ENDEAVOR ENTERPRISES

SEA-TECH 4-H CLUB, MOUNT VERNON, WA

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ABSTRACT

Endeavor Enterprises' ROV (Remotely Operated Vehicle) is designed and manufactured to perform surveys of sunken ships; more specifically, to accomplish an assessment of the SS Gardner as defined by the Marine Advanced Technology Education Center. Because of Endeavor Enterprises concern for marine life, and the people whose livelihoods depend on it, the company's mission is to provide countries with a low cost way of effectively surveying sunken ships which pose serious environmental hazards.

The company, comprised of four members, created a mission strategy which guided them through the design and build process. ROV Endeavor is constructed from 3/16" aluminum, and designed with the mission tasks in mind. A foam float provides a strong righting moment, which promotes stability to accomplish the tasks. The ROV is maneuvered by ten team made thrusters, and controlled by joysticks that command the ROV's four degrees of freedom. A payload sled was manufactured by Endeavor Enterprises out of aluminum, and serves as a source for mounting sensors to accomplish the mission. A 12 VDC gripper was designed in CAD (Computer Aided Design) by a company member, and cut from aluminum. It closes in parallel motion which enables it to transport corals and equipment. A wide angle camera is utilized for the purpose of surveying the ship.

An accurate assessment by the company can provide the necessary information to move onto the next step; whether it be leaving the wrecks alone, or removing the crude. Endeavor Enterprises is more than capable of completing the mission.

1. COMPANY STAFF

Matthew Atilano
Company Role: CEO & CFO
Competition Role: Mission Commander

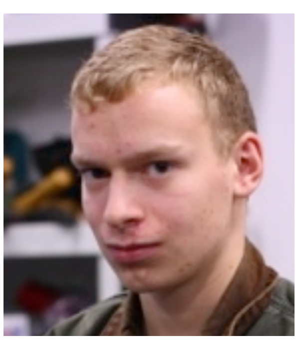
Matthew with his four years of experience in building ROVs in Sea-Tech, has a dedicated get-it-done mindset. His desire to learn more about science, marine technology, and oceanography has inspired him to dig deeper into marine career options. He has one year of experience in the MATE International ROV Competi-

Cameron Hoglund
Company Role: Mechanical Systems Engineer
Competition Role: Payload Tool Operator

In her first year of designing and building an ROV, Cameron learned to utilize CAD, as well as many other skills. She has developed a general knowledge of how each ROV system works as well as a detailed knowledge of the structure and mechanisms of the ROV. These skills have made her a versatile team mem-

Shelby Heim
Company Role: Marketing Director
Competition Role: Tether Manager

Shelby has participated in building an ROV in Sea-Tech for the first time, and has enjoyed the opportunity to learn more about the skills required to design and build an ROV. She also assembled a mission strategy matrix which guided the team through the loops of designing a mission capable ROV.



Dean Jones
Company Role: Electrical Engineer
Competition Role: Pilot

2012 marks Dean's second year in participating in the MATE International competition and his fifth year in Sea-Tech. Dean has developed proficient expertise in electrical systems and has spearheaded the controls of the ROV.

2. DESIGN RATIONALE

2.1 Mission Equipped

Endeavor II is an adept Remotely Operated Vehicle (ROV) utilized by Endeavor Enterprises to complete the tasks presented by its clients. Endeavor Enterprises' client, the Marine Advanced Technology Education Center (MATE), has put forward a proposal requesting a company capable of completing an assessment of the SS Gardner. ROV Endeavor II is designed and manufactured to complete each series of tasks with efficiency. Moreover, each mission tool implement is engineered for its specific purpose; to collect information and perform tasks regarding its assignment. Tooling implements include: an 12 VDC powered aluminum gripper for transporting aquatic organisms and mission equipment, an ultrasonic thickness gauge to determine the thickness of the ship, a neutron backscatter device to test for oil, and an oil filled compass to determine orientation of the ship. Additional tooling includes: a magnetic pendulum to test for metal artifacts, an oil sampling apparatus, an array of four cameras for scanning and navigation, and a measuring instrument for calculating length of the sunken vessel.

2.2 Design Strategy

CAD Modeling

The design team decided to first model ROV Endeavor II by employing CAD (Computer Aided Design), because of its capability to greatly reduce build time and create a more streamlined production. Equally important, the CAD modeler can foresee many size or design related problems which could lead to unwanted consequences, a process know as digital pre-assembly. The frame and core assembly models, which the team designed in 2011, were reprocessed and became the basic platform of the new model. The thrusters and the main camera performed flawlessly in 2011, so were retained, while the balance of the mission tools were removed because they were not mission capable. More innovative and mission friendly concepts have been utilized in order to achieve the highest results.

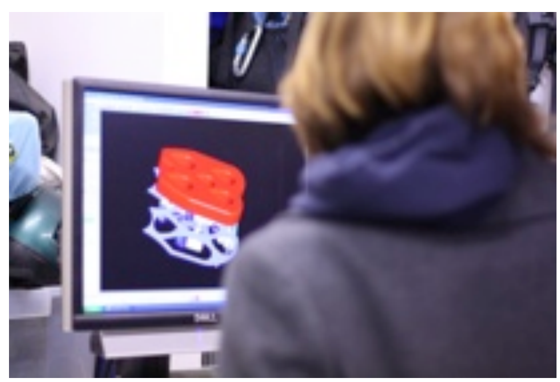


Fig. 1 - Company Member CAD Modeling ROV

Mission Specific.
The redesign began by creating a mission strategy which guided the company through the building process. The company's desire is to have all the components fully mission functional and straightforward, and at the same time, creative and durable. With this in mind, Endeavor Enterprises took a step forward by taking advantage of modern technology such as high-precision water jet cutting. This process is driven by CAD geometry created by Endeavor Enterprises, and accomplished at a sponsors facility by professionals. Members of the team toured the facility to familiarize themselves with the entire process, and experienced modern technology in a real-world industrial environment.

2.3 Mechanical Structure and Stability

Core Assembly.
Endeavor Enterprises chose to utilize the company's large inventory of PVC fittings which, being donated, reduced the cost of ROV Endeavor II. The core is assembled with 1 1/2" PVC, and the interior is filled with a potting compound to eliminate flooding, and consequently, any ballasting inaccuracy. The core interconnects the frame of the ROV and the machine's 10 thrusters which plug into custom concentric plugs which allow for directional adjustment.

