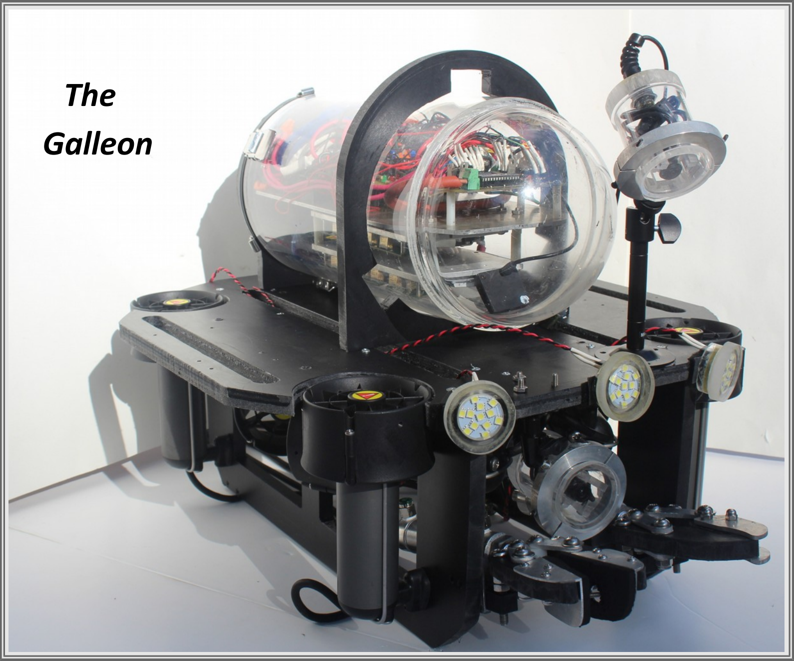
DeepView Technologies



Cornerstone Academy, Gainesville, FL
Technical Report

From Left to Right: (Back) Dr. Alex Angerhofer, Jimmy-Ray Lewis, Will Hodik, Oscar Witte, Carter Wyatt, (Front) Wyatt Savage, Jonathon Gordon, Tirza Angerhofer, Ethan Angerhofer

Company Directory

Carter Wyatt: CEO and Chief Design Engineer

Tirza Angerhofer: Chief Electrical Engineer

William Hodik: Chief Design Engineer

Oscar Witte: Canister Specialist

Jimmy-Ray Lewis: Software Engineer and Design Engineer

Ethan Angerhofer: Software Engineer and CFO

Wyatt Savage: Electrical Engineer

Jonathon Gordon: Design Engineer

Dr. Alex Angerhofer: Team Mentor

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Abstract

With over eleven years of experience, DeepView Technologies strives to produce affordable, quality ROVs for their customers. This year, the company designed and built the Galleon, an ROV made to explore the diverse environments of Europa and the Gulf of Mexico. The Galleon is able to take pressure and temperature measurements as well as recover mission critical equipment. Two pneumatic powered grippers, mounted on the front of the Galleon, can be used to pick up and deliver specimens to the surface. Four strategically placed cameras give the pilot a clear view of the sea floor and the grippers.

The Galleon, powered by 48V, is controlled by a USB Xbox Controller connected to an Arduino Uno board. Electrical signals and air are fed down through a 25 meter tether and into the canister, which houses the voltage regulators and in-house printed circuit boards. Sensor information and exhaust air are sent to the surface. Surface controls are housed in a robust pelican case for easy transportation.

The Galleon is a large multi-decked war ship used in the 16th through 18th centuries. The Manila Galleon was the first European ship to arrive in Mexico.

Company Mission

DeepView Technologies is dedicated to manufacturing safe and efficient ROV systems. Since 2003, DeepView Technologies employees have been creating robotic systems and have created many unique ROVs according to MATE standards. The Galleon was built with attention to detail and experienced craftsmanship. We believe the Galleon is equipped and ready to complete its missions.

Figure 1: The UHMW frame with the thrusters mounted.

Frame

The frame is the backbone of the Galleon. It supports and protects all the components necessary to complete the missions. This year's mission tasks call for smaller and lighter ROVs than in previous years.

Therefore, we designed the Galleon with a smaller frame while keeping the same versatility and modular design as the frames of past ROVs.

Figure 2: Carter and Jonathon assemble the frame.

The frame consists of two vertical skid plates with a base plate mounted on top. A bar connecting the two skids at the bottom is used for mounting the grippers. Also, a brace at the front of the base plate is used to hold the canister in place. This design is simple, sleek, and streamlined. We can easily attach tools to it, such as the pressure sensor, when they are needed.

The frame is made of ultra high molecular weight (UHMW) polyethylene. This material can be easily manipulated and cut using a bandsaw. It has a specific gravity of 0.94, which is very close to that of water, making it almost neutrally buoyant.

Mounting our vector thrusters proved challenging because of the smaller frame. We ended up putting them underneath the frame plate so that the canister, which houses our electronics could be mounted on top. This allowed easy access to electronics for any troubleshooting or repairs. The canister is secured to the frame by its end cap and the mounting brace in the front. We also had to design smaller grippers so that they could fit between the skids of the frame.

The frame was designed in Solidworks by Jimmy, one of our junior team members who served both as design and software engineer. Using a 3D model helped us see how things would fit and look on the ROV. Slits were cut into the frame to make it more hydrodynamic and to have convenient grip points. After the design was finished on the computer, we sent the 3D drawing to Astronaut Studios, Inc., a local startup maker company who milled the skids and base plate on a CNC mill. Once the frame was returned, we sanded the edges. We manufactured the front brace and the mounting brace for the canister ourselves.

Buoyancy

Buoyancy is essential for precise and accurate steering. It improves the stability and mobility of the ROV. This year it must complete its missions at around forty feet affecting buoyancy significantly.

An integral part of buoyancy is the acrylic canister that houses our electronics. We have a slightly bigger canister compared to last year's design, which gives us more room for electronics and it increases flotation reducing the need for extra weights to balance out the ROV. We also added a foam cord in the tether to help the tether float on the surface to keep it from interfering with the movements of the ROV.

Figure 3: Will adds foam to the Galleon.

We adjusted buoyancy by using weights and dense foam. First, we put the Galleon in the water and observed its buoyancy. If it started to sink, we attached foam. If it floated too much, we added weights. Next, we drove the ROV and observed its stability. This year's ROV was especially well balanced from the outset. We only needed to add flotation on the mount point of the tether, which brought up the rear end. This change helps the pilot navigate more easily by giving him a better overview of the sea floor. More flotation and weights were added as needed.

