INNOV|OCEAN

Innovation in Marine Technology

Oceanus I

InnovOCEAN Employees

Vehicle: **Oceanus I**

Carrollton High School

Carrollton, Georgia

2011 – 2012 Technical Report

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Abstract

We, InnovOCEAN, are a maritime company dedicated to customer satisfaction and exceptional quality in underwater excavation and exploration. Our skilled group of employees is proficient in marine engineering, software programming, and design innovation. The discoveries and consequent issues during observation of underwater shipwrecks prove that technology capable of surveying and analyzing the wrecks is essential. We have designed and constructed a vehicle to examine the SS Gardner. Our vehicle, **Oceanus I**, named for the Latin word meaning "Ocean", will survey various aspects of the wreck (including its orientation, length, and some of the surrounding debris piles), use sonar to create a momentary "snapshot" of the wreck, remove a sample of fuel, and transplant endangered coral species. The principal features of **Oceanus I** are its size, speed, and maneuverability, all of which allow us to complete the tasks in the most efficient way possible. Our manipulator assists in completing the majority of the mission tasks; our SeaBotix thrusters allow the vehicle to move through the water rapidly. **Oceanus I** features four cameras placed in specific positions for optimum vision of the ocean floor. Our vehicle utilizes an array of payload tools used to complete the analysis of the shipwreck. We developed two innovative research devices, one that retrieves the oil sample using a rod with small holes along its base and another that employs magnets to identify debris piles at the wreck site. At InnovOCEAN, we are committed to providing a vehicle that will deliver expert products in marine technology.

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Company Profile

InnovOCEAN staff pride themselves on efficiency and quality in all products and relations. This was the key factor in hiring employees as well as determining which person best fit each required job. The process began with each applicant submitting a lengthy and detailed application listing previous technical knowledge, strengths, weaknesses, and schedules. This allowed the company CEO, Carter Smith, and mentor, Jeremy Huff, to determine which individuals were the most qualified for our team. Once the application process was complete, six experienced employees (who have participated in MATE competitions for at least two years) were appointed to the InnovOCEAN Board. This group's main goal was to select appropriate tasks for each employee and to design the corporate infrastructure. To better organize employee tasks, the board created a company "tree" to illustrate the task divisions and groupings. Though InnovOCEAN is comprised of two main divisions, the company has two weekly meetings where both divisions meet together to develop new products and ideas, keeping all employees involved in every aspect of the design and research processes. At the onset of the project, InnovOCEAN employees decided upon the company's main goals for **Oceanus I**:

- Reduce vehicle weight and size
- Increase maneuverability and pilot control
- Develop simple yet effective payloads for mission tasks

The Design Cycle

An important goal of InnovOCEAN is following a specific design process throughout vehicle construction and creation of marketing techniques. We have striven to ensure that every component of **Oceanus I** has been intricately designed and tested to optimum perfection. To accomplish this, we created a design cycle that outlines all steps in the creation of our components. We first **explore** possible ideas and designs and **prototype** one or two of them. If the prototype is successful we **build** a full scale version and **confirm** its effectiveness. Once effectiveness is confirmed, we **distribute** the product to suppliers.

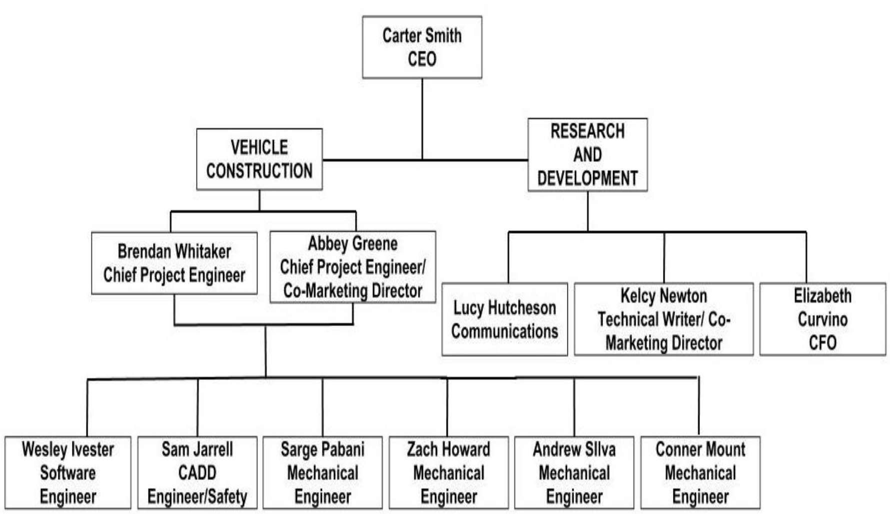


Figure 1: InnovOCEAN Company "Tree"

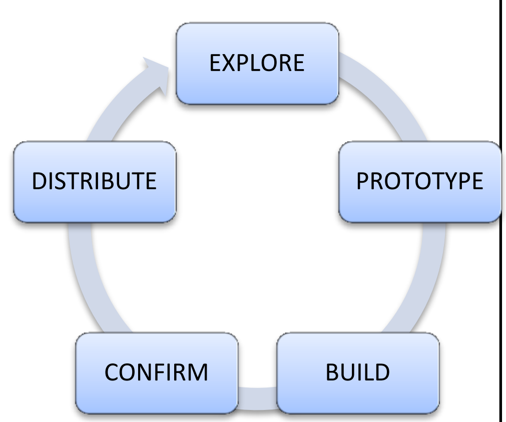


Figure 2: The Design Cycle

Safety

At InnovOCEAN, safety is of the utmost importance and is held to the highest of standards by all employees. Sam Jarrell is InnovOCEAN's safety coordinator and inspector. He ensures that all safety precautions are being followed during construction of InnovOCEAN products. To guarantee all safety rules and precautions are followed by every employee, we have created a safety checklist with reminders and guidelines that is placed in all work stations.

Apparatus

- Are you experienced with the machine?
- Has it been previously inspected for damage?

Personal

- Gloves (If Necessary)
- Ear Plugs
- Safety Glasses
- Close Toed Shoes
- Long Hair Tied Back
- No Baggy Clothes!
- No jewelry (watches, rings, bracelets, etc.)

Following these procedures guarantees that all InnovOCEAN products are delivered not only with quality and efficiency, but safely as well. Safety precautions have been built into **Oceanus I** as well, including safety partitions on all thrusters to protect employee limbs and marine life and rounded edges on the frame to avoid cuts and injuries to employees when handling the vehicle. We have also taken safety precautions in aspects not specifically on **Oceanus I**. These include a 25 amp fuse on the positive lead from the battery and a tether wrapped in abrasion resistant material to prevent fraying and possible electrical failures. Since our control system is our most advanced and valuable component, a great deal of care is taken in protecting it as well. All connections on the surface as well as on the vehicle are wrapped in electrical tape and shrink wrap.