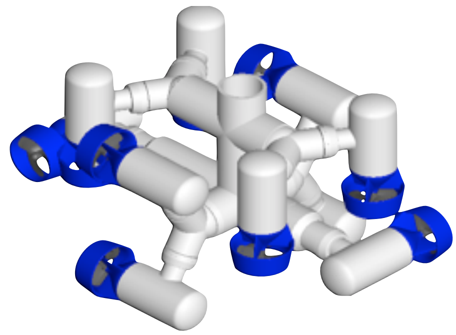


Fig. 2 - CAD Model of Core Assembly

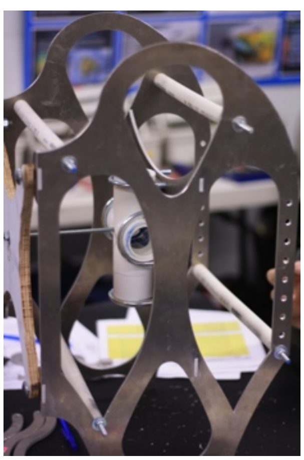


Fig. 3 - Jigged Frame

Frame.
The company's attraction to manufacturing multipurpose parts led to an ROV which is capable of utilizing and attaching ample accessories. For that purpose, external side plates and a cross brace were constructed to protect the core assembly and utilized as the platform for mounting payload tools. These plates were modeled in CAD by the Endeavor design team, water jetted from 3/16" grade 6061-T6 tempered aluminum, jigged by the company, welded together, and anodized. In addition to this, a payload sled was made from 12 cm x 5 cm aluminum tubing. This payload sled houses many of the mission tools, and is easily removed for future projects which require alternate tools.

Tilting Camera Assembly.
In order to give the ROV's 120° wide angle camera a sweeping view, the company created a tilting camera assembly. The camera support frame is cut out of 3/16" aluminum and brake formed to give it the necessary angles required to avoid interfering with the ROV's float. A 12 VDC linear actuator pivots the tilting camera assembly and provides the necessary angles for navigating and surveying undersea artifacts and organisms. Furthermore, the gripper is mounted to the tilting camera assembly giving it versatility, and allowing the camera to track with the gripper's movement.

Stability.
Endeavor Enterprises designed ROV Endeavor II with a high-density foam float, and placed the majority of the weight on the belly of the ROV in order to produce a strong righting moment. This technique provides a level, stiff platform which is not easily effected by the weight of artifacts retrieved, and is capable of smoothly carrying out delicate mission tasks. The float is hand crafted and carved from a slab of 480 kilogram/cubic meter polyurethane foam; this is part of the static ballast system incorporated into the ROV.

Fig. 4 - High-Density Polyurethane Float

2.4 Propulsion Systems

Fig. 5 - Team Made Bilge Pump Thruster

Ten thrusters are utilized by Endeavor II, to provide detailed maneuverability. Four tandem thrusters, two starboard and two port, produce fore and aft movement. Four vertical thrusters control up and down motion, and an additional set of side thrusters enable the ROV to shift from side to side with ease. The design of these thrusters has been a Sea-Tech standard for over 8 years. They are created from bilge pumps and encased within PVC pipe fittings. Each thruster is easily removable, and connects to power via RCA jacks which are sealed by an O-ring. To ensure safety, the propellors are protected with company made kort nozzles. The nozzle shape was created by stereolithography, then molded and cast in urethane foam by the company. Each thruster unit produces an average of .62 kg of thrust at about 4.78 amps of current. The reason these thrusters were chosen, was because of their exceptional accuracy, low power consumption, and their low cost profile.

2.5 Payload Tooling

Fig. 6 - Parallel Opening Gripper

Gripper.
Endeavor Enterprises, desiring to transcend, chose to construct a highly complex 12 VDC powered gripper. The previous year, a similar concept was tried but proved highly ineffective. It lacked control, durability, and was run by a brass rod which had to be replaced multiple times because the thread routinely stripped. Learning from their mistakes, the company chose to make use of CAD to water-jet complex gripper components. The gripper is operated by a worm drive powered by a high-torque planetary gear motor with 100:1 gear reduction. A series of gears revolves by way of the rotating worm gear, and drives the gripper's fingers to open and close in parallel motion. This ability increases the gripping

contact surface which improves the capability to grasp delicate corals, and lift or transport larger artifacts outlined in Task #2 of the mission document.

Fig. 7 - Oil Sampling Assembly with Sampling Rod Extended

Oil Sampler.
To collect an oil sample specified in Task #2 of the mission document, an oil sampler is made from a 18 cm long stainless steel tube. The sample tube connects to an air line which extends along the tether and connects to a vacuum pump/Pneumo-Fathometer. The stainless steel tube is inserted into the oil sample site, and oil is pumped from the sample tube into a vial collection container located on the ROV's port side plate. The sample tube is mounted inside a squared slide tube, and can be extended when in use. The slide tubing and sample tube articulate 90° to the side to prevent interference with the gripper during other operations.

Sensors.
In order to complete assignments from Tasks #1 and #2, defined by the mission document, a series of sensors were manufactured. A compass is mounted on the payload sled to detect the orientation of the vessel outlined in Task #1. Adjacent to the compass is a linear measuring line that will assess the length of the vessel. The end of the linear measuring line is equipped with a catch ring which attaches to the bow, and is fed out of a spring-loaded spool to retain a taut line for an accurate measurement. An ultrasonic thickness gauge and neutron backscatter device are combined into one multipurpose sensor. The ultrasonic thickness gauge is employed to determine the thickness of the vessels hull and the neutron backscatter device is to examine the vessel for oil. The two sensors are combined into one multipurpose sensor which is constructed out of 1/2" PVC pipe, and mounted to the side of the gripper. In order to gather the information needed, the gripper closes, and the end of the multipurpose sensor is placed against the target area. The sensor is spring loaded to provide a compliant link able to maintain constant contact under varying thrust conditions. For locating metal items presented in Task #1 of the mission document, a magnetic pendulum is located beneath the gripper.