Canister and Cap

Figure 4 shows the endcap that was designed in Solidworks. It connects the tether to the on board electronics and protects the electronics from water. The endcap is circlular with a flat, box like extrusion at the bottom so that it can easily be mounted to our frame with two stainless steel screws. The endcap has 6 holes with a diameter of 11.430 mm in the top semicircle for the pneumatic lines which go to the solenoids and operate the grippers. The bottom semicircle contains ten 7.62 mm diameter holes for the thruster and power cables, two larger 8.890 mm holes for the cat5 wires and several smaller holes at 3.175 mm for items such as camera and sensor wires.

Figure 4: The CAD drawing of the endcap.

On both sides of the endcap are slits cut to hold a 3.18 mm thick aluminum board. This board is an effective way to disperse heat. The aluminum plate holding the electronics inside the canister protrudes through the slits into the water. The water cools the aluminum board, which in turn cools the electronics. We waterproofed the holes with epoxy. This design was effective in the previous year and we adopted it for this year's ROV.

The cylinder, which is attached to the endcap by means of DiveRite clips, houses the PCBs and voltage convertors. The cylinder is a 17.8 mm (7”) diameter,30.48 cm (1 foot) long clear acrylic tube with a dome attached with acrylic #3 glue. Its size is somewhat larger than last year's which gave us more room to house the electronics and the pneumatic valves.

The cylinder is sealed to the endcap with two o-rings. A quad cross-section o-ring was placed at the end of the cylinder as an axial compression seal while a round one was placed in a groove milled out of the inner cylinder of the end-cap serving as a radial compression seal. This double seal was considered necessary given the higher hydrostatic pressure of about 1.2 bar at a depth of 40 feet.

Figure 5: Seabotix BTD-150 Thruster.

Propulsion

For this year's ROV propulsion system, we utilized eight Seabotix BTD-150 thrusters (see figure 5). We use these commercial units because they are reliable and making our own thrusters would be too time consuming. The thrusters were reused from last year's model to allow us to stay within our budget, though we did purchase two new thrusters as backups in case of thruster failure.

Four horizontal thrusters were placed in a diamond-shaped orientation 30 degrees away from the direction of forward motion on the bottom of the central plate. This allows us to use them as ‘vector thrusters' where the direction of thrust can be controlled by adjusting the thrust of the four units. Vector thrusters improve the range of motion into potentially all directions in the horizontal plane with high precision, which makes tasks requiring accuracy much easier to complete. Maximum forward power is generated at $4 \cdot \cos(30^{\circ}) \approx 3.5$ times the thrust of one unit (almost the full power of all four thrusters) while sideways thrust is generated at a power of $4 \cdot \sin(30^{\circ}) \approx 2.0$ times the thrust of a single unit. The thrusters are configured this way because speed is more important for forward motion, but sideways motion can still be facilitated in this arrangement eliminating lateral thrusters.

Figure 6: The Vector Thrusters located on the underside of the Frame.

Four vertical thrusters are mounted at each corner of the Galleon, which allows for symmetric application of vertical thrust to the ROV. Each one of the Seabotix BTD-150 thrusters on our ROV produces nominally ~20 N of thrust (2 kgf as per manufacturers specification) and operates at a maximum of 100 W. This results in 80 N of vertical thrust, 40 N of lateral thrust, and 70 N of longitudinal thrust. Each thruster is fitted with a propeller shroud in addition to caution stickers to ensure safety during retrieval and transport.

Pneumatics

This year we only used two pneumatic pistons in our system to power our two grippers. We run our entire pneumatic system at ~2.8 bar (40 psi) pressure. Our pistons, solenoids, and valves were generously donated by Fabco Air. The two pistons are double action with a bidirectional double u-cup seal on the shaft. The seal is located on both sides of the piston shaft. As the water pressure builds, it pushes the external seal down. On the other hand, increasing air pressure, seals the internal u-cup tightly, thereby maintaining a positive seal on the shaft. This seal prevents water moving through the pistons. The pistons have push-to-connect valve stems that are connected to the solenoids in the ROV canister with ¼” tubing. The two solenoids receive pressurized air via 1/4” tubing in the tether coming from the air compressor on shore and distributed by a Y splitter. The other ¼” tube in the tether is used as the system's exhaust to release excess pressure from the canister. The nylon tubes used are rated for 1MPa (150psi) and the pistons are rated for 100 psi.

Figure 7: A Pneumatic Piston from Fabco-Air.

Tether

The tether is one of the most integral parts of any ROV. In the past, we have had very thick tethers with multiple data, power, and pneumatic lines. This year, we designed a thin, streamlined tether, allowing the Galleon to maneuver more freely while performing its tasks.

The 25 m tether consists of a pair of stranded 8 AWG cables, two CAT-5e cables, and two 1⁄4” pneumatic tubes. The 48 volts power is delivered through the pair of stranded 8 AWG cables to the Galleon allowing for up to 40 amps of current. We chose the stranded 8 AWG cables to allow for better flexibility of the tether. They also suited our power draw needs. Our two CAT-5e cables are used to bring information from our Arduino uno board to the microchips on the ROV, as well as to give us signals from the cameras. One of the ¼” pneumatic tubes is used to supply 40 psi of air pressure to the valves operating the pistons for the two grippers. It is connected to an on-shore air compressor. The other ¼” pneumatic tube is used as exhaust for the cylinders and valves back to the surface.

Figure 8: The Tether connections

The tether is attached to our PVC end cap on our ROV. All the wires and pneumatic tubes are tightly wound together by a mesh sheath ensuring protection of the vital cables as well as making tether management clean, organized, and simple. Strain relief is accomplished by fixing the tether to a UHMW holder at the back of the ROV. If the tether is pulled, the force will pull on the UHMW holder rather than the sealed connections. At the surface, the tether is directly connected to the pelican control box.

Grippers

In order to complete the missions, DeepView Technologies designed two horizontal grippers. They effectively grab and move items on the sea floor and are used to pick up the ESP connector and oil samples. They are fastened to the front left and right of our ROV in view of two cameras for easier grasping.

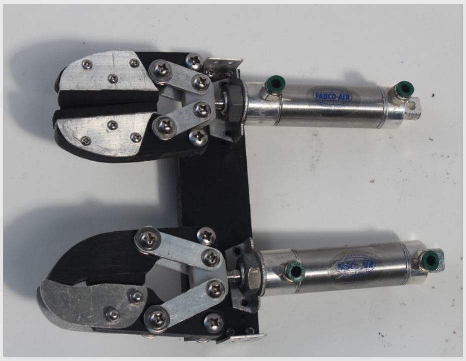


Figure 9: The Galleon's Grippers

The grippers are hand-like tools that open and close upon the extension and retreat of the double-action pneumatic pistons. One gripper is shaped like a claw while the other gripper is flat.

