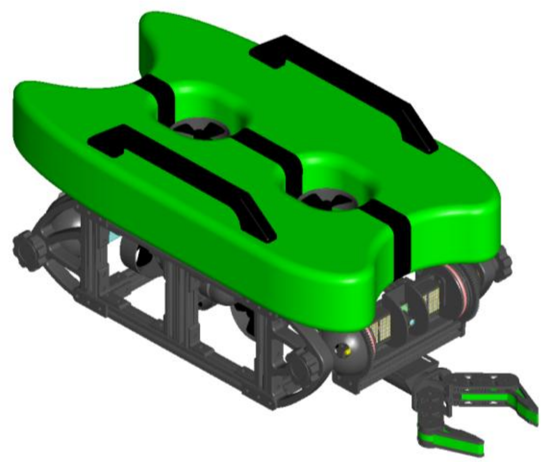
SEA-TECH 4-H CLUB
MOUNT VERNON, WA

EUROPA ENTERPRISES



Preston Peterson - CEO & Captain

Hannah Anderson – CFO & R&D Engineer

Dean Jones - Electrical Engineer

Gunnar Hoglund - R&D Engineer

Tony Harvey - R&D Engineer

Claire Dimock - Documentation

Shelby Heim - Marketing Director

Lee McNeil - Mentor

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1. ABSTRACT

The Europa Enterprises ROV (Remotely Operated Vehicle) is designed and manufactured to assemble and repair ocean observing equipment. The ROV is designed to accomplish four tasks: complete a primary node and install a scientific instrument on the sea floor; install a temperature sensor over a hydrothermal vent; replace an Acoustic Doppler Current Profiler (ADCP) on a mooring platform; and remove bio-fouling from underwater equipment.

Because Europa Enterprises has a focus on robust, cost effective technology, and a passion for marine conservation, the company can provide clients with a low cost solution to effectively maintain ocean observing equipment. Reliable access to these systems is vital to the future health of the world's oceans.

Seven members of the company created a mission strategy which guided them through the ROV design and build process. ROV Europa is constructed from an adaptable framing system to enable reconfiguration of the mission tools in field. A large float and ballast system provide a strong righting moment to promote stability for delicate mission tasks.

The ROV is maneuvered by six, custom made thrusters, which produce four degrees of freedom. They are controlled by a portable joystick station. A custom built gripper, driven by a 12 volt DC gear motor and worm gear, produce a wide grip range, closing in a parallel motion. This enables delicate operations like removing bio-fouling, as well as holding large equipment like an ADCP. A wide angle camera tracks with claw movements for detailed viewing of the manipulator operations.

2. COMPANY STAFF

Preston Peterson

Company Role: CEO

Competition Role: Team captain

Preston, with his four years of experience in building ROVs in Sea-Tech, has desire to learn more about science, marine technology, and oceanography which has inspired him to dig deeper into marine career options. This is his first year attending the MATE International ROV Competition.

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

2013 marks Dean’s third year in participating in the MATE International competition and his sixth year in Sea-Tech. Dean has developed proficient expertise in electrical systems and has spearheaded the controls of the ROV.

Gunnar Hogland

Company role: Mechanical Engineer - Leading Edge Actuation

Competition role: Manipulator Operator

This is Gunnar's first year participating in the Mate competition and his first year in Sea-Tech. He helped construct the frame of the ROV, drilled parts, and worked on the gear for the motor of the claw. He also made the skis for the ROV and put together the components for the tether.

Tony Harvey

Company role: Mechanical Engineer - Frame/Buoyancy Control

Competition role: Mission Commander

Another addition to 2013's team is Tony. Tony assembled the frame for the ROV, he also put together the claw and the motor for rotating the camera and made the acrylic plate that goes on the front of the tether connection box. Tony also helped by cutting the handles for the float.

Claire Dimock

Company role: Engineering Documentation

Competition role: Science Officer - Sensor Deployment

This is Claire's first year in Sea-Tech. Head of the documentation department, she kept track of all the team's purchases and design concepts. She also helped create the unique shape of the float on the ROV.