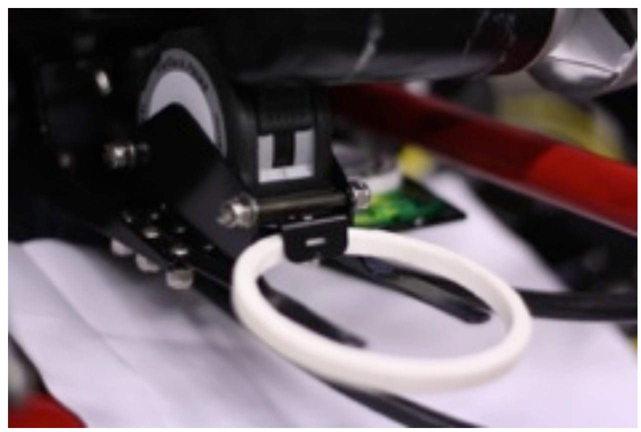


Fig. 8 - Linear Measuring Line with Catch Ring

2.6 Cameras

In previous years, the company has had the disadvantage of having cameras locked in one position, giving limited viewing angles. The company chose to utilize one Sony HD 120° wide angle color camera as the main camera, and three Sony 90° auxiliary color cameras for viewing task details. The wide angle camera is installed inside a PVC housing and covered by a 3" clear acrylic dome. The camera assembly is inserted into a PVC camera back shell, sealed by O-rings. The three auxiliary camera housings are manufactured out of a piece of 3.8 cm square stainless steel tube. Each camera is mounted with a dual axis gimbal made from 5.1 cm x 7.6 cm aluminum tubing, using a pair of SS thumb screws and serrated washers to lock its position. To make the auxiliary camera housings waterproof, each is filled with a potting compound. A silicone O-ring seals the lens to the acrylic plate on the front to prevent the potting compound from leaking into the field of view. A Delrin cap on the back provides the base for the underwater connectors. These auxiliary cameras can be placed almost anywhere on the ROV, and provide a diverse selection of views. Each camera is readily replaceable. Two auxiliary cameras focus on the payload sled which allow the team to read the measurement and orientation of the vessel. The wide angle camera is situated in the forward camera mount so that it is capable of viewing the gripper and tasks immediately in front of the ROV. The cameras are connected to a 5-line multi-coaxial cable which runs through the tether. The coaxial cable connects to a quad video multiplexer at the deck side control box. The quad processor combines four video signals into one monitor signal. The multiplexer is capable of numerous combinations, including; four views; two views; discrete view; picture in a picture, and digital zoom. This approach was chosen because it allows for multiple cameras without multiple video monitors giving the pilot better mission awareness which is similar to the method applied by professionals.

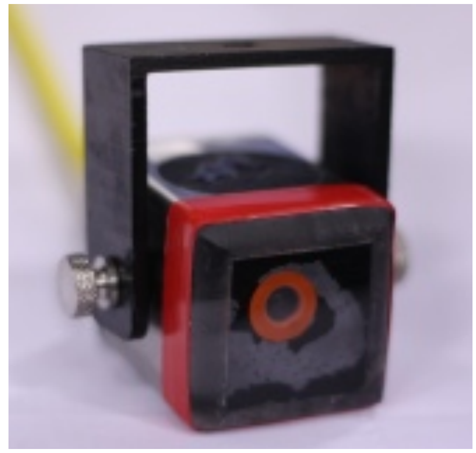


Fig. 9 - Auxiliary Camera with Gimbal for Adjustment

2.7 Control Systems

Controls.

It was decided that an electric-mechanical switching approach would be more robust for an ROV. This method was chosen because the company felt that solid state controls can be prone to damage. In addition, the complexity of software is unnecessary to accomplish the maneuvers Endeavor II requires to complete the mission tasks. Endeavor's controls are simple, robust, and effective. Switching is relay based, and runs on 12 VDC. The thrusters are operated by two joysticks which control the ROV's four degrees of freedom; yaw, surge, sway, and heave. These joysticks are located on a control box which connects to the main control case. To electrically control the gripper, a double pole, double throw toggle switch, is placed inside the

Fig. 10 - Joystick Controller That Utilize the ROV's Four Degrees of Freedom

main control case. To ensure safety at all times, and meet the requirements by the MATE center, the main control case is equipped with an emergency shutoff switch, and a 25-amp fuse.

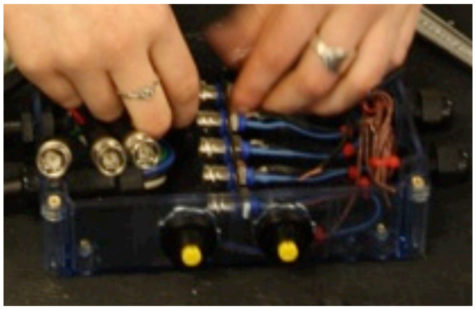


Fig. 11 - Mission Interconnect Box During Assembly

Mission Interconnect Box.

The company determined to make all of its cameras easily replaceable in the event of a failure. For this purpose, the company purchased a 12 cm x 17 cm x 4 cm Lexan box which terminates all the camera's coaxial and electrical payload tool conductors. Each camera is attached externally to the mission interconnect box via a three pin waterproof receptacle purchased from Cooper Interconnect. Inside this box, the conductors from the female end are soldered to a series of BNC bulkhead connectors. The BNC connectors, which are encased inside the mission interconnect box, attach to the tether's coaxial cable. A hydrophone is placed inside the mission interconnect box and linked through the fifth coaxial line. The hydrophone provides the ROV's pilot with extra sensory feedback when completing the mission tasks. To power the cameras and actuators, seven 18 gauge conductors are connected to the common and ground of each electrical component. The mission interconnect box is filled with a clear gelled wax to eliminate the possibility of water intrusion while maintaining visibility of the interconnections. Reentry for maintenance is easily accomplished by removing the wax, performing the task, and restoring the wax.

Fig. 12 - Tether Interconnect for Detachability

2.8 Tether

The tether contains twenty-five 18 gauge power wire conductors, a coaxial cable for cameras, and a pneumatic air line for the oil sampler assembly. It is encased in an expandable vinyl sheathing to keep the lines secure. The tether is 15 meters long and is connected to the main control case via a military grade 17-pin circular connector. To ease transportation, the tether is equipped with a detachable interconnection.

2.9 Safety

Safety being paramount, several creative functions, designs, and labels are utilized. All thrusters are protected by guards and ducts, warning labels are placed near any moving parts, and a printed safety protocol is followed during testing of the electronics. The ROV is manufactured to protect the thrusters from damage or doing damage to others by insetting them behind the aluminum side plates. A 25 amp fuse and emergency shutoff switch are included in the electrical control system. The company has established a mindset dedicated toward the safety of its operators, and its ROV. In summary, ROV Endeavor II is a safe and effective way to complete each of the 2012 mission tasks.