The flat gripper is mounted on the right side of the ROV and has a bolt through the middle, which helps us pick up the ESP cable connector. The pilot maneuvers the ROV to the Cable Connector and closes the gripper so that the bolt goes through the hook on the top. The ROV has a secure and stable hold on the connector, which facilitates placing it into its receptacle. Because the bolt is far enough back on the gripper plate, it does not impede picking up other objects later on in the mission. The claw-shaped gripper is used for opening and closing the door of the milk crate. The claw also facilitates picking up oil samples.

Figure 10: Jonathon works on the grippers.

The grippers are each made of UHMW, a sheet of aluminum, and sponge nitrile rubber. We used UHMW for the base and hands of the gripper. The material can be easily manipulated and matches our frame. The aluminum, which is a light but strong metal, was used to create oval-shaped arms, which allowed the gripper to open when the piston was extended. Aluminum was also used for the mounting brackets. The rubber was placed on the gripper hands to improve traction and soften the impact on objects when closing the grippers around them. Stainless steel bolts and nuts were used to fasten the grippers together.

Figure 11: Tirza and Jonathon wire the PCBs.

Each piece of the grippers was painstakingly designed and created by DeepView Technologies members. They cut each piece using a bandsaw or chopsaw and then sanded them so that they would be the right size and have rounded edges.

Electronics

The Galleon runs at 48V and has a 40 Amp fuse on the positive side of the power supply. This voltage goes through two 8 AWG cables, which connect to a main power switch in the control box. If the switch is on, the voltage continues through the tether to our voltage regulators. Vicor Corporation generously donated the VICOR VA- A2962649 and the VA-E2962613 models last year. We decided to reuse these expensive regulators because they worked very well. The voltage regulators convert 48V to 20V, which powers the thrusters, and 12V, which powers our printed circuit boards. Each 20V convertor is able to pull 20 amps. Therefore, each of the two convertors powers four thrusters, which pull 3.75 amps each, so that the system will not be overloaded. The 12V convertor only pulls 10 amps. However, this is enough because the printed circuit boards pull no more than 3 amps.

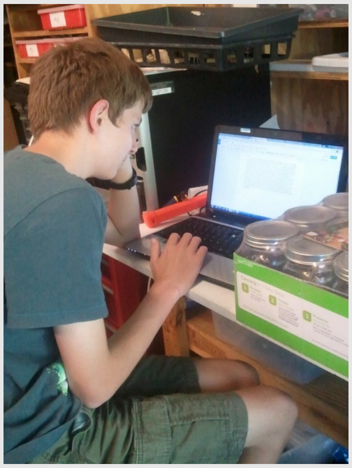


Figure 12: Wyatt works on the PCBs.

The Printed Circuit Boards (PCB) control the thrusters, sensors, and the grippers by interpreting the Xbox commands using the arduino microcontrollers. We designed the PCBs using the CAD program EAGLE, version 7.5.0 Light. The 7.5.0 version of EAGLE, the newest update, is compatible with our method of making PCBs. The 7.5 Light version is free but has some restrictions, yet it allows us to design everything that we need. Wyatt, our Electronics Specialist, worked with Tirza, learning the program and designing the Galleon's double-sided PCBs as compactly and efficiently as possible.

After the design was complete, the image of the design was saved and modified with GIMP 2.8. We manufactured all the PCBs in the shop, because we can make easy modifications. Also by making the boards ourselves, we understand the electronics better. The presensitized double sided 1.5875 mm copper board was bought from MGChemicals along with the rest of our PCB supplies. Once the design was printed on a transparency, it was imprinted on a green laminated copper board. We placed the transparency on top of the board, which we cut to size. Then we irradiated it using a UV lamp. The laminated green film is impervious to ferric chloride solution but susceptible to UV light. We placed the board into a developer solution which removed the exposed parts of the laminated film.

When designing a double-layered copper board, we need to correctly imprint the second side of the board without ruining the already completed side of the board. We put tape over the completed side to protect against sunlight's UV rays. In order to match up the design on both sides correctly, two/three holes were drilled through the board in specific locations. The transparency of the other side was irradiated using the methods mentioned previously. Finally, the exposed copper was removed using ferric chloride solution. Throughout this process our team members wore gloves and eye protection to guard against the various chemicals. Then we drilled holes into the board and soldered the components. The boards were mounted to the aluminum plate in the canister and the appropriate wires were connected to the boards.

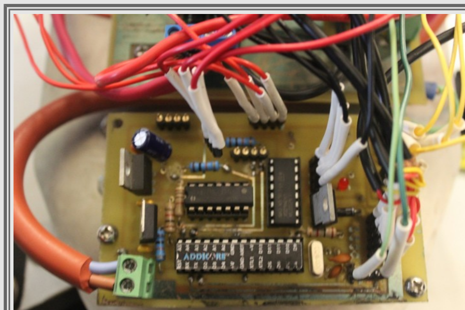


Figure 13: The Pneumatics PCB with components.

DeepView Technologies used one Arduino Uno with a USB host shield for the Xbox controller with the surface controls and two ATMega328 microchips on the

PCBs as on-board controllers. We have used Arduino in previous years and are familiar with the programming language and logic. The Arduino platform is also supported by many online forums making help readily available if needed.

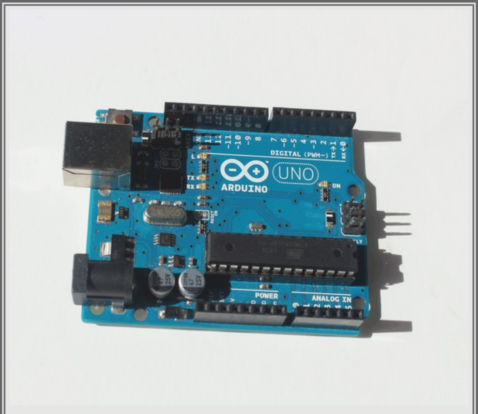


Figure 14: The Arduino Uno

The Arduinos communicate with each other, sending information to and from the ROV. One microchip located on the Pneumatics PCB controls the grippers, lights and pressure sensor. The other microchip located on the Propulsion PCB controls the thrusters. First, the Xbox controller, which connects to the Arduino Uno by means of a USB host shield, inputs data.

