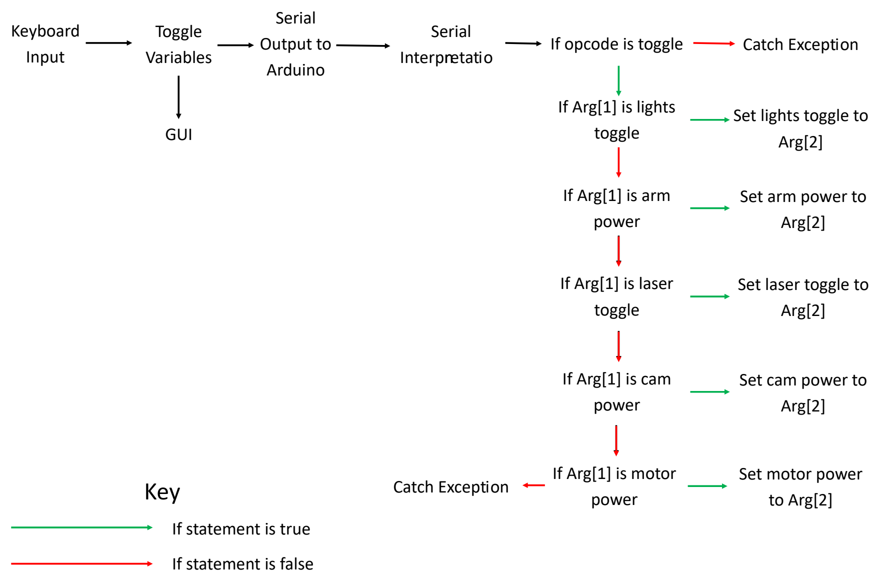
Electrical

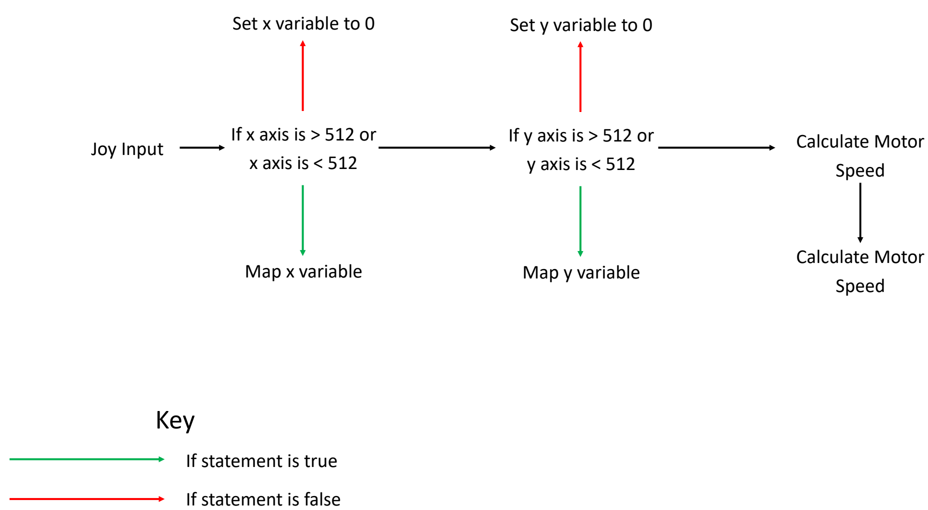
- No metal parts of cables are exposed
- No cables are damaged
- Installed circuit breaker within 30 cm of attachment point
- No loose wires are detected
- All soldering joints in the tether are covered in heat shrink
- Single attachment point to power source

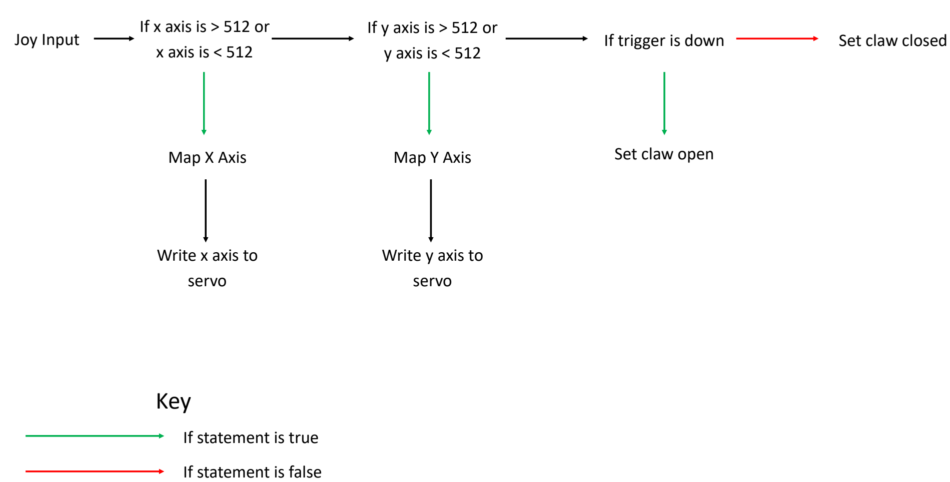
Waterproofing

- All soldering joints in the tether are covered in liquid tape
- Servos liquid dipped as a precaution