3. EXPENDITURE SUMMARY

The following table is a summary of the ROV project expenses. A more detailed expenditure report is located in **Appendix A.**

Category:	Company Expenditure:	Donated Amount:	Total Cost:
Core Assembly	$104.58	$0.00	$104.58
Aluminum Frame	$0.00	$800.00	$800.00
Propulsion	$356.00	$0.00	$356.00
Tilting Camera Assembly	$263.21	$0.00	$263.21
Tether	$212.45	$150.00	$362.45
Ballast System	$115.98	$200.00	$315.98
Gripper	$167.89	$250.00	$417.89
Cameras	$214.00	$132.00	$346.00
Oil Sampler	$84.52	$0.00	$84.52
Control System	$148.88	$104.00	$252.88
Sensors	$69.75	$0.00	$69.75
Mission Interconnect Box	$214.58	$0.00	$214.58
Miscellaneous Parts	$56.43	$0.00	$56.43
Grand Total:	**$2,008.27**	**$1,636.00**	**$3,644.27**

4. TROUBLESHOOTING

Troubleshooting is a necessary process when encountering unplanned results in assembling and testing a ROV. Throughout the year, the company was required to utilize the process of troubleshooting, and when a problem is discovered, an efficient technique is applied. The technique is to:

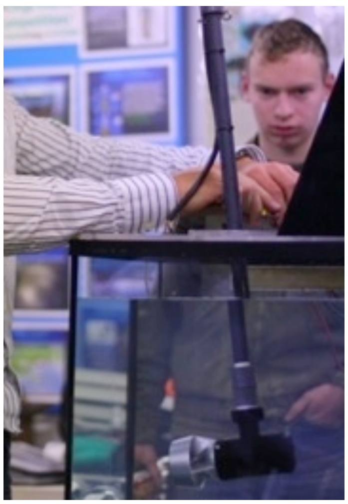


Fig. 13 - Thrust and Amperage Draw Test in Test Tank

- Diagnose the problem to understand the effects,
- Develop a list of potential sources,
- Eliminate sources by test,
- Confirm the location of the problem,
- Repair or replace the defective part, and
- Test the system to ensure correct operation.

One such troubleshooting example involves the thrusters of ROV Endeavor II. When wiring the controls for the ROV, it was discovered that a series of thruster propellers were rotating incorrectly. The possibilities were examined, and it was determined that the thrusters were wired with the polarity reversed. After discovering the problem, the team listed the possible places were the wire connection was incorrect. One possible reason was that the wiring in the main control case was in error. Another possibility was that the joysticks, which control the ROV's motion, were wrong. After close examination, another more likely possibility was discovered. The tether interconnect, which connects the tether to the ROV, had connections which were not labeled. This error increased the likelihood of this problem.

The first two possibilities were assigned to the least likely, and the third was tested. The team utilized a multimeter to determine the correct polarity, and labeled each conductor to its correct pair. The problem was determined to be a series of tether connectors affixed to the wrong connectors, and was fixed by simply changing the connections.

This situation is just one example of testing achieved by Endeavor Enterprises. The ROV was also tested in a small tank preceding a full dive test to ensure correct operations. In addition, a test on the ROV's thrusters was utilized for the purpose of gathering data to determine the amperage draw and thrust. The results of the testing performed by the company have proved beneficial to the operation and workability of the ROV.

5. CHALLENGES FACED

5.1 Team Size

This year, Endeavor Enterprises consisted of only four members. Having a four member team has its advantages, such as easier distribution of tasks, and easier coordination of team meetings, but it also has its challenges. Such a small team required each member to pull a heavier workload than has been required in previous years, and develop a more comprehensive knowledge of all the ROV systems. This challenge was overcome by careful planning and division of tasks amongst the team members. Developing task checklists ensure that all components of the ROV were completed on time. The checklist also provided a way to manage an even workload. It became evident throughout the progression of the year, that this approach was highly beneficial.

5.2 Gripper Design

The company has tried many different gripper designs, which functioned poorly. A pair of hooks, a gripper run by a bilge pump, and a pneumatic gripper, have all been tried, and have provided the team with a great learning experience. This year, the company challenged itself to create a gripper that would surpass all previous concepts. A gripper design was conceived that utilized a 12 VDC planetary gear motor which makes use of a worm gear assembly to open and close the grippers fingers' in parallel motion. This was a highly complex concept, and required the team to confront the challenge with a willingness to endure. The team addressed each obstacle with the knowledge base previously developed from constructing other grippers, and the new team members developed a thorough understanding of the concepts applied. Extra research was carried out to overcome the challenges of creating a state-of-the-art gripper. The gripper was an overwhelming success, and functioned up to, and beyond the expectations of Endeavor Enterprises.

6. LESSONS LEARNED

6.1 Team Member Communication

In the last month before the regional competition, the rush to complete the ROV made the project schedule very demanding. The task list seemed to constantly grow, and tension amongst the team was high. While projects were in their final stages components were placed around the team's work area. On occasion, in the rush to finish the ROV, a component was lost, or a piece of equipment was left behind at the poolside because of lack of communication. Loss of components caused no end of frustration, and required the team to purchase the parts again which set projects behind schedule. It was decided something had to happen in order to fix this dilemma.

As it turned out, communication was the key to overcoming this dilemma. The team communicated through e-mail to confirm that every member was aware of their necessary responsibilities to finish the project on schedule. An assignment checklist was made and updated each time a task was finished or added, and distributed throughout the team. The team took inventory of their storage crate, and created a list of components, placing the list in the crate. Each team member made a commitment to ensure each part and piece of the project was restored to its proper place. In addition, a mission setup and dive inventory checklist was made to guarantee each mission implement was available when needed.

The team learned that written checklists and protocols were a great benefit. Had this been initiated earlier in the season, time could have been saved. Although this was not the case, the lesson learned improved the teams capability to function as a coherent team.

6.2 Tether Negligence

Late in the project, an inspection of the tether showed that all eighteen conductors were corroded from exposure to chlorine water, some to the point of a green powder. The team determined that this problem was created while stripping the outer jacket off of a multi-conductor control cable. The stripping tool was incorrectly set too deep, cutting through the individual jackets of the twisted conductors, leaving exposed wires. The cuts were small enough, that they went unnoticed. This condition created a safety hazard that was not recognized by the team until corrosion eventually created faults in some of the conductors. This set the team back several weeks. This challenge was met with determination by all team members, meeting extra days and working long hours to ensure the rewiring was completed correctly with sufficient time to complete the rest of the ROV.