Each button on the Xbox controller either sends an on or off input to the Arduino, which is stored in a specific location in an array, or more simply, a list. This array packages the information and sends it to the ATMega328 chip on the Pneumatics board. After validating the program, the chip unpackages the array and tests values. The location of the signals in the array determines what Xbox button was pressed and consequently which component is affected. The ATMega328 will send signals to the components depending on the values it received. Afterward, it repackages the data and also adds sensor data from its sensors. Then the Pneumatics microchip sends the data to the ATMega328 on the Propulsion board. This microchip unpackages the data and sends signals to the H-bridges, which control the speed and direction of the thrusters depending on the information it receives from the array. The Propulsion board repackages the data and sends it back to the Arduino Uno at the surface. All three microcontrollers exchange information at a baud rate of 115,200, which is 115,200 bits per second.

Figure 15: Jimmy and Ethan testing their Arduino programs with the Xbox controller.

The Software Engineers also programmed an inversion switch and a slow mode switch. When pressed, the inversion switch allows the pilot to use the controls as if he were going forward even though the ROV moves in reverse. The pilot uses the backward facing camera to steer. This switch facilitates reverse movement. The slow mode switch allows the pilot to move at half the speed of the thrusters. In some situations, the pilot needs to have precise movements, which are facilitated when the ROV is moving slower.

We were able to fit all of our surface controls within a 56×23×35 cm Pelican Case. This case is very robust and compact, which makes it ideal for a mission to Europa. It also has a pull out handle and wheels, which makes it easy to transport.

Figure 16: Oscar and Will work with the pelican case.

The box was modified so that the tether connections could be connected to the surface controls. Holes for three ethernet ports, two Anderson Power Connectors, and a male 110 volt connector were drilled. Each of these is clearly labeled and mounted securely. A monitor was attached to the lid of the pelican case by means of double sided tape, which holds it securely in place.

Figure 17: The Control Box

The body of the box holds the BNC to VGA converter and camera splitter, needed for the cameras. It also houses the Arduino Uno and Xbox controller. Two LCD screens display the temperature, pressure, and depth. These sensitive electronics are protected by a clear piece of acrylic. Two switches located on this acrylic plate give power to the control box and to the ROV, respectively. These switches allow us to instantly turn off power if we see a problem. The box is easily modifiable and we can install extra switches, LCD screens, or LEDs, as needed.

Navigation Lights

Figure 18: The Navigation Lights

The Navigation lights are DC12V LED lamps, each with twelve small, white LEDs arranged in a circle with a 3 cm diameter. Their leads were soldered to 22 gauge wires that connected through the endcap to the Pneumatics PCB. Deepview Technologies decided to use these lights, to ensure that the pilot has a bright view at forty feet underwater were ambient lighting might be dim.

We waterproofed the LEDs using a small acrylic cylinder and cap, and epoxy. The shallow acrylic cylinder was glued to the cap with acrylic glue #3. The lamp was put into the depression and covered with epoxy. Three lights were mounted at the bow while one light was mounted at the stern. They were attached to the frame with velcro, which allows us to easily remove them if they are not needed.

Cameras

Figure 19: One of the waterproofed cameras.

The design of the cameras and their waterproofing system are crucial. We used four Fisheye FPV cameras, which were low cost, had a 170 degree angle field of view and had 1280×960 pixel resolution.

In past years, waterproofing the cameras has been challenging. For the 2015 competition, the team was able to design a waterproofing system, which included a closed canister, that did not leak. Because of the good performance, the team decided to reuse this camera design.

First, two u-shaped acrylic brackets were attached to both sides of the camera and then glued to a clear acrylic circle with a 5 cm diameter. These brackets stabilized the camera. Next, the end cap with the camera was glued to a 6.35 cm long acrylic canister using acrylic glue #3. A second end cap with a hole for the camera wires was glued to the other end of the canister in the same way as the previous one. A gland was screwed into the second end cap and epoxied to give a good seal. All the parts of the canister were made in the company's shop, except for the gland, which was bought commercially.

Figure 20: The Control Box shows the camera views on the monitor.

The camera wires were attached to the Pneumatics PCB in the canister. From there, they were connected to a cat5e cable which brought the signals to the control box at the surface. The signal wires were attached to a video splitter which conditioned the signals and sent them through a BNC to VGA convertor. Finally, the camera views were displayed on a monitor.

Figure 21: Wyatt mounts the back camera.

The Galleon has four cameras placed strategically around the perimeter and inside the canister to provide all important views of the surroundings. Three cameras are placed in front. One of these cameras is placed directly above the left gripper facing forward. This camera gives the pilot a good view of the ROV's depth compared to different objects the grippers need to pick up. Another camera is mounted on a 10 cm stand on top of the ROV plate at the bow. This camera focuses on the grippers and gives the pilot a good view of both grippers and what they need to pick up. The third camera is placed inside the main canister. It faces forward and gives a wide angle view of what is in front of the ROV for steering. The fourth camera is located on the stern of the Galleon and is useful for orientation and can also be used as a front facing camera when the ROV is using its inversion switch.

Sensors

Figure 22: The A-232 Temperature Sensor

Temperature Sensor

DeepView Technologies was tasked with measuring the temperature of the fluid coming out of a hydrothermal vent. We designed a sensor that is flexible and effective based on a commercial A-232 thermistor which measures temperature in degrees Celsius. The temperature sensor was connected to the surface controls by means of its own tether, which allows us to pull it to the top after it has served its purpose.

In order to read the temperature, we used a voltage divider made up of a 33k resistor and the thermistor. There is a linear relationship between the voltage drop and the change in temperature. When the temperature is colder, the resistance of the thermistor is higher, while warmer temperatures have lower resistance. We used the Arduino map command, which uses ratios to calculate the temperature from the voltage drop. We calibrated the sensor by placing it into two buckets of water with known temperatures and inputting these values into the code as the base values. The Arduino in the control box displays the temperature in celsius on an LCD screen inside the control box.

The temperature sensor is attached to a 1” to 3” PVC reducer. When it is needed, the ROV grabs the 1” part of the PVC reducer and places the reducer with the 3” side down on the venting fluid. The reducer facilitates the task for the pilot, because the funnel like shape allows for a large margin of error when placing the temperature sensor over the venting fluid.

Pressure Sensor

As part of our mission, we have to determine the depth at specific locations with pressure measurements. To do this, we used the MS5837 ceramic pressure sensor from Measurement Specialties, Inc. It is very small, affordable and, most importantly, compatible with our software.

The team created a small PCB board to house the pressure sensor. Signal wires from the pressure sensor connected to the Pneumatics board and its ATMega328. We connected the sensor to an LCD screen in the control box which we programmed to show both the pressure and depth.