Design Rationale

InnovOCEAN's top vehicle, **Oceanus I**, performs its most basic functions using six main systems: Frame, Thrusters, Manipulator, Ballasts, Cameras, and Software.

Frame

The primary objectives in the design of **Oceanus I** were to decrease mass while increasing speed and maneuverability. In order to achieve these goals, we focused on enhancing three main aspects of the frame: materials, size, and shape.

Materials

Previous models of **Oceanus I** have featured various construction materials ranging from PVC pipe to aluminum. However, in the past, we have found these materials have several disadvantages. PVC, while light and versatile, does not allow structural integrity and sophistication like sheeted metals or plastics; aluminum, while sturdy, is not nearly as versatile and bears significant weight. After experiencing firsthand the advantages and disadvantages of both materials, we decided to look further into sheeted plastics. The research and design branch of InnovOCEAN immediately began researching which plastics would best suit the needs of our vehicle. Extensive research lead us to ⅛ inch Lexan polycarbonate, which we found to be cost efficient, light, versatile, and sturdy. To confirm that the polycarbonate was going to be structurally stable and sturdy enough to support the weight of our ROV, we used a materials buster to calculate just how much force the Lexan could take. Satisfied with our results, we began formulating ideas for a way to further reduce weight of our vehicle while increasing stability. From this think tank came one of our most innovative solutions: to increase our buoyancy while also securing our frame, we constructed our frame in four layers. The two outer layers are pieces of Lexan polycarbonate. Sandwiched between these two sheets are identical pieces of 3/16" Minicell foam. This foam is very buoyant in water, which reduces our need for large ballasts, therefore making **Oceanus I** even more hydrodynamic. All elements of the frame were designed using Inventor and cut out by our engineers using a router.

Figure 3: Router Program used to cut frame

These pieces were used for the two side panels of the vehicle frame. The mounting base is constructed of a rectangular piece of expanded aluminum. It is light, hydrodynamic, and versatile. Its versatility allows us to make easy changes in the mounting placement of various payloads, thrusters, and cameras.

Size

Another major modification we wished to make was decreasing the overall size of the frame. This process came to fruition through the construction of three prototyped frames, all made of wood. Prototyping the frame allowed us to make quick changes before creating a final model.

Figure 4: All Frame Prototypes

This is an effective way to be sure that the final frame is exactly how we envisioned and planned it. This new frame is also significantly smaller than previous designs. The new dimensions are 45.72 cm (L) by 33.02 cm (W) by 27.94 cm (H), a 57% percent decrease in volume from previous models.

Shape

Each side panel features four rounded openings that permit water to pass through the frame horizontally. Initially, the frame featured three triangle cutouts and two rounded cutouts, but the addition of a strafing thruster called for a larger opening to not obstruct its water flow. The structure is essentially a rectangular prism but features a slightly tapered front, which enables the ROV to be more hydrodynamic and the cameras mounted on top of the vehicle to have enhanced vision of the sea floor.

Propulsion

The ability to move rapidly through the water is essential to underwater excavation and was

Figure 5: SeaBotix Thrusters

therefore made a priority when placing the thrusters. **Oceanus I** houses five SeaBotix thrusters, each drawing 4 amps of power and providing 28.4 N of thrust. Our thrusters are positively buoyant (-413 grams in water) and include safety partitions to protect both InnovOCEAN employees as well as marine life. Two thrusters are used for lateral movement and are secured to the posterior of the ROV, with the propeller facing the back. Two other thrusters are used for vertical movement and are mounted onto the aluminum base plate. To minimize drag, the vertical thrusters are mounted flush with the expanded metal base panel of the ROV. To further enhance our maneuverability, we have also incorporated a strafing thruster into our propulsion system. It allows for fine adjustments in the water that would not be possible with a traditional parallel thruster orientation. Our strafing thruster is mounted to a Lexan cross bar on the top of **Oceanus I**. This placement allows maximum water flow through the side panels as well as conservation of space on our base plate. This motor configuration is not only efficient but is more organized as well.

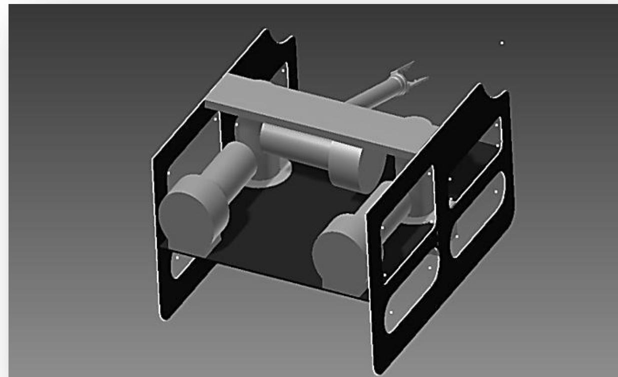


Figure 6: Inventor drawing of Motor Configuration: Rear View

Another aspect of our propulsion system that will be further discussed in Programming/Control System (page 7-10) is variable speed. In previous iterations of our ROV designs, we used a manual system that constricted our thrusters to only three actions: full speed forward, full speed backward, and static. However, with motor controllers, we are now capable of specifying the speed of our thrusters which allows for more precision in the movement of the vehicle.

Manipulator

Arguably the most important aspect of an ROV used in marine exploration is its ability to manipulate its environment--collect samples, remove damaged materials from the workspace, and make additional installations. At InnovOCEAN, we realize the importance of this tool and have invested in a powerful manipulator capable of performing a wide variety of jobs and ensuring maximum quality performance.

Figure 7: SeaBotix Manipulator

The device measures 36 cm in length, has 200 kg of gripping force, a lifting capacity of 100 kg, and weighs 235 g in water. The manipulator is three-pronged, fixed, and measures 60 mm when the jaw is fully opened. The prongs are attached to an axle measuring 50 mm in diameter. The manipulator draws a maximum current of four amps and runs off twelve volts of power. It is extremely durable and has been used on previous iterations of **Oceanus I**. It is mounted on the front of the vehicle at an angle that allows maximum extension while not protruding from the base of frame.

Ballasts

During our design process, we realized that we could reduce the size of the ballast tanks needed to maintain neutral buoyancy by incorporating extra buoyant forces into other parts of the vehicle. Doing so, we manufactured an innovative solution that incorporated Minicell foam sheets into the layering of our frame. The foam is thin, lightweight, and positively buoyant, providing not only stability to our frame but increasing vehicle buoyancy as well. **Oceanus I** features a passive ballast system comprised of a singular tank made of polyurethane foam. The tank was constructed by pouring two part foam into a mold and then shaving down the foam to the desired shape. The foam is closed cell, meaning that all air pockets inside the foam are separate. Should water fill one air pocket, it will not spread to any others, allowing the ROV to remain neutrally buoyant. The tank has been coated in Plastidip as an extra precaution.