The team learned a valuable lesson from this experience. A detailed inspection of each completed task will help ensure machine reliability. In response to this lesson, safety and tether protocols were created to reduce the opportunity for error.

7. FUTURE IMPROVEMENTS

7.1 Structural Refinements

The configuration of the ROV was designed to be robust, with mission adaptability in mind, which proved highly beneficial. During practice, the company noticed that the added mass of the ROV had reduced maneuverability. Adjustments were made, but the team decided more modifications would be beneficial.

Scaling down elements of the aluminum frame by about fifteen percent would give the ROV a more streamlined, hydrodynamic shape thus enabling it to maneuver better. Another improvement would be to reduce the amount of floatation and ballast. Incorporating some type of programmable logic controller into the ROV's controls, with the reduced amount of float and weight, would enable the pilot to perform maneuvers such as pitch and roll, as well as thruster speed control. The resulting reduction of vehicle stiffness would be compensated by pitch trip superimposed on the pilot command.

Making these improvements would enhance the ROV's capability to perform in a more effective manner with additional mission friendly maneuvers. The reduction in vehicle weight and volume would also decrease the amount of the drag, which is one of the inherent disadvantages of large machines. While also improving the design and functionality of the ROV, these improvements would also increase the knowledge of company members. Developing software for a PLC controller would be a welcome learning process for the team, challenging each member to readily expand their knowledge.

7.2 Additional Improvements

Other improvements that the company would like to make, include improving the resolution of the video feed. When completing mission tasks, it was discovered that the quality of the video feeds were lacking enough resolution to read numbers on the compass. An option was discovered for improving the quality without fully replacing the cameras. This option would require purchasing and installing an adapter which converts the video signal to a format which utilizes the full resolution of the cameras.

8. TEAMWORK

The Endeavor II ROV is the result of successful collaboration, which required excellence. Having only four team members in the company required full participation of each member, and many months of devoted time and money to complete the ROV by the competition. This took a huge effort by the team as a whole to overcome the difficulties of designing and manufacturing a ROV in a short period of time.

Fig. 14 - The Team Completing a Mission Run

A milestone schedule, action item list schedule, and a project checklist were developed to track the project. In addition, project roles were assigned to each member to evenly distribute the tasks among the company members, and assure the project was a dedicated team effort. The project checklist also ensured that each team member was fully aware of their individual responsibilities, and that no work was left undone. The project required a large majority of each member's time because of minimal mentor participation, and because each component was built from scratch. The reason the machine was built from scratch, was to allow the team to learn and expand their knowledge of the building process. The electrical system, which was also designed and manufactured by the team, was built solely from basic components.

In order to design a mission efficient ROV, the team discussed the mission tasks as a team, and created a mission strategy chart. Final decisions were not made until they were addressed with the whole team, to avoid misunderstandings. Meeting outside of normal Sea-Tech 4-H meetings to work on design modifications and strategies was necessary to insure that ROV Endeavor II would be ultimately finished by the competition. In addition, the technical report was created and written with contribution from each team member's area of expertise.

9. MANAGING WWII SHIPS

World War II maritime materiel of all varieties has rested on the ocean floor for over 70 years. Recently it has been brought to light that these ships are on the verge of crumbling and spilling millions of gallons of oil into the sea, a catastrophe that could destroy aquatic life and take millions of dollars and numerous years to clean up. One of the many questions arising from this situation is who is responsible for the clean up?

Fig. 15 - A Diver Inspects Japan's Amagisu Maru Wreck in Chuuk Lagoon.

(*A.L. Giddings/National Geographic)*

Who is responsible for extracting the oil from the sunken rigs is a challenging question. Governments have accepted that the underwater carnage belongs to the government "who had control of the ship at the time of its sinking."[1] However, if the flag nation does not give consent to remove the fuels from the wreckage, a major leak could ensue and cause millions of dollars worth of damage; much more than it would cost to remove the fuel from the vessel in the first place.

This is the problem that Chuuk Island now faces. Three Japanese oil tankers, carrying a combined volume of 32 million liters of oil, were sunk by U.S. forces during WWII and now lie at the bottom of Chuuk Lagoon.[2] Seventy years of corrosion has made the vessels ticking "time bombs,"[3] able to ruin the beautiful coral reefs and beaches of Chuuk Island in moments. The primary source of food and income for the people of Chuuk Is-

[1] http://news.nationalgeographic.com/news/2008/12/081210-pacific-shipwrecks-missions.html

[2] http://www.youtube.com/watch?v=-8JCfjhfrDo

[3] http://www.islandsbusiness.com/islands_business/index_dynamic/containerNameToReplace=MiddleMiddle/focusModuleID=20028/overideSkinName=issueArticle-full.tpl

land is fishing, and an oil spill would kill the mangroves where the fish breed and cause the population of fish to plummet. According to corrosion export Ian McLeod, an oil release of this magnitude could prove worse than the recent BP oil spill in the Gulf of Mexico.[4] The U.S. has resources such as the Oil Spill Liability Trust Fund and the Federal Spill Liability Trust Fund to help cover the cost of either cleaning up an oil spill, or taking measures to prevent an oil spill, including those related to war vessels.[5] However, these funds are not utilizable by countries other than the United States.[6] Governments such as Chuuk Island must request aid from the country that has ownership of the war vessel.

Fig. 16 - The SS Montebello Photographed in 1921
(California Department of Fish and Game/

An important question now remains: Do we leave the ships alone out of respect for those who went down with the ships and risk the possibility of the oil on board causing a disaster? Or do we disturb these maritime graves by removing the potentially harmful oil and eliminate the possibility of an environmental catastrophe? These questions are of such controversy, that the Director of NOAA's (National Oceanic and Atmospheric Administration) Maritime Heritage Program, Dr. James Delgado, in a email conversation regarding these questions, stated that NOAA has developed a program which deals specifically with this issue.

Perhaps the answer is subjective and there is no one "right" way to go about handling something with so many delicate components involved. Just as each vessel has its own story, so each vessel must be handled in its own unique way. Not every WWII vessel poses a risk to its immediate environment;[7] therefore not every vessel need be disturbed.