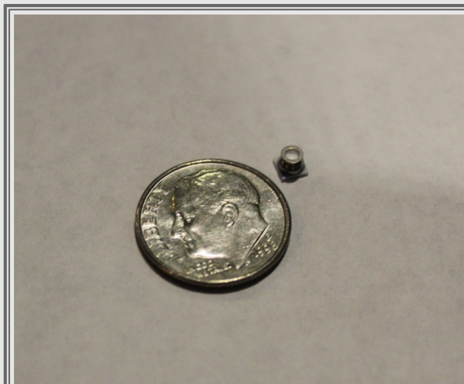


Figure 23: The Pressure Sensor next to a US dime.

The Pressure Sensor has to be open to the water on the sensor side while the other side with the solder connections must be sealed. Sealing is performed with a #4 o-ring. We milled a rectangle of clear acrylic containing a shallow, rectangular dip to hold the Pressure Sensor PCB. A small hole was drilled in the front so that the pressure sensor could stick through. Finally, the back was covered with epoxy to seal it against water.

Safety

At Deepview Technologies, safety is our number one priority. By following our safety checklist, which is in the appendix on page 23 we were able to avoid any serious injuries. Every new employee was trained in the proper use of power tools and learned safety rules to ensure that they would be well prepared to face any potentially dangerous situation. Whenever we use a power tool or other possibly harmful tool, such as a band saw, we wear eye protection and in some cases ear protection. Each team member is held accountable to the safety rules by the other team members. In preparation for emergencies, a licensed adult driver has to be present at every team meeting.

Figure 24: Jonathon wears Personal Protective Equipment while using the bandsaw.

The Galleon was designed to be as safe as possible for our operators and potential customers. A 40 amp fuse is located on the positive side of the power supply. The ROV does not have any protruding hooks or screws and the edges of our ROV are well rounded. All thrusters have shrouds and caution stickers, which minimize the risk to the environment and operators. Our pneumatic system is rated to 100 psi, but only operates at 40 psi, which allows for a big safety margin. Finally, the Galleon is slightly buoyant so that in case of a power failure it will float to the surface without having to be pulled.

Troubleshooting

Troubleshooting is crucial for the success of such a complex vehicle as the Galleon. Our troubleshooting procedures can be summarized as: **Isolate the problem**, **Implement a solution**, **Check the solution**, and if necessary **Repeat this process** until a good working solution is found.

Throughout the year, this troubleshooting technique has helped the team solve many problems. If the ROV stops working during a mission, the team begins by isolating the problem. First, we would check to see if the control box has power. If it does, we know the problem lies with the tether or ROV. If the control box does not have power, we would check connections and the power supply. If the problem occurred with the Galleon, we would carefully bring the ROV to the surface. Each of the PCBs has diagnostic LEDs that help with troubleshooting. For example, LEDs connected to the pneumatic pistons will switch on and off when the gripper button on the Xbox controller is pressed. If the pneumatic pistons were not working, but the LEDs were, we would know that either the solenoids or the pneumatic pistons were not working. The propulsion PCB also has diagnostic LEDs.

Figure 25: Carter and Tirza troubleshoot the ROV in between practice missions.

A specific example of how we implemented our troubleshooting technique was with our end cap that seals the main canister, which holds the electronic components. In our initial tests, we found small amounts of water in the canister. The first step was to isolate the problem. We found the leakage was coming through the endcap. Next, the team replaced the o-ring and regreased it to see if this would solve the problem. The canister and end cap were again placed in the water. However, there was still water leakage. The problem was investigated further to distinguish between the o-ring and the glands feeding the electrical wires and the pneumatic tubing into the canister. The canister cap was lowered vertically into the water by about 1 cm. This ensured that the glands were below the water surface, while the o-ring was not. We found that water continued to leak into the system and therefore knew that the problem had to do with the feed-through glands. We added another layer of epoxy to the inside of the end cap where the glands are located. Upon further testing no water leakage was found.

Challenges

Technical

This year we contracted Astronaut Studios, Inc. to CNC mill our endcap. However, the work was not up to our standards. When it was delivered two weeks behind schedule we didn't have the time or resources to make a new endcap since we had to produce the qualifying video. Consequently, we had to modify the endcap to make it work. Fortunately, we were able to remill the endcap. In order to get back on track with our time plan, we scheduled more frequent team meetings at the shop in order to finish and troubleshoot our ROV. This allowed us to complete the qualifying video by the deadline.

Non-technical

This year we had a lot of turn-over in the team. Two seniors aged out of last year's team while two of our juniors left to pursue other interests. We were fortunate to hire four new team members two of whom had just completed the Junior Varsity Robotics program (Jimmy and Ethan) while the two other junior members (Wyatt and Jonny) had to learn everything on the job. They were quick to pick up our technology and develop their skills and complemented the rest of the team well. Due to these changes in team make-up we decided to work primarily with the solutions and the technology that had been developed by our team during last year's competition and focus on bringing the new team members up to speed rather than embarking on completely new technologies.

Another issue was that many of the DeepView Technologies employees had different schedules because they attended different schools, which reduced the times we could meet as a whole team. For example, spring break took place during three different weeks for different members of the team. Not having all hands on deck at all work sessions complicated design and building discussions. We solved this issue by adapting our robotics schedule to maximize overlap considering everyone's schedule and by arranging more frequent meetings and additional weekend sessions.

Lessons Learned

Technical

During the past year, DeepView Technologies faced problems with its thrusters. In previous years, the team had placed some of the thrusters in parallel, connecting them to the same H-bridge. In this situation, one of the thrusters could pull more current, work harder and potentially fail. This happened to us during one of our tests and alerted us to the problem. After redesigning our propulsion board and assigning individual H-bridges to each thruster, the thrusters worked again normally. From this experience we learned that one has to critically review solutions that may have worked in the past.

Interpersonal

Throughout the 2016 year, many new members joined DeepView Technologies. We learned how to work together and manage many tasks. The senior members taught junior members how to be productive employees. New tasks were created not just to fit each and every one's personal involvement, but to create a helpful and effective work environment. After months of working together, the new faces became our friends and true partners in the ultimate goal to design, build, and test our ROV.

Teamwork

This year four new team members joined DeepView Technologies. The older members worked side by side with the new members, mentoring them and monitoring their designs and creations. Carter, our CEO and an experienced member, oversaw the design and construction of the tools we would need for the ROV. He was also in charge of making sure the ROV was assembled on time. He mentored Jonathon who designed and created the grippers. Will, another experienced member was in charge of the frame and other mechanical designs. He mentored and helped Jimmy design the frame in Solidworks. Oscar was in charge of the end cap and canister. Finally, Tirza was in charge of the software and electronics that made the ROV work. She taught Wyatt how to design and create PCBs.