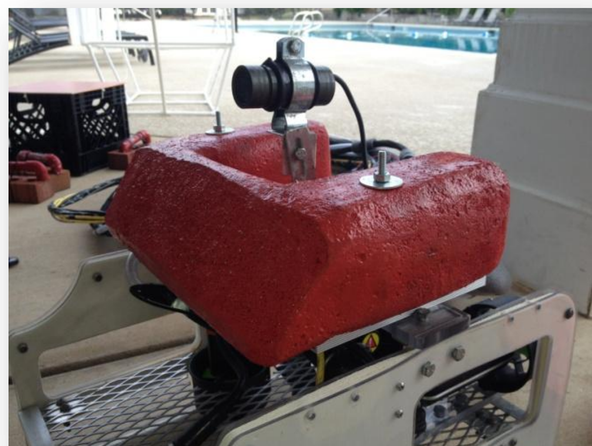


Figure 8: Foam Ballast Tank

Cameras

When discussing possible camera placements, one team member suggested using a pan and tilt camera system, which would allow a single camera to be used to view multiple payload tools. Brendan Whitaker, one of our Chief Project Engineers, created a prototype of this system using VEX parts. The system worked fairly well, but after further company discussion it was decided that having a camera controlled by a motor would just be one more electrical component to control. We decided it would be more feasible to have several cameras placed in specific positions on the vehicle to provide optimum view of the payload tools.

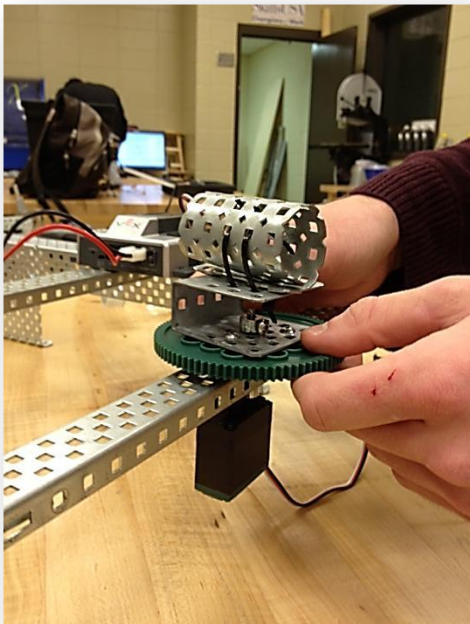


Figure 9: CPE Brendan Whitaker modeling his prototype for the pan and tilt camera

Once we decided to employ multiple cameras, we faced the decision of where we would place them. With so many basic systems as well as various payload tools, camera placement has proved to be a key factor in mission efficiency. Oceanus I features a total of four underwater cameras. All cameras were purchased from Lights, Camera, Action. Cameras 1 and 2 are Blu-Vue models and Cameras 3 and 4 are earlier Lights, Camera, Action models. Camera 1 is used to give the pilot a bird's eye view for precision and accuracy when steering. Camera 1 folds down when not in use to prevent damage to our most important viewing device. Camera 2 provides vision of the manipulator, which is our most utilized component, the simulated sonar sensor and the magnetic sensor. Camera 3 is mounted underneath the expanded metal baseplate and permits the pilot to view the measuring device

Figure 10: Camera 1 (Blu-Vue Camera)

Camera 4 delivers a view of the saline extraction rod on the back of the vehicle. All four cameras feature six white Light Emitting Diode (LED) lights to provide clear vision in the water.

Control System

This model of **Oceanus I** not only features improved materials and design, but a more

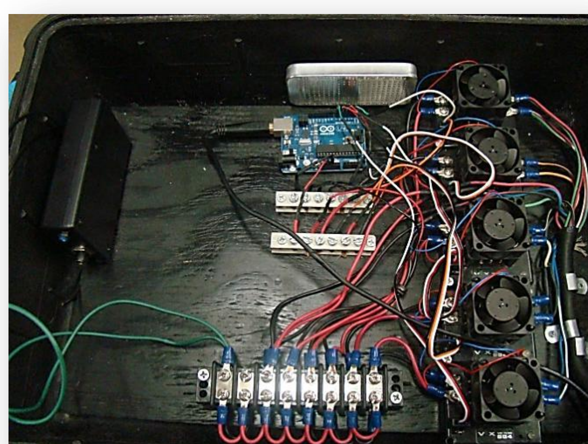


Figure 11: Control System

sophisticated control system as well. In previous control systems, we used hardware-based systems that involved no programming or software in their design. However, as our technology has developed, we at InnovOCEAN have realized that in order to fully take advantage of hardware capabilities, we must accommodate for a more advanced control system. Our primary objective was to be able to utilize variable speed, preferably through use of an Xbox controller. The setup of an Xbox controller seemed optimal for our needs because it houses two joysticks as well as plenty of buttons and triggers that we could use for payload tools. Meanwhile, several engineers at InnovOCEAN had been experimenting with an Arduino Uno microcontroller for their own side projects. When discussing potential ideas for integrating an Xbox controller with our system, we decided that the best method would be to look into using the Arduino programming platform.

Figure 12: Arduino Microcontroller

Two employees at InnovOCEAN already had their own Arduinos, and one more was purchased for a prospective software engineer. To make sure that each person was familiar with the hardware and its many functions, one of our executive engineers created an Arduino Challenge Program-- a list of projects to be completed before moving on to vehicle applications. After each person felt that they had sufficient experience with the Arduino hardware and programming platform, a select group of software engineers began meeting to develop a way to integrate the Arduino into our vehicle's control system. The first challenge was getting input from the Xbox controller. After extensive research and testing, we discovered this was most proficiently done through XBCD, an Xbox controller driver, and the Python programming platform. Our Python code is capable of receiving input from the Xbox controller through XBCD, converting it into PWM (pulse width modulation) values, and then sending them to the Arduino microcontroller.