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[4] http://www.youtube.com/watch?v=-8JCfjhfrDo

[5] http://www.cencoos.org/documents/news/Montebello_Factsheet.pdf

[6] http://www.uscg.mil/npfc/About_NPFC/osltf.asp

[7] http://news.nationalgeographic.com/news/2008/12/081210-pacific-shipwrecks-missions.html

10. REFLECTIONS

The ROV Endeavor II is a very unique and incredible piece of machinery that has put forward many challenges that we, as a team, have overcome efficiently. Endeavor Enterprise's ROV is capable of completing tasks, put forward by its clients, with adequacy and thoroughness. Designing and manufacturing this mechanism has brought the team members of Endeavor II unified as one.

As individual team members, we all have found aspects of this project that we excel in. Many new implements were introduced to Endeavor II in which we worked hard in learning and adapting to. In working on the ROV, our group has discovered that we are capable of working together with little to no altercations. We listen to, and reinforce each other's opinions with care.

We have all witnessed each other develop an attitude of professionalism, and many others have witnessed it also. Moreover, the MATE Center's goal of giving students the opportunity to enhance their entrepreneur skills has been quite beneficial to us. We have broadened our entrepreneur skills by reaching out to other businesses and organizations, in a professional manner in search for funds and sponsors.

The MATE Center's competition has inspired us all to expand our knowledge in science and technology. We all have found that the skills developed in participating in the competition spread without and beyond the competition field. It has motivated many of us to search and explore real-life careers and jobs pertaining to such areas, and we deeply appreciate the challenges that the MATE Center has put forth.

11. ACKNOWLEDGMENTS

Endeavor Enterprises would like to acknowledge the following individuals and companies who made this year's ROV project possible:

- Thank you to Jesus Christ - the Creator of all things, because of Him we endeavor.
- MATE - Your competition has challenged us to create greater things. Thank you for your inspiration.
- Mrs. McNeil - For letting us take over her garage for the last 9 months.
- Production Plating - Thank you for the anodizing services!
- Janicki Industries - Janicki Industries who donated the aluminum, water jetting, and the raw float materials. Thank you!
- Mr. Lee McNeil - We would like to specifically thank Mr. McNeil for all his advice and guidance which led our team in a straight path toward success.
- Our Parents and families - They allowed us to live and breathe Sea-Tech for the last year. They drove us around and were very supportive. We can't thank them enough.
- Stanley Janicki – Thank you Stanley for all the time you donated to our betterment.
- Mr. Cocheba – Thank you for the donation of the video multiplexer.
- The Skagit County 4-H Office – Thank you for your continued support of our endeavors.

12. APPENDIX

Appendix A: Detailed Material Expense Report

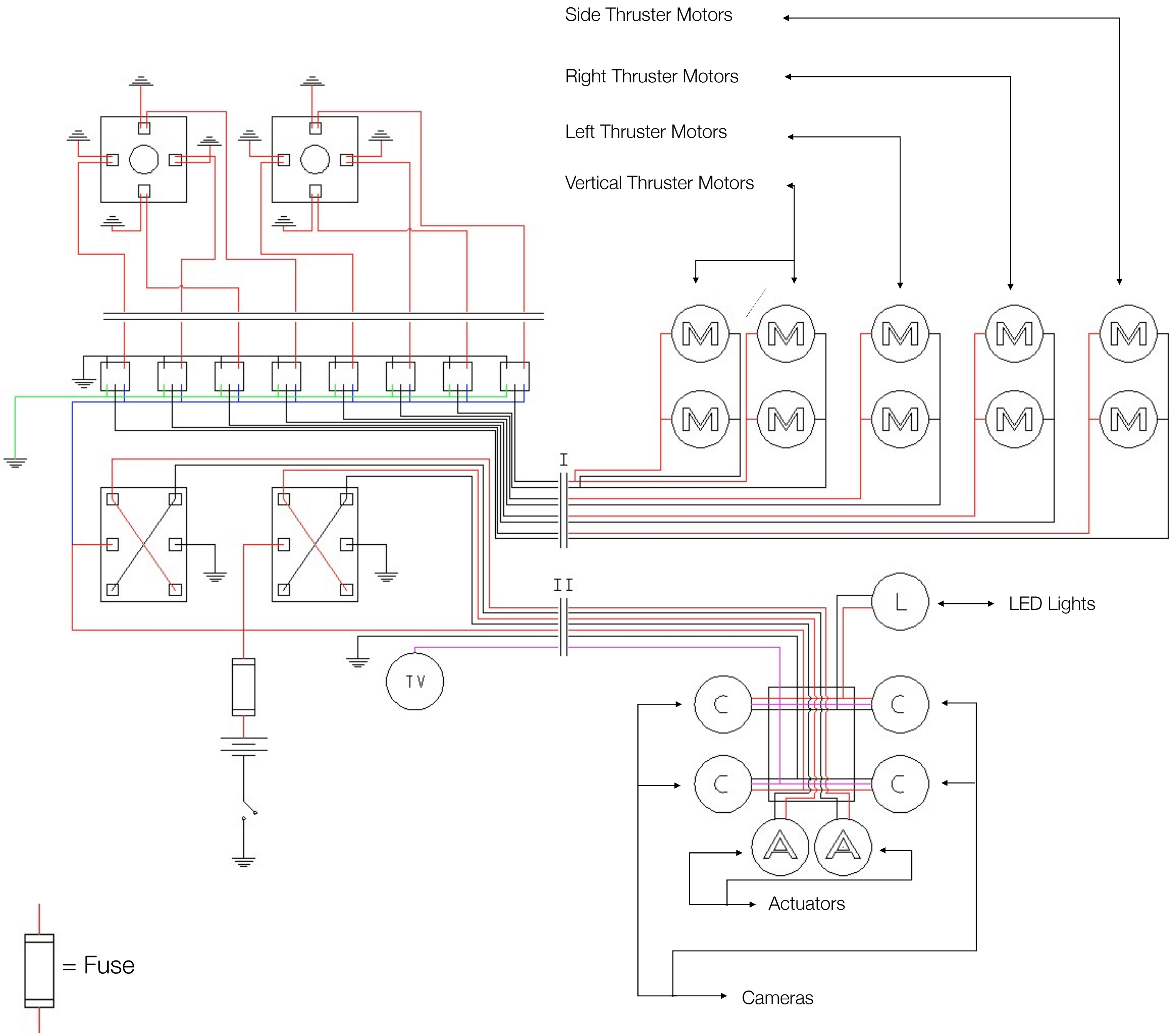
	Core Assembly - Material List				
Qty:	**Item Description:**	**Source:**	**Cost:**	**Donated:**	**Total:**
4	U-bolt: 8896T129	McMaster-Carr	$4.64		$18.56
2	1.5" spigot x 1" slip true wye PVC fitting	Flex PVC.com	$6.37		$12.74
2	1.5" slip x 1" slip true wye PVC fitting	Flex PVC.com	$7.78		$15.56
1	1.5" slip 5-way side outlet tee PVC fitting	Flex PVC.com	$6.70		$6.70
6	1.5" slip x 1" slip reducing bell PVC fitting	Flex PVC.com	$1.78		$10.68
1	1.5" slip cross PVC fitting	Home Depot	$2.25		$2.25
1	1.5" spigot x 3/4" FIPT reducer bushing PVC fitting	Lowes	$1.69		$1.69
10	1" spigot x 1/2" slip reducer bushing PVC fitting	Home Depot	$0.39		$3.90
10	1/2" slip o-ring union PVC fitting	Sea-Tech 4-H	$3.25		$32.50
			Total	**$0.00**	**$104.58**
	Aluminum Frame - Material List				
Qty:	**Item Description:**	**Source:**	**Cost:**	**Donated:**	**Total:**
1	Frame Side Plate: 3/16" alum	Janicki Industries			
1	Frame Top Plates: 3/16" alum	Janicki Industries			
1	Frame Seat Plate: 3/16" alum	Janicki Industries			
1	Frame Saddles: 3/16 alum	Janicki Industries			
1	Frame Cam UPR Plt: 3/16" alum	Janicki Industries			
1	Frame Cam LWR Plt: 3/16" alum	Janicki Industries			
1	Frame UPR C-Pivot: 3/16" alum	Janicki Industries			
1	Frame LWR C-Pivot: 3/16" alum	Janicki Industries			
1	Frame Camera Link: 1/4" alum	Janicki Industries			
1	All Water-jetted parts	Janicki Industries	$700.00	$700.00	$700.00
1	Anodized Aluminum Finish	Production Plating	$100.00	$100.00	$100.00
			Total	**$800.00**	**$800.00**
	Propulsion - Material List				
Qty:	**Item Description:**	**Source:**	**Cost:**	**Donated:**	**Total:**
10	Thrusters	Sea-Tech 4-H	$30.00		$300.00
10	Core: Thrust Connectors	Sea-Tech 4-H	$5.60		$56.00
			Total	**$0.00**	**$356.00**