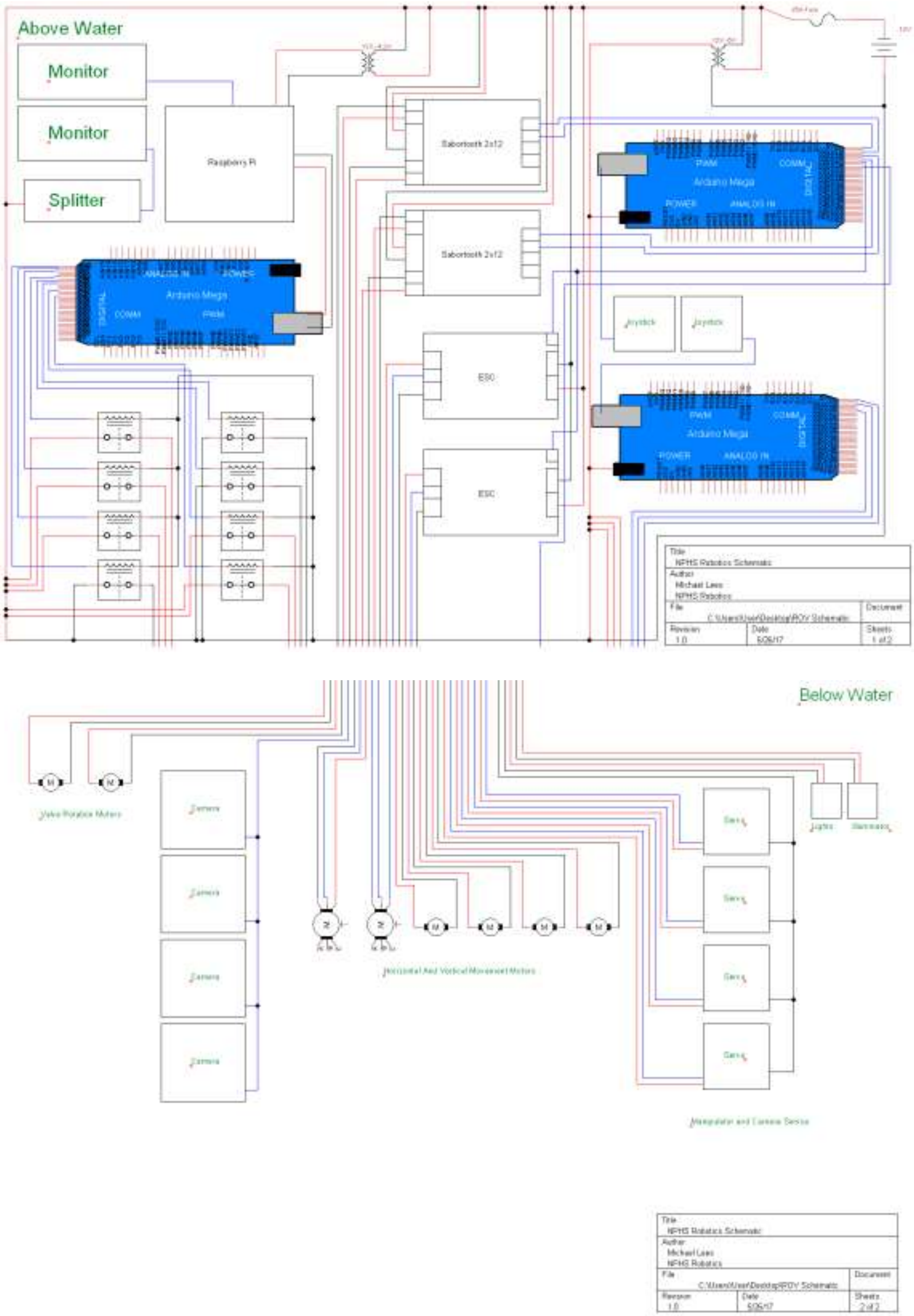
Appendix B: Software Flow Chart







Appendix C: SID



Appendix D: Company Budget

Company Name: Wolfpack Robotics **School: North Paulding High School** **Instructor/Mentor: Gardener, Lees, Lewis**					**Reporting Period** **From: 8/25/16** **To: 4/15/17**	
Revenue						
Date	**Type**	**Expense**	**Description**	**Source/Notes**	**Amount**	**Balance**
8/1	Dues	Dues	NPHS Dues	Member Dues	3900.00	3000.00
9/1	Cash Donation	Fundraiser	Auto bell Fundraiser	Fundraiser Ticket Sale	250.00	3250.00
2/15	Cash Donation	Fundraiser	Longhorn Breakfast and Raffle	Ticket Sale for Breakfast and Raffle sales	250.00	3500.00
Expenditures						
Date	**Type**	**Expense**	**Description**	**Source/Notes**	**Value**	**Balance**
Control System						
9/1	Purchased	Control box	Amazon	Pelican case	200.00	3300.00
9/1	Re-used	Controller	Micro Center	Logitech 3D Pro Flight stick	145.00	3300.00
9/1	Purchased	2 Motor Drivers	Amazon	Saber tooth Dual 12V motor Drivers	159.98	3140.02
9/1	Purchased	Arduino Boards	Micro center	Arduino Boards, bus bars, cables	150.00	2990.02
9/1	Purchased	Switches	Amazon	DPDT Switches	25.00	2965.02
9/1	Purchased	2 Monitor	Walmart	Acer 24 inch computer monitor	298.00	2667.02
9/1	Purchased	Splitter	Amazon	4 way splitter	41.99	2625.03
9/1	Purchased	Laptop	Amazon	Programming laptop	188.62	2436.41
Framing System						
9/1	Re-used	Frame	Stage Left Fabrication	Frame material and welding	200.00	2436.41
9/1	Re-used	Frame	Maco Body Shop	Painting of frame	100.00	2436.41
10/1	Purchased	Frame	Home depot	Modifications of frame	15.00	2421.41
Manipulator						
10/1	Purchased	Tilt mechanism	Tilt mechanism SPT400	Tilt mechanism for arm	69.99	2351.42
10/1	Purchased	Servos	3 Savox digital servos	Waterproof servos for tilt mechanism, claw	245.94	2105.48
10/1	Purchased	manipulator	Parallel Gripper	Claw	14.99	2090.49