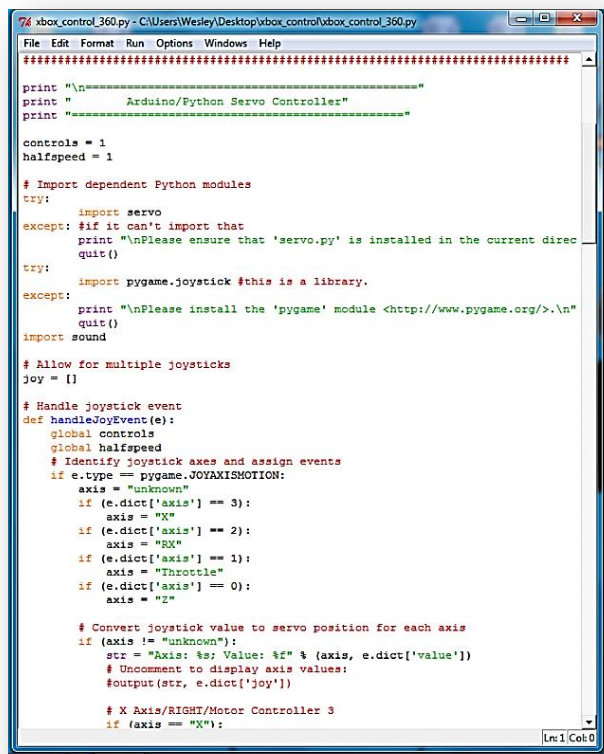


Figure 13: Python Programming Platform

Another challenge that we faced while designing our control system was purchasing motor controllers that could convert PWM values from the Arduino to voltage for our thrusters, giving us the capability of variable speed. Because the motor controllers would be a crucial aspect of our system and they can be very expensive, we wanted to make sure that we were investing in the most reliable,

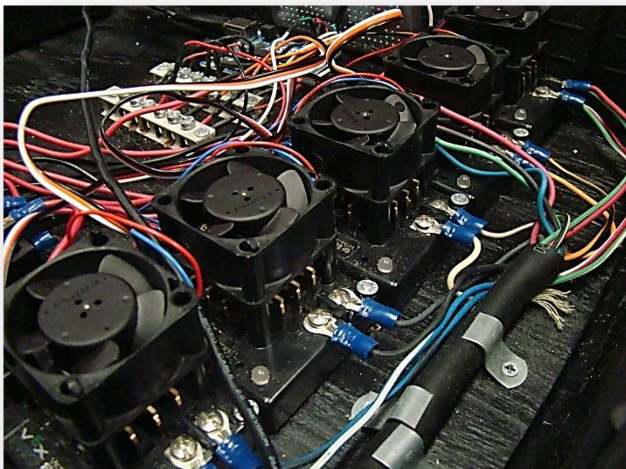


Figure 14: VEX Victor Motor Controllers

high quality products for our purpose. After thorough investigation into several brands and models of motor controllers, we decided to use VEX Victor Speed Controllers. We chose these because of their concise, clear schematics, and several engineers at our company had previous experience working with VEX parts and found them to be very high quality.

Special Features of the Software

Using the Arduino and the Python programming platform has provided many advantages over the traditional hardware previously used, and InnovOCEAN pilots have fully utilized these advantages within our control system. One such advantage is the ability of the vehicle to maneuver at half speed. Essentially, the PWM value is cut in half to allow the vehicle to move half as fast as it normally would while still maintaining the normal controls (Pressing full forward or backward) on the Xbox controller. The most important advantage of half speed is that it enables the pilot to make more precise movements during shipwreck excavation,

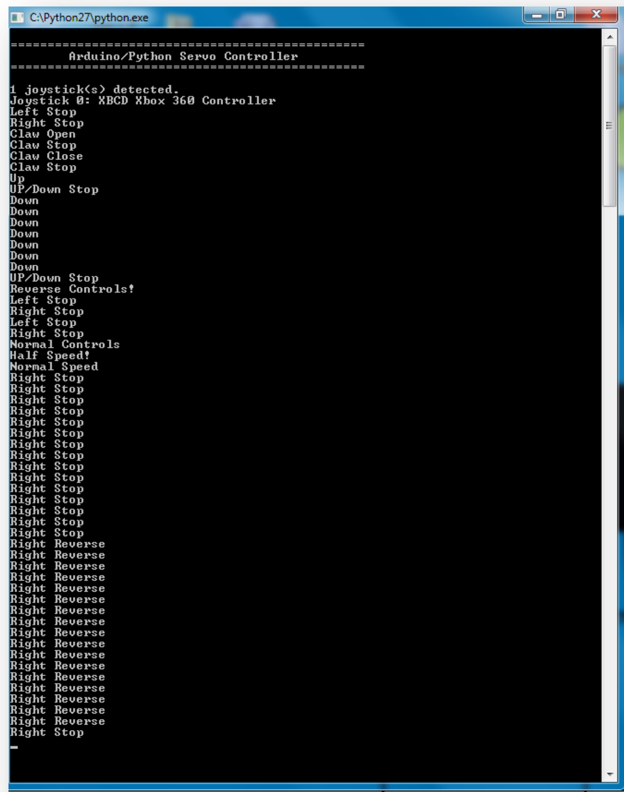


Figure 15: Program screen that shows the pilot the signals the python code is receiving from the Xbox controller

enhancing our reliability to our customers. Another modification we made to the original software is the creation of reverse controls. This allows the pilot to use the rear facing cameras (meaning the ROV is moving in reverse) but use normal forward and reverse motions on the Xbox controller. With several different control settings, it often became confusing to identify which mode the vehicle was in. Chief software Engineer Wesley Ivester created an innovative solution that uses voice commands to identify which mode the vehicle is presently in. Pre-recorded voices indicate which mode the vehicle is in when the appropriate button is pressed. When the button for half speed is pressed, a voice comes through the computer monitor saying, “Half Speed”. The same occurs for “Full Speed Ahead” and “Reverse Controls”. The voice commands allow the pilot to quickly and accurately move from one mode to another without delay or confusion.

Additional Aspects of the Control System

Another important aspect of our control system is the four terminals, two of which are positive and two of which are negative. These are essential to the controls because they allow power from the battery to be easily organized and distributed to all components. One pair of terminals carries and distributes twelve volts of power from the battery to all components. The other terminals distribute five volts from the Ardunio microcontroller to the VEX motor controllers.

Oceanus I features a 24 lead tether covered in abrasion resistant wrapping. All vehicle components (Thrusters, cameras, etc.) lead to soldered connections at the tether. The tether joins the control system at the motor controller ports. In order to protect our control system, including our new investments, we were determined to keep our housing unit both protected and organized. We purchased a Pelican waterproof box to house our control system (motor controllers, terminals, and Arduino microcontroller) as well our on board hydrophone sensor.