	Tilting Camera Assembly - Material List				
Qty:	Item Description:	Source:	Cost:	Donated:	Total:
1	Aluminum mounting plate	Sea-Tech 4-H	$2.00		$2.00
1	Sony 1/4" CCD color camera; 120° FOV	Super Circuits	$69.99		$69.99
2	3" Acrylic Compass Dome Port	Ritche Navigation	$11.00		$22.00
2	Back Ring: .25" PVC jetted plate	Tap Plastics	$1.00		$2.00
2	Middle Ring: .25" PVC jetted plate	Tap Plastics	$1.00		$2.00
2	Dome Ring: .25" PVC jetted plate	Tap Plastics	$1.00		$2.00
2	3"- 2.5" PVC reducer bushing	Lasco	$3.25		$6.50
2	2.5" PVC pipe sleeve	stock	$0.50		$1.00
2	3 1/4" x 3 7/16" x 3/32" buna-N o-ring: AS568A-152 N70 ($8.33 / 50 pcs.)	McMaster-Carr	$0.17		$0.34
2	Camera Plug: 3" dia x 2.38" Type I grey PVC bar ($18.64 / ln. ft.)	McMaster-Carr	$3.73		$7.46
2	2-3/8" x 2-3/4" x 3/16" silicon o-ring: AS568A-332 S70 ($9.04 / 10 pcs.)	McMaster-Carr	$0.94		$1.88
2	Plug Cap: 1/8" PVC jetted plate	Tap Plastics	$0.50		$1.00
8	#2-56 x 1.0 18-8SS hex socket head cap screw: ($5.57 / 50 pcs.)	McMaster-Carr	$0.11		$0.88
8	#2 Spacer .183 OD x .090" I.D. x .38 long black nylon: ($8.76 / 100 pcs.)	Grainger	$0.09		$0.70
2	Coaxial BNC bulkhead connector: Amphenol 31-102	Allied Electronics	$6.09		$12.18
2	Miniature Power Jack: Switchcraft #L722A	Allied Electronics	$4.38		$8.76
2	Sea-Life Desiccator capsule: Moisture Muncher	Diver's Supply	$0.95		$1.90
1	1/8" NPT brass square head pipe plug	McMaster-Carr	$0.62		$0.62
1	Linear Actuator		$97.00		$97.00
1	Delrin Attachment piece and fasteners		$15.00		$15.00
1	Alternate Turnbuckle assembly	ACE Hardware	$8.00		$8.00
			Total	**$0.00**	**$263.21**
	Tether - Material List				
Qty:	**Item Description:**	**Source:**	**Cost:**	**Donated:**	**Total:**
1	Coax Cable in tether	Skagit Whatcom Electronics	$17.95		$17.95
3	Tether Connectors	Janicki Industries	$50.00	$150.00	$150.00
1	5-line BNC Multi-conductor Coaxial Cable x 50’		$132.00		$132.00
1	7-conductor 18 gauge cable x 54’	Sea-Tech 4-H	(Stock)		(Stock)
1	18-conductor 18 gauge cable x 54’	Sea-Tech 4-H	(Stock)		(Stock)
1	.125” I.D. urethane air line		$17.50		$17.50
2	2” PVC pipe caps	ACE Hardware	$1.25		$2.50
1	1.75” I.D x 3/32” section o-ring		$1.50		$1.50
1	1/8” MNPT Schrader valve		$3.50		$3.50
1	1.25” black expandable sleeving x 50’		$37.50		$37.50
1	X-pin Connectors		(Salvage)		
			Total	**$150.00**	**$362.45**