Hannah Anderson

Company role: CFO

Competition role: Science Officer – Mission Tools

Hannah is another new member of the company. She machined the fore and aft camera and the tether connection box mounts. She also helped shape the float for the ROV and wired the LynxPower connectors onto the thrusters.

3. DESIGN RATIONALE

3.1 Mission Equipped

Europa is an adept Remotely Operated Vehicle (ROV) utilized by Europa Enterprises to complete the tasks presented by its client, the Marine Advanced Technology Education Center (MATE). MATE submitted an RFP proposal requesting the company to design and build a custom ROV, capable of completing the accomplishing the following four tasks: complete a primary node and install a scientific instrument on the sea floor; install a temperature sensor over a hydrothermal vent; replace an Acoustic Doppler Current Profiler (ADCP) on a mooring platform; and remove bio-fouling from underwater equipment. ROV Europa is designed and manufactured to complete each series of tasks with efficiency. Mission tools are engineered for universal operations, which can also accomplish the specific tasks requested in the RFP. The primary mission tool is a custom built gripper for transporting mission equipment such as installing a temperature sensor on a hydrothermal vent, and removing bio-fouling. A system of four cameras perform scanning and navigation functions effectively accomplishing situational awareness.

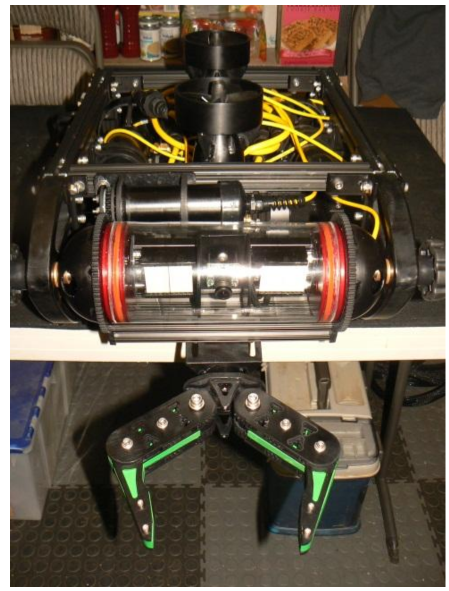
3.2 Design Strategy

Europa Enterprises is part of a larger organization called Sea-Tech, which has been creating ROV's for over a decade. The Sea-Tech ROV technology knowledge base is extensive. The primary team strategy was to leverage this knowledge base by capturing the best designs from previous ROV's, and making improvements to functionality and fabrication.

The design team modeled ROV Europa by employing CAD (Computer Aided Design). Both predefined component models and new designs created by team members were integrated into the ROV assembly. This "digital pre-assembly" process, where the CAD modeler can foresee many size or design related problems, reduced build time and created a more streamlined product.

The design process began by creating a mission strategy which guided the company through the concept selection process. The company's desire is to have all components fully functional upon assembly, reducing rework and custom fit up. With this in mind, Europa took advantage of modern computer aided manufacturing technology such as high-precision water jet cutting and CNC milling. This process is driven by CAD geometry created by Europa Enterprises team members, and accomplished at a sponsor's facility. Members of the team toured the facility to familiarize themselves with the entire process, and experienced modern technology in a real-world industrial environment.

3.3 Mechanical Structure and Stability



3.3.1 External Frame System

Europa Enterprises chose to utilize the slotted aluminum framing system manufactured by 80/20, Inc. This framing system enables convenient adjustment or reconfiguration of the mission tools in the field without making new components. The frame is assembled with the 1" Series 80/20 Inc. framing in a simple box configuration, with the interior left open to locate all six thrusters. This provides protection for the thrusters, and operating personnel. The frame interconnects the floatation, ballast, all six thrusters and the camera/claw assembly to the tether termination box and tether.