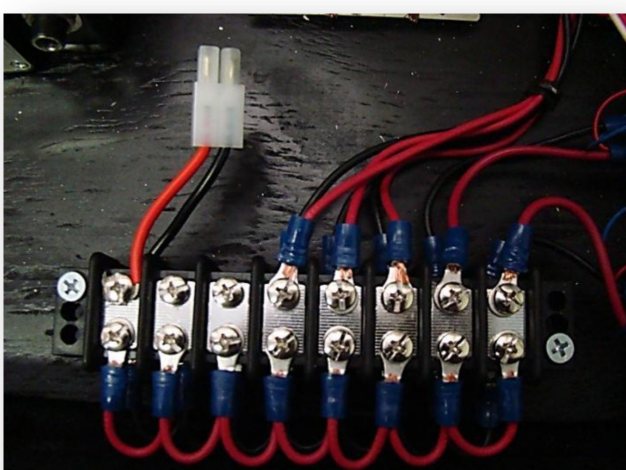


Figure 16: Terminals

Electrical Schematic

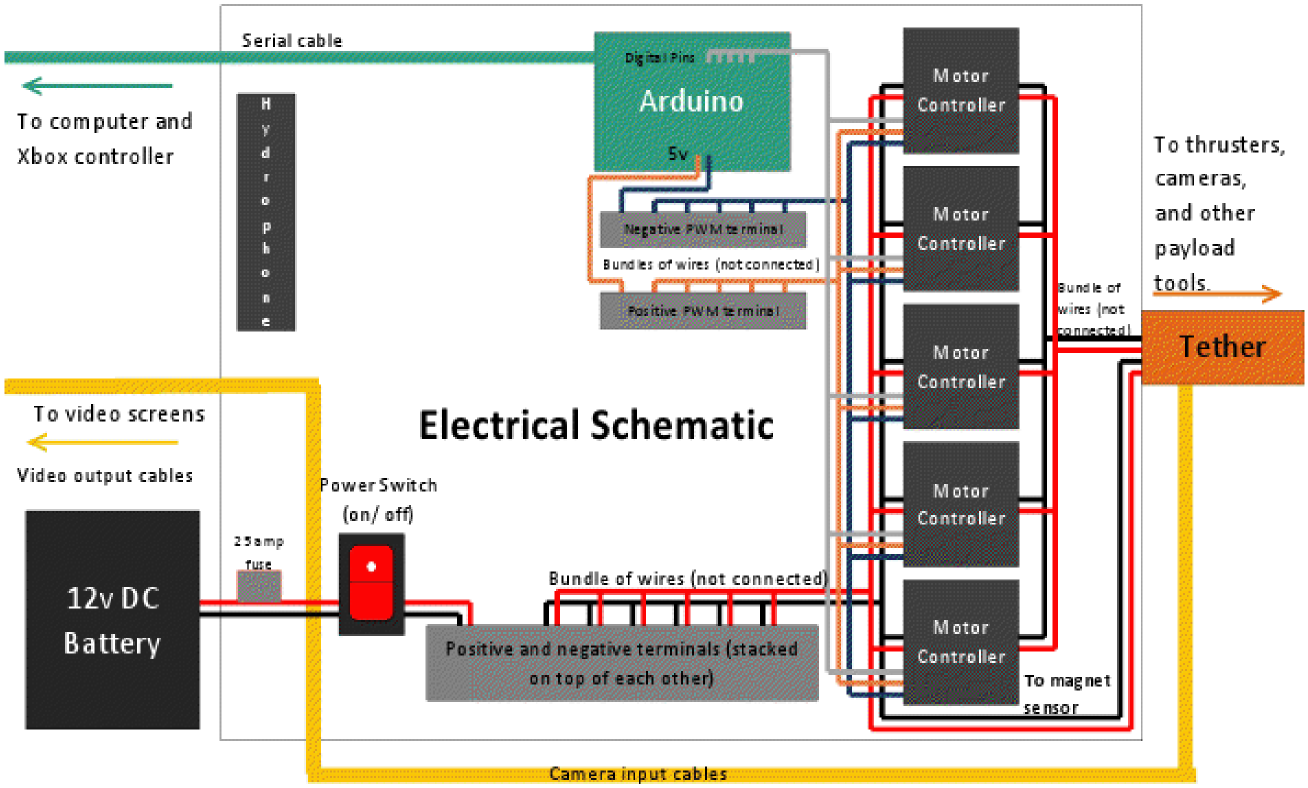


Figure 17: Electrical Schematic

Control Block Diagram

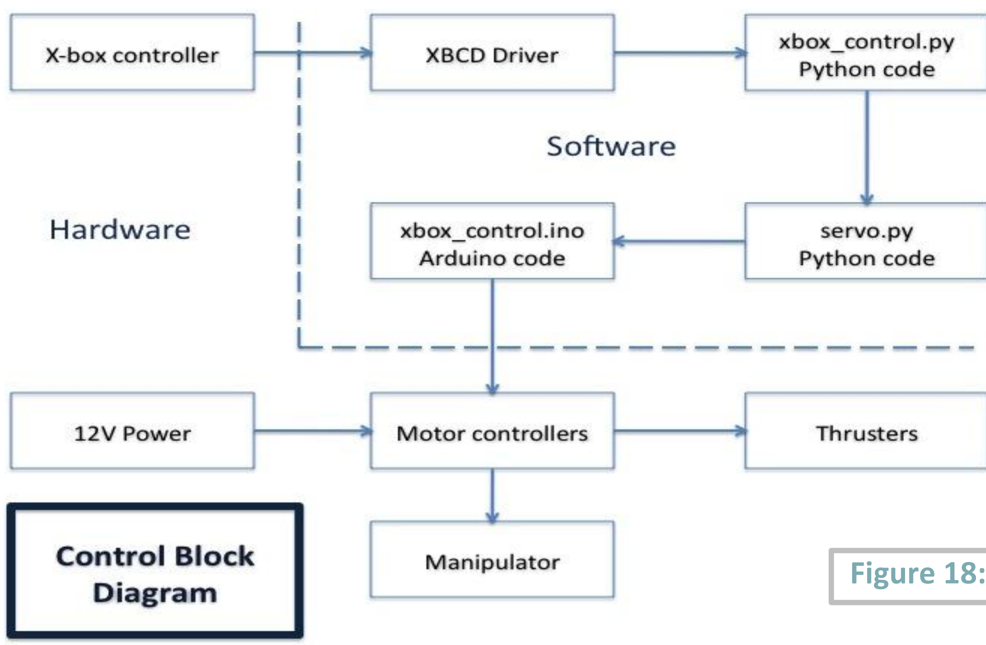


Figure 18: Block Diagram

Mission Overview

Oceanus I also has scenario specific mechanisms which make it the ideal vehicle for underwater exploration and excavation of World War Two shipwrecks. These payload tools include: a measuring device, magnetic sensor, orientation verifier, simulated sonar, lift bag clamp, and saline extractor.

TASK 1 OVERVIEW

The first task required of InnovOcean's marine vehicle, **Oceanus I,** is to survey the SS Gardner and the surrounding site for various types of damage. **Oceanus I** will determine length and orientation of the ship on the sea floor, identify whether debris piles are metal or nonmetal, and create a detailed map of the seafloor based on all observations (Length, orientation, and placement of debris piles).