Figure 26: Tirza teaches Wyatt how to design PCBs.

She also advised Ethan and Jimmy, our new programmers, on the software logic so that the electronics and software would be compatible.

Our mentor, Dr. Alexander Angerhofer, was not always able to be at our meetings, because of his work as a faculty member at the University of Florida. When he attended meetings, he offered advice when we needed it and corrected some of our mistakes. However, the ROV we built was our team's effort. We relied mostly on our own research, ingenuity, and communication to design and build an ROV that would complete the missions it was tasked with.

Future Improvements

Figure 27: Waterproof Circular Connector Cable from H.S.P. Connector Co., LTD

At DeepView Technologies, we always strive to further improve our ROV systems and facilitate its use for our operators and clients. We want our clients to be able to setup and run our ROVs with ease. Next year, we hope to design and create a detachable tether which would facilitate storage and transportation of the ROV, because the tether and ROV could be transported separately. For this purpose we would have to modify our endcap so that it can hold detachable waterproof connectors. Figure 27 shows a waterproof circular connector cable from H.S.P. Connector Co., LTD. Because this connector can connect 18 wires, it can replace our cat5e cables. A detachable tether would facilitate both storage and transportation for our ROVs.

Reflections

This year, DeepView Technologies participates again at the explorer level but also received four new team members. This created quite a few challenges. Although the year has been riddled with adversity we succeeded with hard work, dedication, and perseverance. The new team members brought in new ideas that we didn't think about before. It also allowed the senior members to step into new leadership roles. This year was one of growth and offered each member there own share of experiences and expansion in knowledge.

Figure 28: The team holds a planning meeting while enjoying refreshments.

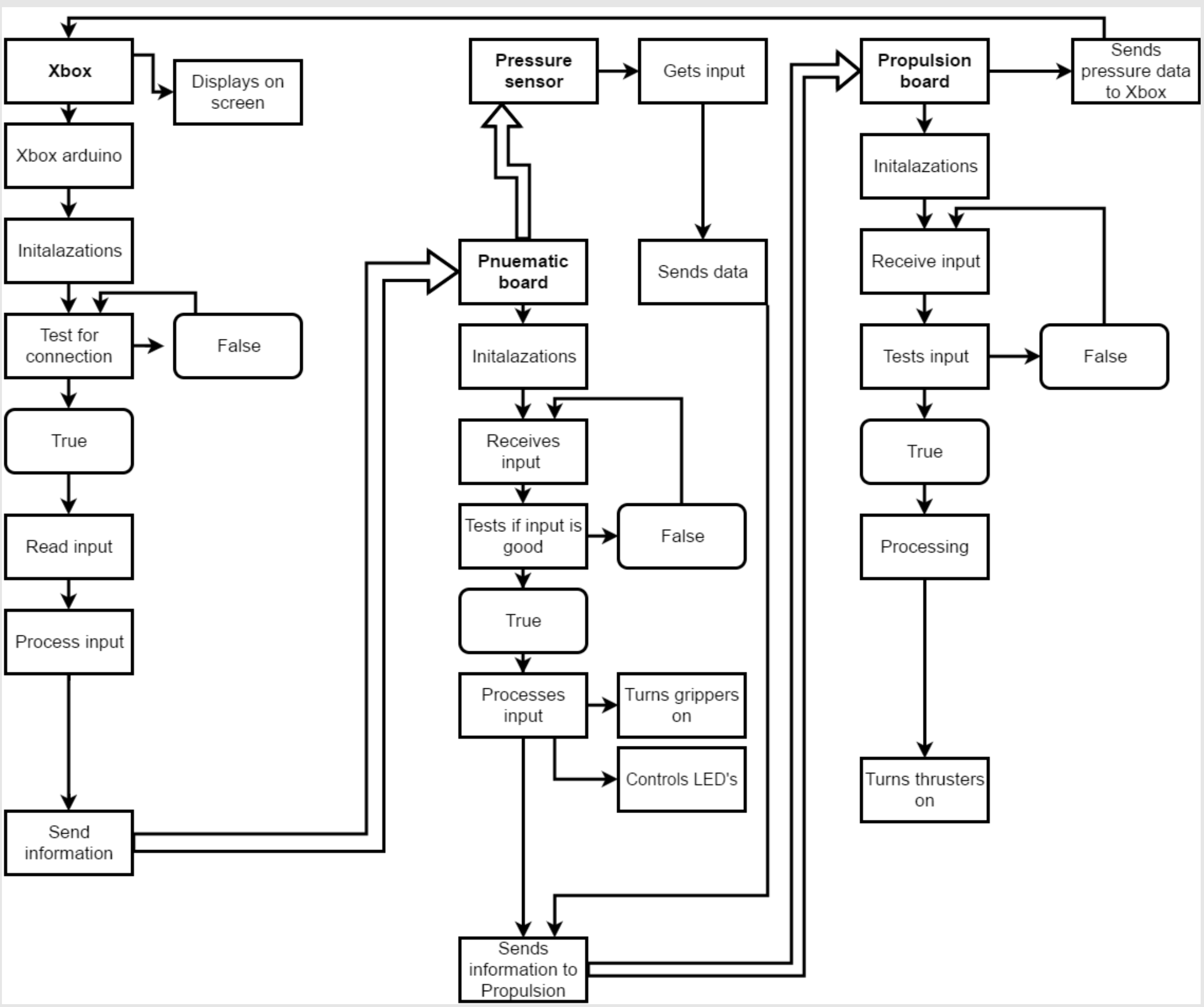
Project Management

Before the mission manual was released, DeepView Technologies members researched new and innovative technologies they could contribute to our ROV. After the mission manual was released, Carter Wyatt, our CEO, led a team meeting. Here, we decided the tasks and jobs each employee would complete. See our schedule on page 18 to see the deadlines we established for each task. Our team met every Monday and Thursday afternoon. As the regional competition came close, we also added Saturdays to our schedule.