3.3.2 Fore-aft Rotating Assemblies.

In order to give the ROV's main camera and claw assembly a sweeping range of motion, the company created a tilting camera assembly. The camera is mounted inside a 4" cast acrylic cylinder sealed with machined aluminum end caps. These caps are mounted to aluminum hemi-spheres with sleeve bearings and water-jetted spur gears. The camera assembly is supported by a ball-lock pin inserted through the sleeve bearing and a 1" aluminum water jetted bracket attached to the frame. A sealed, 12 volt DC planetary gear motor drives a spur gear, pivoting the tilting camera assembly. A full 120 degree range of motion provides the necessary angles for navigating and surveying undersea equipment and bio-fouling. The gripper is mounted to the tilting camera assembly enabling the camera to track with the gripper's movement. The tether termination box is similarly pinned.

3.3.3 Stability

The ROV Europa floatation is made from a slab of 480 kilogram/cubic meter hydrostatic proof poly-urethane foam. It is configured in the same manner as a working class ROV. The float is bolted to the frame through the launch and retrieve handles. The team made a rough estimate of the ROV displacement to rough size the hand-crafted form. Two sliding ballast weight assemblies mount to the lower slotted aluminum rails. The majority of the weight is located on the bottom of the ROV in order to produce a strong righting moment. This technique provides a stiff platform, which is not easily effected by the weight of objects retrieved. Minor trim of the buoyancy was accomplished by casting encapsulated lead shot into the floatation.

3.4 Propulsion Systems

Six custom built thrusters are utilized by Europa to provide detailed maneuverability. Two thrusters, one starboard and one port, provide fore - aft movement and yaw maneuverability. Two vertical thrusters control up and down motion, and an additional pair of lateral thrusters enable the ROV to shift from side to side. The thruster design is an evolution of previous thrusters used on Sea-Tech ROV’s from 2009 to 2012. They were created by significantly modifying Sevylor brand trolling motors. These trolling motors are inexpensive, compact, lower power water proof motors.

In 2010 Team Hydrazilla solved poor reverse propeller performance by testing alternate propellers. Team Europa repurposed those thrusters and designed a new aft thruster housing to shortened the thruster length by 35% and add integrated propeller shrouds. The aft housing was modeled on CAD by the team, and CNC milled at Janicki Industries using the CAD model. The fins and ring were handcrafted and welded to the “coke bottle” shaped housing. The shaft seals were harvested from the original housing and re-installed.

Each thruster is connected to power via waterproof IP68 rated LynxPower in-line receptacles. The re-propellered thruster unit produced an average of 0.62 kg of thrust at 4.7 amps of current before the housing modification. The new housing is much more stream-lined, which should improve performance, but the team ran out of time to re-test.

3.5 Payload Tooling

3.5.1 Gripper.

Europa Enterprises chose to construct a custom built gripper, based on last year's design. It is driven by a 12 volt DC gear motor and worm gear. This is a third generation design within Sea-Tech. The winning 2012 Ranger team successfully employed a similar gripper. The existing claw from the previous year was not compatible with the new machine's mounting rail system. Improvements to the gear motor canister made the repositioning of the claw much more versatile. Details of the shaft seal were also improved.

A high-torque planetary gear motor with 100:1 gear reduction turns a worm gear set. A series of water-jetted spur 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 small objects. They also form a constant force device able to produce a wide grip range. This enables delicate operations like removing bio-fouling, as well as holding large equipment like the body of an ADCP.

3.5.2 Thermal Couple

In order to complete assignments from Task #2 defined by the mission document and the RFP, a custom thermal couple device was manufactured. The thermal couple shroud was fabricated from a 2"-3" PVC bell adapter. The team chose this design avoid obstructing water flowing out of the hydrothermal vent, which could cause the instrument to pop off. The hollow tube design is stable and allows the water to flow freely. A silver-copper junction probe is positioned in the stream so the team can get an accurate temperature measurement.