Magnetic Metal Sensor

To determine whether the debris piles are metal or nonmetal, we designed a device that uses basic magnetic forces. It is comprised of a modified spring scale and several rare, earth magnets. The magnets fasten to the scale with rubber bands, allowing the magnets to sit in a neutral position when not in use. When the magnetic tube hovers over a metal debris pile, magnetic forces pull the inner magnet down to touch the debris pile. The sensor is placed in prime view of camera 2 so that the pilot may see when the magnets are pulled down to touch the debris pile.

Figure 19: Magnetic Metal Sensor

Measuring Device

To determine the length of the ship wreck, company employees fabricated a device that works similarly to a tape measure. Initially, the company opted to simply mount a tape measure onto the vehicle, but after further discussion and research, we chose to make a modified tape measure to save money and keep the ratio of purchased to fabricate payload tools 2:1

Figure 20: Measuring Device

The device is constructed of a circular plastic piece which functions similarly to the inner part of a tape measure. Inside this plastic piece is a metal spring in the shape of a spiral. The fabric measuring tape is attached to the plastic piece and is wound around it so that when the tape is pulled outwards, the metal spring tightens. This tension, when released, causes the tape to retract back into the device. A PVC ring attached to the end of the measuring tape allows the pilot to hook onto the PVC pipes on either end of the ship. The PVC ring also keeps the tape from retracting all the way back into the device while the device is not in use. The device mounts to the underside of the frame between two pieces of expanded metal**.** To determine the length

Figure 21: PVC Ring

of the shipwreck, the pilot maneuvers backward in a straight line and utilizes the rear facing camera to view the measurement.

Orientation Determiner/Cap Carrier

In order to determine the orientation of the SS Gardner, **Oceanus I** is equipped with a simple compass. The compass is placed in a clear, waterproofed box on a portable device that is carried down on the vehicle's initial descent. To identify the ship's orientation, two red lines on the compass are lined up parallel with the ship so that the pilot may see the reading. The device is made of a PVC bracket, and the compass attaches via a Velcro strip. The cap used to plug the drilled hole is also carried down in this device.

Figure 22: Compass and Cap Carrier

TASK 2 OVERVIEW

The second task requires **Oceanus I** to remove a sample of fuel from the wreck. Before the sample can be taken, the wreckage must be cleared. This involves: lifting the fallen mast with an inflated lift bag, transplanting an endangered coral species to a secure location, and using simulated sensors to determine whether fuel remains inside the fuel tank. Once these precautions have been made, the oil sample can be taken. To collect the fuel, the ROV must simulate drilling a hole in the hull of the ship by punching through a layer of petroleum jelly. We must then extract the sample and reseal the hole with a velcro strap. **Oceanus I** will finally return the fuel sample to the surface for further testing and analysis.

Sonar Sensor and Hydrophone

Initially, we wanted not just to simulate the sensor, but actually to show on the surface the sensor creating an image of the wreck. One employee suggested using another series circuit and LED light to signal that the sensor was functioning. Although we knew this was feasible, we chose simplicity over extravagance and developed a basic sensory tool. **Oceanus I** employs a sensor that will simulate creating an image of the shipwreck. The sensor consists of a PVC elbow joint connected to a PVC tee tube. Two plastic prongs connect to the tee tube.

Figure 23: Simulated Sonar Sensor

When the prongs come into contact with the ship, the device will be in full view of a camera which will allow the pilot to see that the prongs are touching the ship, activating the sensor. The sensor attaches to the side of the manipulator using a PVC tube and a hose clamp. InnovOCEAN has also incorporated a hydrophone into **Oceanus I's** sensory tools. The hydrophone allows the pilot not only to have a visual representation of the wreckage but an auditory signal as well. It enables the pilot to hear all sounds surrounding the wreckage, including marine life and other exploration vehicles.

Saline Extractor

A previous InnovOCEAN vehicle, TANK, featured a saline extractor that functioned by using suction and an air hose. Although this technique was successful, it was not always reliable, and as a result, we opted for a much simpler saline extractor design for **Oceanus I.** This device is a hollow plastic rod which comes to a point on one end, permitting it to punch through the petroleum jelly layer. Tiny holes are drilled in the point of the rod. The

Figure 24: Tip of Saline Extractor

holes allow the solution to flow into the rod, but are not large enough to suck up any viscous petroleum jelly. A plastic airline connects to the rod and runs through the length of the tether to the surface where it is attached to the side of a small, plastic container. A vacuum attaches to the top of the open container, creating a vacuum system to suck the solution through the airline and into the container. When it is observed that enough solution has been collected, the airline is detached from the side of the container.

Figure 25: Saline Extraction System

Lift Bag Clamp

To inflate the lift bag and lift up the fallen mast, an air hose must be inserted inside the lift bag. The challenge we faced was designing a tool to hold the hose securely inside the lift

Figure 26: Lift bag clamp attached to Lift Bag

bag. Keeping things simple, we chose to use a clamp with grasping pads to attach to the lift bag. A hole is drilled into a handle of the clamp. Zip ties secure the clamp to the air hose, holding it in place while air is being pumped through the hose using and into the lift bag. **Oceanus I** utilizes its manipulator to attach the j bolt of the lift bag to the fallen mast.

Transplanting Coral

When exploring underwater environments it is imperative to protect and maintain the surrounding habitat, including marine life. InnovOCEAN takes the utmost care to ensure that all marine species are transferred to a safe location before beginning any mission tasks. The safe removal of the coral is made possible by **Oceanus I's** multifunctional manipulator. The claw safely grasps each coral species off of the ship's hull and transplants it to a secure location on the grid