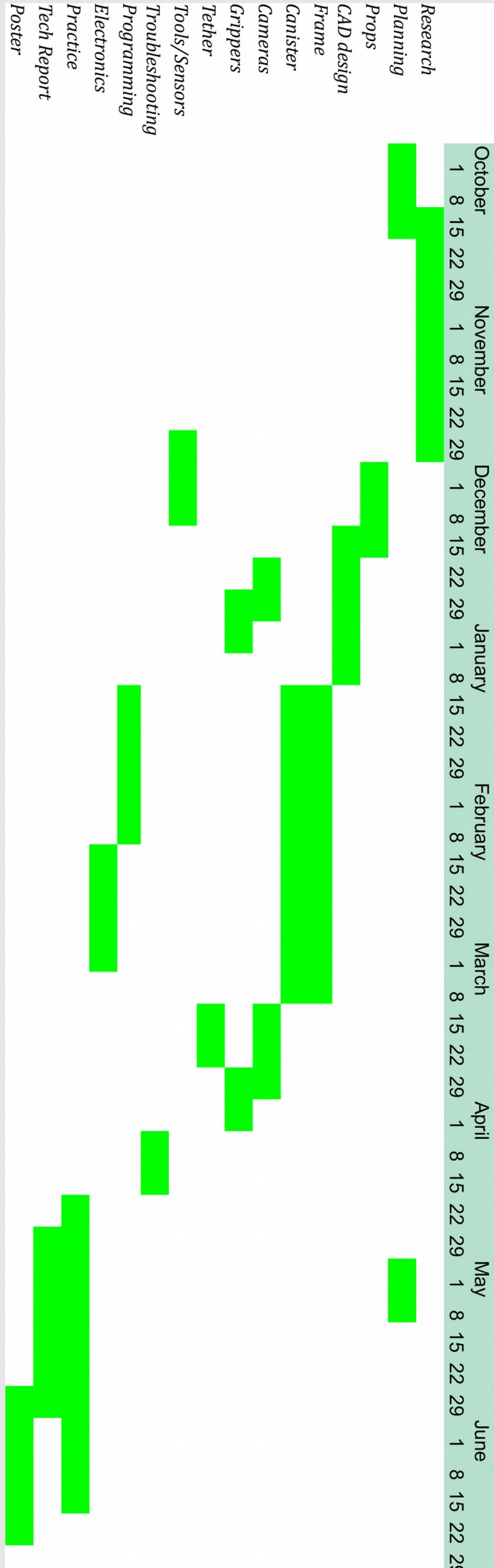
Throughout the year we had regular meetings where we would discuss how far we had come, how far we needed to go, resources we needed, and ROV designs and creations. These meetings helped us to stay focused and on task as well as giving us an understanding of all the different parts of the Galleon. These meetings helped motivate us and improved our communication.

Our hierarchy of employees, based on each member's experience, allowed the designing and building process to go smoothly. The more experienced members advised and encouraged the junior members to complete their respective assignments. When the junior members had questions they would approach the experienced members who would help them think through their problems and come up with their own solution. This method made our team more cohesive and allowed us to stay focused on our goals.