	Ballast System - Material List				
Qty:	Item Description:	Source:	Cost:	Donated:	Total:
2	Stainless Steel Rods for weights	Online Metals	$24.00		$48.00
4	Bolts and nuts for weights	Ace Hardware	$4.50		$18.00
2	Aluminum Square Tubing for weights	Online Metals	$3.00		$6.00
1	High Density Foam	Janicki Industries	$200.00	$200.00	$200.00
2	Water-proof LED Light ribbon strips	Oznium	$13.49		$26.98
1	Aluminum Weight Container	ACE Hardware	$2.00		$2.00
1	Stainless Steel Rod Weight		$15.00		$15.00
			Total	**$200.00**	**$315.98**
	Gripper - Material List				
Qty:	**Item Description:**	**Source:**	**Cost:**	**Donated:**	**Total:**
1	Adapter Plate	Sea-Tech 4-H	(Stock)		(Stock)
8	bolts and nuts for adapter plate	ACE Hardware	$0.79		$6.32
4	bolts and nuts for adapter plate to gripper	ACE Hardware	$0.86		$3.44
2	5/16” Stainless steel bolts	ACE Hardware	$1.55		$3.10
2	5/16” Stainless steel lock nuts	ACE Hardware	$1.83		$3.66
4	3/16” nuts and bolts	ACE Hardware	(Stock)		(Stock)
	Water jetted parts	Janicki Industries	$250.00	$250.00	$250.00
2	Delrin gears	Jameco	$25.00		$50.00
1	Stainless steel worm	Jameco	$50.00		$50.00
4	Sealing Screws with O-rings	Jameco	$1.88		$7.52
1	Planetary Gear Motor	Allied Electronics	$24.00		$24.00
4	5/16” Plastic Washers	ACE Hardware	$1.00		$4.00
8	3/16” Plastic Washers	ACE Hardware	$0.80		$6.40
4	Bolt Spacers	ACE Hardware	$1.50		$6.00
2	Rubber finger tip screws		$1.25		$2.50
1	Canister plug	Sea-Tech 4-H	(Scrap)		(Scrap)
1	O-Ring	Sea-Tech 4-H	(stock)		(Stock)
1	Strain Relief Connector		$0.95		$0.95
			Total	**$250.00**	**$417.89**
	ROV Handles - Material List				
Qty:	**Item Description:**	**Source:**	**Cost:**	**Donated:**	**Total:**
4	Aluminum Handle Brackets	Sea-Tech 4-H	$1.00		$4.00
4	1/4"-20UNC x 4" hex socket head cap screw SS	ACE Hardware	$3.50		$14.00
8	1/4"-20UNC hex lock nut SS	ACE Hardware	$0.59		$4.72
4	1/4" fender washer	ACE Hardware	$0.40		$1.60
2	PVC Handles	Sea-Tech 4-H	$0.50		$1.00
4	PVC end caps	Lowe's	$0.79		$3.16
			Total	**$0.00**	**$28.48**
	Cameras - Material List				
Qty:	**Item Description:**	**Source:**	**Cost:**	**Donated:**	**Total:**
3	Auxiliary camera Assembly and gimbal		$54.00		$162.00
4	Underwater 3-pin plug and cord		$13.00		$52.00
1	Quad Video Multiplexer		$132.00	$132.00	$132.00
			Total	**$132.00**	**$346.00**

	Oil Sampler Assembly - Material List				
Qty:	**Item Description:**	**Source:**	**Cost:**	**Donated:**	**Total:**
1	0.250" Stainless Steel tube		$1.00		$1.00
1	Aluminum Square Tubing	Sea-Tech 4-H	(Stock)		(Stock)
1	Aluminum pivot PI extrusion	Sea-Tech 4-H	(Stock)		(Stock)
1	Aluminum Bracket for attaching assembly	Sea-Tech 4-H	(Stock)		(Stock)
1	1/8" MNPT – ¼" tube Swage-lock adapter fitting		$7.50		$7.50
1	1/8" MNPT - #10-32 fittings and hose		(Salvage)		(Salvage)
4	Collection vials (air filter housings)	ACE Hardware	$13.50		$54.00
1	1/8" MNPT - #10-32 fittings and hose		(Salvage)		(Salvage)
3	1/8" MNPT hex nipples		$3.50		$10.50
16	M4 x 25 SS hex socket cap screws		$0.72		$11.52
			Total	**$0.00**	**$84.52**
	Control System - Material List				
Qty:	**Item Description:**	**Source:**	**Cost:**	**Donated:**	**Total:**
2	double pole double throw toggle switches	Rick Hamiter	$7.99		$15.98
1	Control Box: Pelican 1450NF Protector Case - OD Green - No Foam	Pelican	$79.03		$79.03
2	ETI miniature Joysticks	Neptune ROV	$52.00	$104.00	$104.00
1	2" x 3" x 5" project box		$7.95		$7.95
8	5-pin relay socket		$1.79		$14.32
8	5-pin marine Change-over Relay; 12 VDC; 30 A w/ resistor		$3.95		$31.60
			Total	**$104.00**	**$252.88**
	Sensors - Material List				
Qty:	**Item Description:**	**Source:**	**Cost:**	**Donated:**	**Total:**
1	Mission Sled – 5" x 2" x .125" wall x 12" alum tube		$12.00		$12.00
3	Metric Tape Measure – FastCap "Flat Back"		$6.95		$20.85
1	Miscellaneous SS fasteners		$12.00		$12.00
1	High-visibility Compass		$14.95		$14.95
1	Nickel plated Neodymium magnets	ACE Hardware	$9.95		$9.95
1	1/2" PVC pipe		(stock)		
			Total	**$0.00**	**$69.75**
	Mission Interconnect Box - Material List				
Qty:	**Item Description:**	**Source:**	**Cost:**	**Donated:**	**Total:**
4	Underwater 3-pin bulkhead connectors		$12.00		$48.00
1	Clear Polycarbonate Washdown Enclosure		$22.19		$22.19
3	3/8" NPT Strain Relief connectors		$0.95		$2.85
5	BNC bulkhead Connectors		$3.35		$16.75
1	H1b Aquarian Audio Hydrophone		$95.00		$95.00
1	Phone jack		$9.95		$9.95
1	Gelled candle wax		$14.95		$14.95
1	Snap-in strain relief		$0.50		$0.50
3	Pond light cable plugs		(Salvage)		(Salvage)
4	#8-32 x 1.25" SS screws and nuts		$0.86		$3.44
1	½" Delrin knockout plug		$0.95		$0.95
			Total	**$0.00**	**$214.58**
	Miscellaneous Parts - Material List				
Qty:	**Item Description:**	**Source:**	**Cost:**	**Donated:**	**Total:**
5	Krylon paint	ACE Hardware	$4.59		$22.95
	Urethane potting compound		$5.00		$5.00
			Total	**$0.00**	**$27.95**

Appendix B: Electrical Schematic



Appendix C: Pneumatic Schematic Diagram