Motors						
9/1	Reused	Thrusters	Seabotix	Thrusters- vertical motion	2748.00	2090.49
9/1	Purchased	Thrusters T200	Blue Robotics	Purchased 2 thrusters for up and down movement and ESC controllers	456.00	1634.49
Tether						
9/1	Purchased	Tether	Wire to Go	18/8 Gauge wire	75.00	1559.49
9/15	Purchased	Covering	Cable Organizer	Green Tech Flex covering	36.00	1523.49
Payloads						
9/1	Reused	Rotor	servos	Damaged servos, remodified to run rotor	60.00	1523.49
12/1	Purchased	Tape Measure	Home depot	Tape measure and brackets for mounting	20.00	1503.49
12/1	Purchased	AGAR device	Amazon	Bottle, tubing, valve	15.00	1488.49
12/1	Purchased	Container magnet	Amazon	Magnets for detection of contaminated container	15.00	1473.49
Buoyancy						
12/1	Purchased	Buoyancy	Foam mix part A and part B, acrylic board	Foam and board for molding of floatation	70.00	1403.49
Camera & Lights						
9/1	Purchased	Servos	Amazon	Savox servos Waterproof 180 and 90 degree servos	163.98	1239.51
9/1	Purchased	4 Cameras	Aamzon	Fish finder camera with 50 ft cable	240.00	999.51
9/1	Purchased	Camera Mount	Servocity	Tilt mechanism for cameras DDT 500 Tilt Kit	24.99	974.52
Expenditures/General						
12/1	Purchased	PVC parts	Home Depot	PVC parts for prop building, screws, crimps, tools	400.00	574.52
2/15	Services	Posters	Graphic Design	Printing and mounting of posters	95.00	479.52
12/1	Services	Registration	MATE	Registration Fee	75.00	404.52
3/15	Services	Presentation	Staples	Technical report, business cards, printing brochures.	100.00	304.52
1/1	Donated	Shirts	Interstate batteries	Shirts for competition	300.00	304.52
Total						
Total Donated or Reused					3253.00	
Total Spent on other Expenditures/General 2016-2017 Year					670.00	
Total Spent on ROV 2016-2017 Year					3195.48	
Total Collected 2016-2017 Year					4400.00	
Total Value of ROV					6448.48	
Balance					304.52	