Challenges

As with any company, we have encountered and overcome various obstacles and challenges throughout the duration of this project. These obstacles were technical as well as company based. Though at times these challenges (as well as others) seemed too difficult to overcome, our team was determined to surmount the obstacles and generate ideas to overcome them. The InnovOCEAN board, along with our mentor, Jeremy Huff, came to the realization that the makeup and number of employees in the company had changed drastically since last year. Our total number of employees decreased by over half, and many of our most experienced engineers and analysts moved onto new jobs in other marine areas. In spite of these circumstances, we chose to approach and view this change as a growing experience for the company and to make the circumstances fit our needs. We recognized that a smaller team would mean better team communications and consequently less confusion during the building process. New team members helped bring fresh ideas when collaborating with more experienced members. New members were also less experienced technically than returning employees. Consequently, at the start of the year, time had to be allotted to teach those new members the skills they would need during vehicle construction. This greatly affected our building schedule and put us behind schedule early on in the project. Fortunately, the new employees came prepared to handle the challenge and learned quickly and skillfully, minimizing the time needed to teach them technical skills. InnovOCEAN also experienced technical challenges during vehicle construction. At the onset of the project, we made an executive decision to use software and circuit boards to power our vehicle as opposed to a manual system which we relied on in years past. Implementing software was the next major improvement to our vehicle, so we delved into the mysterious and treacherous terrain that is programming. The most major step of incorporating our software (the Arduino Uno circuit board) was developing a great amount of knowledge in the area because no company member had any prior knowledge or experience working with the software. During the software development process, we ran into difficulties concerning new types of hardware: motor controllers. We had previously worked with servo motors which are controlled using PWM (pulse width modulation) values. In order to have variable speed of our thrusters, we needed a way to convert the PWM values to electrical pulses. Another difficulty presented itself in the number of different motor controller brands. With no previous knowledge of which brand or model would be most effective and cost efficient, it was a challenge trying to decide which type to purchase (especially because they were a significant portion of our budget!). After looking at the electrical schematics of each brand, we chose to purchase the VEX Victor motor controllers since the VEX schematics were simpler and cleaner than other brands. Because we had used VEX parts in past vehicles we also knew their products would be high quality and efficient.

Troubleshooting

A key component to any successful business is the ability to analyze and tackle problems swiftly by utilizing a versatile troubleshooting process. This process was used in almost all designs of **Oceanus I** and streamlined the process of developing new concepts and technologies, as opposed to the infamous "guess and check" method which is far from expedient. At the onset of this year, we foresaw potential problems and weaknesses with our previous frame, so we mitigated these possible issues at the beginning using our troubleshooting flowchart.

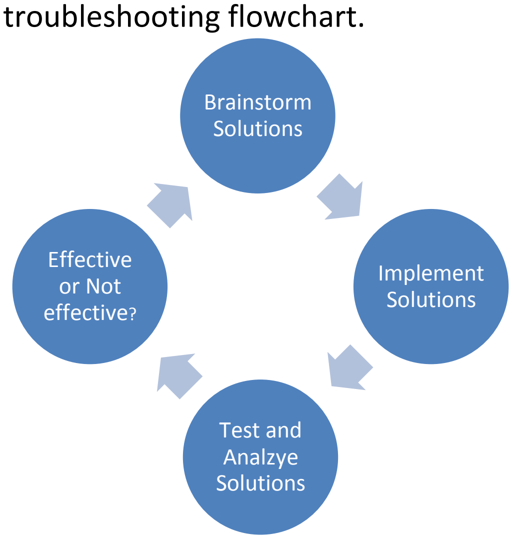


Figure 27: InnovOCEAN Troubleshooting Process

When we first began to design a new frame, we knew we wanted to decrease the frame's overall size and weight, thus increasing the vehicle's maneuverability. Although initially we were unsure of how to accomplish this feat, we turned to our troubleshooting flowchart as a step by step guide.

Brainstorm

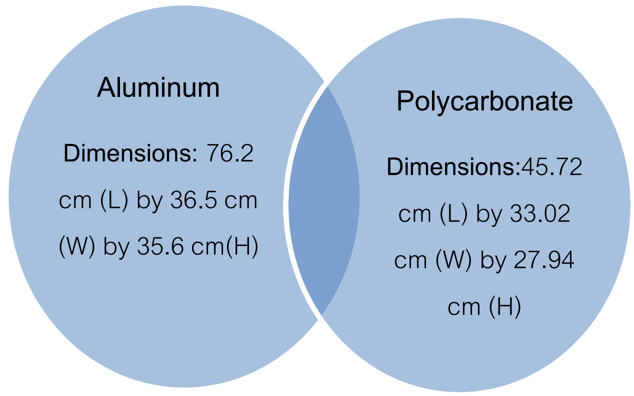
Clearly, a primary problem with the frame's weight was the material from which it was made. All previous InnovOCEAN vehicles had been constructed from various types of aluminum. Although aluminum is very lightweight when compared to other metals, we wanted to make our frame lighter. This realization led to extensive research in other materials and the subsequent discovery of a material called Lexan Polycarbonate. This new material fit all requirements: durable, versatile, and most importantly, lightweight. To reduce overall size, we decided to decrease the frame dimensions while still allowing space for vehicular components.

Implement Solution

We proceeded to cut out two panels of polycarbonate which would act as the siding and then bolted them together. We also cut out openings in each side panel to allow for water flow through the frame. Since we needed to reduce overall dimensions but still maintain space for necessary payloads, we chose to drill two holes through the mounting base plate allowing the thrusters to sit inside the base plate, with the propeller beneath the plate.

Test Solution

After all assemblies had been made, we made several, detailed observations about the characteristics of our old frame and of its new counterpart, including dimensions and material used. To compare the two side by side we compiled all observations into a simple Venn diagram:



Effective or Not Effective?

The comparison clearly shows that the new frame's modifications were successful, as its dimensions were reduced significantly. Our chief pilot Abbey Greene, even commented on the improved maneuverability of the vehicle due to the size reduction and material change. The modification is definitely a success!

Future Improvements

We as InnovOCEAN employees have gained many new skills this year such as software programming and coding, but we also recognize the importance of progressing even farther in the marine technology field. After a group evaluation of our vehicle and the construction process, we determined a few areas that could potentially improve later InnovOCEAN vehicles:

- Starting Time: Unfortunately, we began designing our vehicle much later than in previous years, and we consequently were pushed for time towards the end of the project. Ideally, we would like to start earlier in the fall to allow for as much time as possible to complete our vehicle.
- Have a completely Arduino based vehicle: Ideally, we would produce a vehicle that runs all systems including cameras and payload tools through the Arduino microcontroller. As our knowledge and skills concerning the software continue to expand, we hope to produce and market a vehicle that runs all functions solely through the Arduino, streamlining the design and overall performance of our vehicles.

Lessons Learned

Throughout the duration of this project, we have gained significant knowledge in both technical and company based areas that we hope will only increase the efficiency of InnovOCEAN in the years to come. Our biggest accomplishment this year was certainly incorporating the Arduino microcontroller into the control system.

The leap from a manual system where all motor speeds are fixed to a software based system where variable speed is possible is no simple task, but the rewards are monumental. Since every employee gained knowledge about software, we increased our foundation for vehicle ideas and troubleshooting techniques. We also continue to learn new lessons from one another. As a team, we have spent endless hours on this project working and learning together. That experience cannot be taught or learned in a classroom environment. We have learned to encourage one another and to respect each person's ideas and opinions. With a smaller team, a couple of employees stepped up to the challenge of heading specific systems. With less members at the head of the company, it allowed all employees to fully express their ideas for **Oceanus I**, something that had been difficult in past years with such a large company.