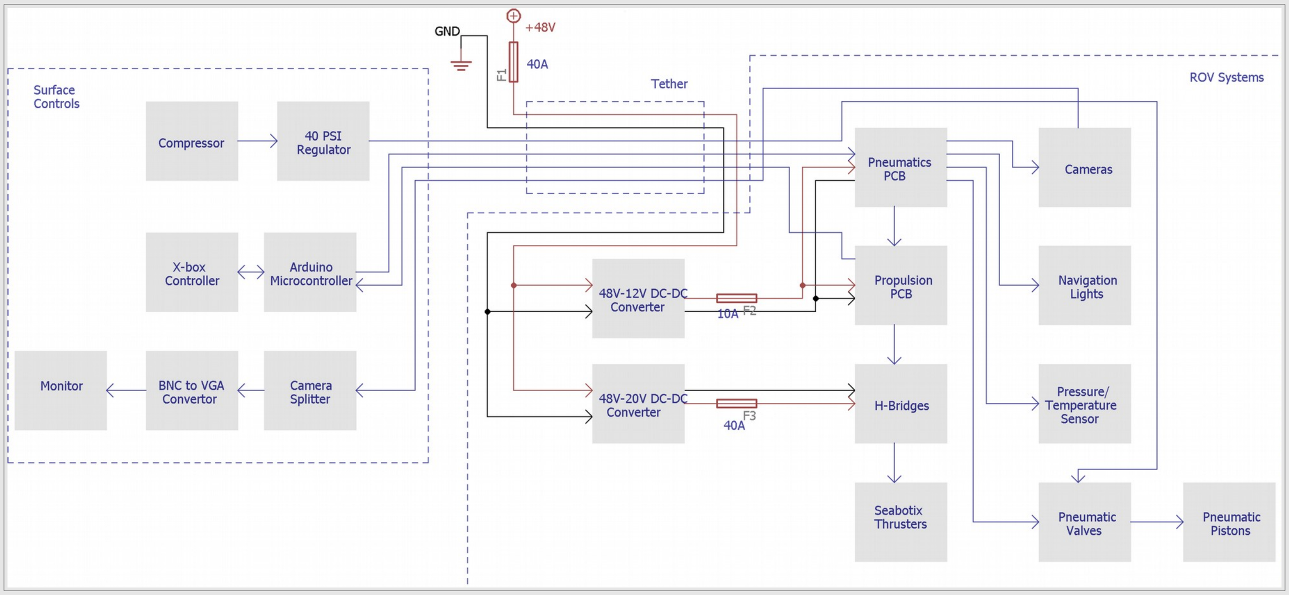
Software Flow Chart



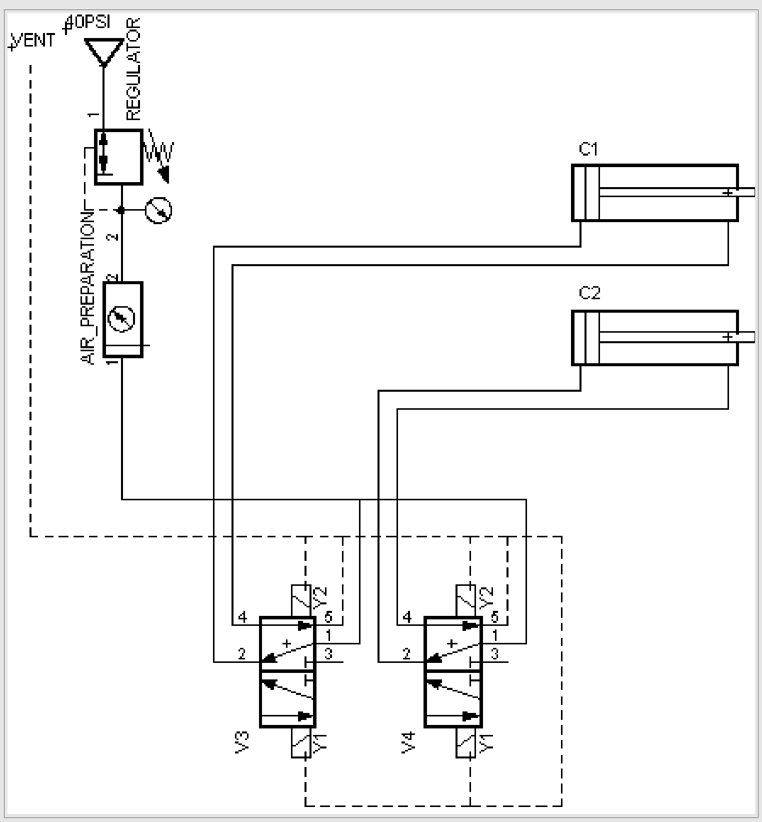
Schedule


Research
Planning
Props
CAD design
Frame
Canister
Cameras
Grippers
Tether
Tools/Sensors
Troubleshooting
Programming
Electronics
Practice
Tech Report
Poster
October
November
December
January
February
March
April
May
June

System Interconnection Diagram



Pneumatics System Interconnection Diagram



Finances

Budget

This year we had a budget of $4,000.- for the Galleon in order to make it affordable yet be able to utilize our advanced technologies. This meant that each of the eight team member's families had to contribute $500.- to the project. Some of the individual families' contributions were donated by the Pamphalon Foundation and by Infinite Energy, Inc., for which we are grateful. Travel costs are not included in this budget because team members are responsible for getting to Houston on their own and will pay for it themselves. We were able to reuse some of the more expensive items from last year thereby staying within our projected budget for the Galleon. To date we spent $3972.07 leaving us with a surplus of $27.93. However, there will be additional costs before and during the competition that will be distributed equally over the participating families.

Project Costs

Description	Source	Acquisition	Cost ($)
Props			
spray paint cans		reused	14.00
misc materials	Home Depot	purchased	114.58
Electronics			
power supply	Amazon	reused	454.44
4x H-Bridges	Pololu Corporation	reused	177.25
48 V to 20 V and 12 V converters	Vicor Corporation	reused	1109.00
Micro lugmate converter kit	Vicor Corporation	donated	57.29
raspberry pi/ accessories	Newark/element14	purchased	118.19
beaglebone black/ beaglebone book	Amazon	purchased	124.43
adapter for beaglebone	Amazon	purchased	33.69
conductive epoxy	Amazon	purchased	59.03
watch battery, pack of 3	Amazon	purchased	4.27
pressure/temperature sensor	Digikey	purchased	56.66
camera/ micro SDXC card	Amazon	purchased	60.18
H.264 170 degree fisheye lens camera	AliExpress	purchased	40.05
anderson connectors	Allied Electronics	purchased	77.09
terminal block connector	Digikey	purchased	37.82
3x copper boards, box of inkjet film	Amazon	purchased	83.73
4x H-Bridges	Pololu	purchased	177.25
LEDs, pack of 10	ebay	purchased	34.16
transparency film	Amazon	purchased	14.89
resistors/ PCB headers	Amazon	purchased	21.00
8 gauge heat shrink terminals	Amazon	purchased	12.58
1x pressure sensor, 10x Atmega328 chips	Digikey	purchased	87.91

ROV Materials			
8x Teledyne-Seabotix BTD-150 thruster	SeaBotix	reused	5600.00
4x camera	Dx.com	reused	59.96
2x Teledyne-Seabotix BTD-150 thruster	Teledyne-Seabotix	purchased	1398.99
acrylic sheet and nycast tube	US plastic corp	purchased	93.50
acrylic tubing	US plastic corp	purchased	67.74
fish eye camera	AliExpress	purchased	40.05
4x video cables/ 2x camera mount	Amazon	purchased	67.94
UHMWP sheets	McMaster Carr	purchased	220.22
polyethylene tubing	Lowes	purchased	16.52
O-rings	Amazon	purchased	29.45
O-rings/ xbox controller	Amazon	purchased	46.55
100' nylon tubing	AutomationDirect	purchased	23.50
epoxy/ other sundries	Lowes	purchased	40.80
PVC Blocks for end cap	USPlastics	purchased	208.99
2x PVC reducer fittings	PVC Fittings Online	purchased	24.73
Acrylic tube 7.5" OD	EPlastics	purchased	94.48
Misc			
caulk backer rod/ screws	Home Depot	purchased	17.26
end cap mill job	Astronauts Studios	purchased	100.70
registration/pneumatics test	MATE Center	purchased	260.00
left fence for saw	ereplacementparts.com	purchased	38.38
IPS Weld on acrylic	Amazon	purchased	24.76
Total		reused	7414.65
		donated	57.29
		purchased	3972.07
		total	11444.01

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3. MATE Center, Underwater Robotics Science, Design & Fabrication, <http://www.materover.org/main/.>

4. Monk, Simon. Programming Arduino: Getting Started with Sketches. New York: Mc-Graw Hill, 2012. Print.

6. Xbox library for Arduino, January 15, 2014,

<https://github.com/felis/USB_Host_shield_2.0/blob/master/XBOXUSB.cpp>

Acknowledgments

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- Seabotix
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- Vicor Corporations
- Fabco-Air, Inc.
- Parents of team members
- Pamphalon Foundation
- Infinite Energy, Inc.
- MATE

Local Team Supporters:

- Alex Angerhofer - Team mentor and Instructor
- Jeffery and Kimberly Knack (use of shop)
- The Administration of Cornerstone Academy
- Jeff and Emily Savage (use of pool)
- all Team Parents (time and financial support)

Appendix A

Safety Checklist

Company

• Always wear personal protective equipment when working with the ROV

• Long hair must be tied back

• Wear correct safety apparel including long pants, closed toed shoes, and safety goggles when on deck

• No loose clothing

Physical

• The ROV has no sharp edges or exposed harmful materials

• All items are connected securely to the ROV and will not fall off

• All connections have strain relief

• Caution stickers are placed on any possible hazard (thrusters, grippers, etc.)

• Every propeller contains its own shroud to protect wildlife and pool managers

• Tether is properly secured at surface and in ROV

• The ROV must be carried by at least two people when moved

Electrical

• 25 amp fuse on the positive side of the main power source

• All electrical wires and parts are kept away from water

• All wiring and electrical parts are properly sealed

• All electrical components are enclosed in a box at the surface

• Check all connections before turning on power

• Make sure the compressor's pneumatic pressure is lower than 40 psi before turning on