3.6 Cameras

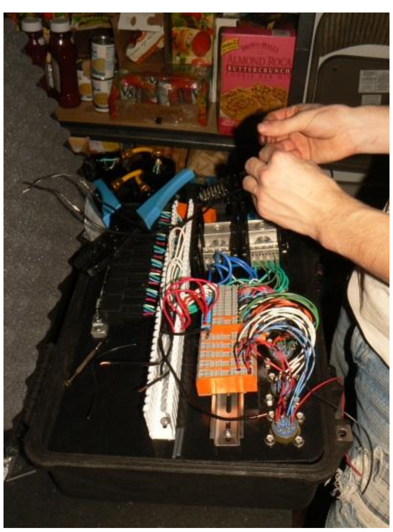
In previous years, the company has had the disadvantage of having cameras locked in one position, giving limited viewing angles. The company chose to utilize one Sony HD 120° field of view (FOV), wide angle color camera as the main camera, and three Sony 90° FOV auxiliary color cameras for viewing task details. The wide angle camera is installed inside an acrylic cylinder and covered by an aluminum cap on each end. The camera assembly is inserted into a 4" diameter cast acrylic cylinder, sealed by silicon o-rings. The three auxiliary camera housings are hand-crafted 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. One auxiliary camera is focused down so that when the ROV is descending, we can have a view of the layout of the tasks. The wide angle camera and an auxiliary camera are situated in and around the forward camera mount so that they are capable of viewing the gripper and tasks immediately in front of the ROV.

The cameras are connected to a 4-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.

Two LED arrays are situated on either side of the main camera in the cast acrylic housing to provide illumination. A shade surrounds the main camera to avoid glare in the wide angle view.

3.7 Control Systems

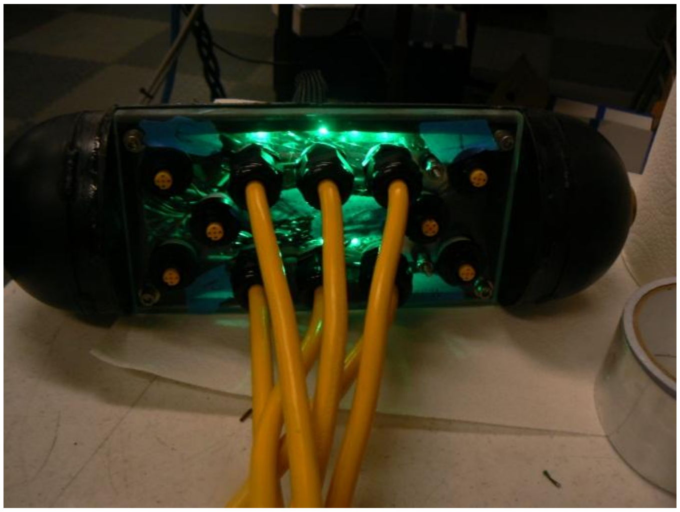


3.7.1 Thrust Control

It was decided that an electric-mechanical switching approach would be more robust for the ROV than solid state controls. This method was chosen because the company felt that solid state controls are prone to water damage. In addition, the complexity of software is unnecessary to accomplish the maneuvers Europa requires in order to complete the mission tasks. Europa's controls are simple, robust, and effective, (refer to schematic on page 13). Switching is accomplished by tandem relays. The relays are 5-pin change-over style, marine grade potted; 12 VDC; rated for a maximum of 30 amps. They include a resistor to dissipate voltage spikes during switching. The thrusters are operated by two 4-pole, momentary joysticks which control the ROV's four degrees of freedom; yaw, surge, sway, and heave. These joysticks are mounted in a portable control box which connects to the main control station. To control the gripper and camera tilt, double pole, double throw toggle switches, are placed inside the main control station. To ensure safety at all times, and meet the requirements of the MATE center, the main control case is equipped with an emergency shutoff switch, and a 25-amp fuse.

3.7.2 Tether Interconnect Box

In 2011 Team Neptune designed a rotating tether termination, which removes the tethers influence on pitch control. Last year Team Endeavor used a clear plastic box to pot the tether interconnects with gelled wax. Europa Enterprises captured these concepts into an enlarged cylindrical stuffing box that is pinned for easy removal and rotation. Connectors mounted to a clear acrylic plate interface allow for ready removal of the tether and add the enhanced viewing features.