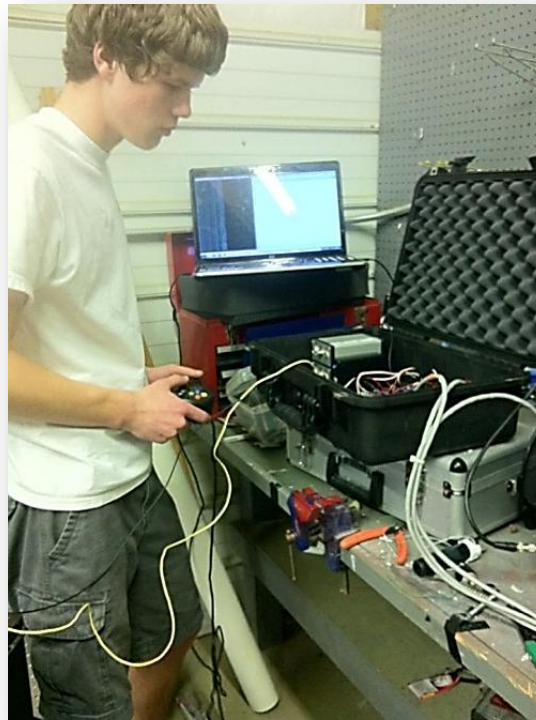


Figure 28: Wesley Ivester, Software Engineer, inspecting the control system

Reflections

"Though being a member of the ROV team is quite demanding at times, the lessons, skills, and knowledge that I have learned over the past four years has been the main contributing factor to my success in school and has helped to solidify my career path as well. The time commitments, deadlines, and critical thinking skills developed through my participation in the ROV program have better equipped me for college and the demands of a future job. ROV is a way to apply classroom concepts to something tangible and requires you to think out of the box. Home Depot doesn't have an ROV aisle, so you must come up with new ways to solve problems that do not have a resolute answer. It breaks the cycle of "correct or incorrect" that students have become accustomed to in today's classrooms. It provides a real world situation where the teacher or mentor doesn't have all of the answers. It requires teamwork, critical thinking, and problem solving to come up with the best solution." **–Carter Smith, Junior**

"ROV has been the most incredible and rewarding experience of my life. I always loved science and math classes at school but was never given a way to apply those skills I learned outside of a classroom environment. ROV has provided an outlet to do so. It allows me to think on a higher level and challenge myself to learn more and be better with every vehicle and every competition. When you're working with the brightest kids at your school, you know you're truly learning from the best and that everyone you're working with loves it just as much as you do! Ocean Engineering is still an underdeveloped field but ROV and the MATE organization have opened up so many doors for summer programs and college opportunities I don't think I would have had otherwise." **-Kelcy Newton, Junior**

Acknowledgements

InnovOCEAN and its employees would like to acknowledge several companies and individuals for their assistance in our endeavors throughout this project. We would like to thank: Sunset Hills Country Club for allowing us to use their pool for practice runs; Whitman's Glass for donating polycarbonate for our frame; SubConn for donating 16 pin connectors; Carrollton Junior High School for allowing us to use their cameras; Security Solutions for giving us a discount on our tether; Kasey Austin and the Carrollton High School STEM lab for allowing us to use their router; The Smith family for allowing us to use their shop for a work space. Additionally, we would like to thank our families for chaperoning, creating schedules, and providing snacks. We could not do this without your continuous support! We would also like to thank our mentors, Jeremy Huff and Kristi Bradford-Hunt for all of their guidance and wisdom. Thank you for pushing us to succeed and always believing in us! Finally, InnovOCEAN would like to thank MATE and The Gray's Reef National Marine Sanctuary for providing us with the opportunity to participate in this competition.

Servicing Warranty

To ensure customer satisfaction and reflect InnovOCEAN's confidence in our product, **Oceanus I**, a one year servicing warranty is included with each vehicle. If at any time a system fails due to a technical malfunction, an InnovOCEAN engineer will fix and/or replace that part at no expense to the customer.

Budget

Donated Item:	Donor:	Fair Market Price:
Lexan Polycarbonate	Whitman's Glass	$167.00
Underwater Cameras (2)	Carrollton Junior High School	$160.00
Mini Waterproof 16 Pin Connectors	SubConn	$60.00
Minicell Foam	The Whitaker Family	$30.00
Thrusters, Manipulator, Cameras (3),	Tools/ Spare parts from previous years	$6,028.00

Date:	Provider:	Part:	Price:
10/10/2011	InnovOCEAN Employees	Contributions and Dues	+ $1,200.00
10/24/2011	Security Solutions	1000 foot Six Lead, 18 gauge Tether	$100.00
11/5/2011	Amazon	Arduino Uno MicroController	$30.00
11/9/2011	Home Depot	Grounding Strips	$9.95
11/11/2011	Autozone	Terminals (2)	$10.00
11/14/2011	Lowe's	¾ Inch Sprinkler Valve Tubing, Heat Shrink Variety Pack	$25.97
12/17/2011	Staples	Blue Print, Web-Rush Fee	$8.55
12/20/2011	Lowe's	ABS Pipe, PVC Elbow and Caps	$10.57
12/20/2011	Home Depot	Velcro, PVC (Pipe, Elbows, Caps, and Tees), Fuse, Krylon	$125.08
12/22/2011	Home Depot	Heat Gun, Power Strips, Alligator Clips	$52.13
1/2/2012	Lowe's	PVC Pipe, VP-PPH Self Drill	$10.46
1/2/2012	Home Depot	Lexan Sheet	$56.66
1/5/2012	Home Depot	Dremel Sander, Dremel Sanding Band, Jigsaw Blade Set, Screws	$29.43
1/10/2012	VEX.Com	VEX Victor Motor Controllers (5)	$449.95
1/30/2012	Pelican Company	Waterproof box	$100
2/23/2012	Home Depot	Pex Pipe, Hex Bolt, Clamps	$8.77
2/24/2012	Radio Shack	P/B Switch	$3.95
3/2/2012	Home Depot	Screws, Nuts, PVC Coupling and Plug	$25.93
3/2/2012	Home Depot	Rotary Chuck, Dremel	$112.51
3/2/2012	Home Depot	Tubing, Clamps, Plastic Bags	$20.35
3/10/2012	Lowe's	Foam Gaps and Crack, Hex Bolts and Nuts	$11.68
3/10/2012	Home Depot	Heat Shrink Tubing, Washers, Spackling, Velcro	$18.56
3/14/2012	Lowe's	ABS Caps	$23.94
4/22/2012	Anonymous Donor	Monetary Value	$350.00
4/26/2012	Plastic Depot	Two Part foam for Ballast	$172.50
		Total:	$1,372.50
		Remaining Balance	$133.06