The company determined to make all of its cameras and thrusters readily replaceable in the event of a failure. For this purpose, the company designed an interconnect box at the aft end of the ROV where the tether terminates. The interconnect box terminates four video coaxial cables, two electrical payload tool cables, and six thruster cables. Each camera coax is attached to an acrylic face plate via a three pin waterproof bulkhead receptacle purchased from LynxPower.

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. 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 encapsulated with a clear gelled wax to eliminate the possibility of water intrusion. Potting with gel candle wax instead of urethane makes the wires viewable and is readily removable if a change is needed; LED's light up wiring box for viewing. Re-entry for maintenance is easily accomplished by removing the wax, performing the task, and restoring the wax through two ports in the back of the tubular box.

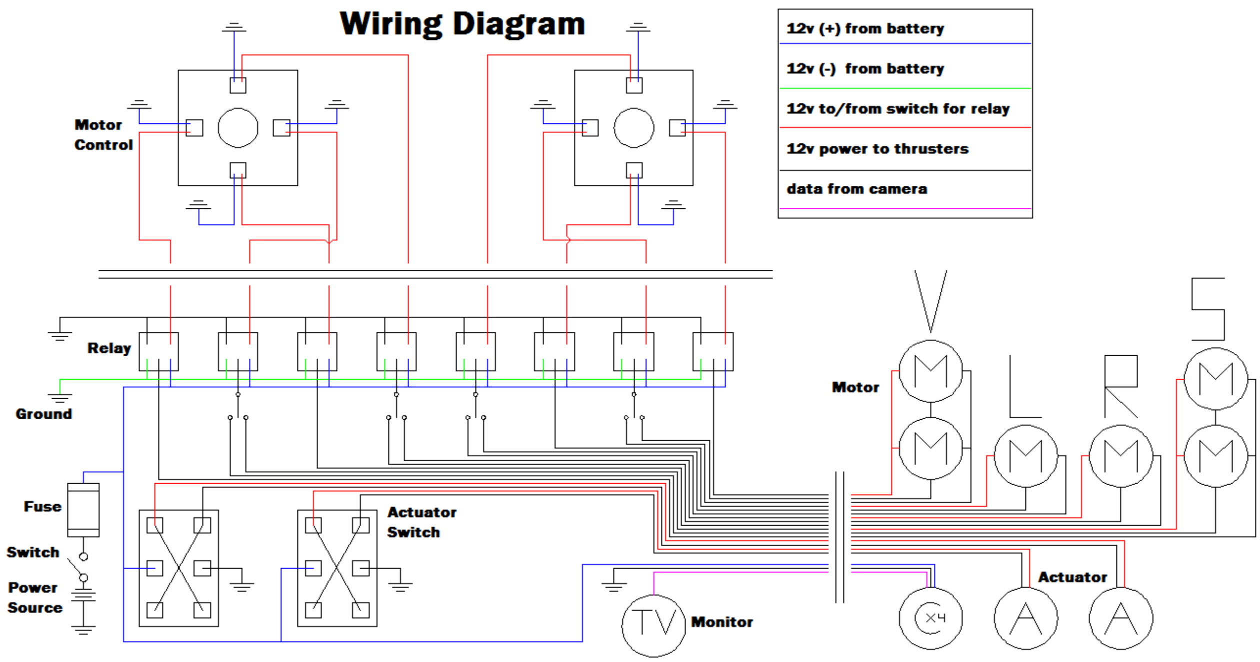
3.8 Tether

The tether contains twenty-one 20 gauge power conductors, and a 4-line multi-coaxial cable for video signals. 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 three military grade 17-pin circular connectors. A potted strain relief connector terminated the sleeving to the interconnect box. To ease transportation, the tether interconnect box is detachable from the ROV via two ball-lock pins as mentioned in section 3.3.1.

3.9 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. The float is painted high-visibility green. A printed safety protocol is followed during testing of the electronics, and a safety check list is used during mission operations setup.

The ROV is configured to protect the thrusters from damage or doing damage to others by placing them inside the aluminum frame, or tightly to the ROV body. A 25 amp fuse and emergency shutoff switch are included in the electrical control system. The use of CNC manufacturing processes has also minimized the opportunity for fabrication related injuries. The company has established a mindset dedicated toward the safety of its operators, and the ROV. Safety glasses are worn during fabrication, testing and operations. Protective clothing is worn when using chemicals such as paint, and these operations are accomplished in a well ventilated area. In summary, Team Europa has an excellent track record of safety through-out the entire process.



Control Schematic (see Appendix C for full size image)

4. 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:
Frame and Buoyancy	522.41	650.00	1172.41
Propulsion	89.70	2960.00	3049.70
Video System	271.32	120.00	391.32
Tilting Camera/Termination Box	276.55	200.00	476.55
Tether and Interconnect	310.09	15.00	325.09
Control System	378.13	229.00	607.13
Gripper	82.98	650.00	732.98
Thermocouple Sensor Assy	0.00	100.00	100.00
Engineering Documentation	107.44	0.00	107.44
Grand Total:	2038.62	4824.00	6862.62

5. TROUBLESHOOTING

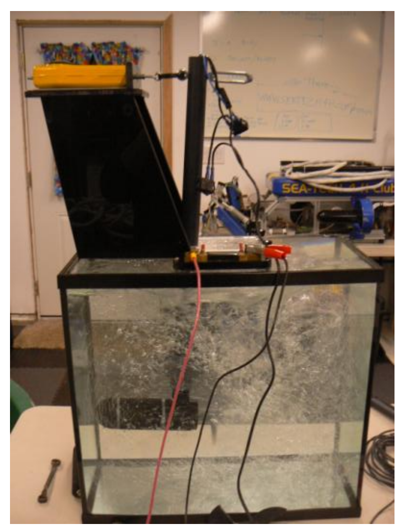
Troubleshooting is a necessary process when encountering unplanned results in assembling and testing an ROV. Throughout the build process, the company utilized troubleshooting techniques when a problem is discovered. The technique looks like this:

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

A troubleshooting example involves the ROV thrusters. When wiring the controls for the ROV, it was discovered that a couple of thruster propellers were rotating incorrectly. The condition was diagnosed to determine the extent, possible sources were discussed and listed and systematically eliminated until it was determined that the thrusters were wired with the polarity reversed.

The team listed the possible places were the wire connection could be incorrect, such as: the wiring in the main control case was crossed; the joysticks controls were improperly wired; or the onboard interconnect could be crossed. After close examination, it was discovered that the tether interconnect, which connects the tether to the ROV, had not been labeled. This error increased the likelihood of a problem.

The first two possibilities were assigned to the least likely, and the third was tested. The team utilized a multi-meter to determine the correct polarity, and labeled each conductor to its correct pair. The problem was determined to be a series of bulkhead connectors soldered\ to the wrong leads changing the polarity.



This situation is one example of testing achieved by Europa Enterprises. The ROV was also tested in a small tank of water preceding a full test dive to observe correct operations. Initially, a test on the ROV's thrusters was conducted 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.

6. CHALLENGES FACED

6.1 Team Size

This year, Europa Enterprises consisted of seven diverse members. Having a seven member team has its advantages, such as easier distribution of tasks, but it also has its challenges. It is desirable to divide the workload evenly so that each member has a proper share of the workload, and can develop a more comprehensive knowledge of all the ROV systems. This challenge was overcome by a tracking the 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.

6.2 Unexpected Frame Design Issues

The company selected the 1” series 8020, Inc. extruded aluminum profile because of the utility of easy adjustment, and the size seemed the best fit for the compact configuration of the overall ROV. Part of the ease of adjustment is the feature where drop-in nuts can be readily inserted into the slots. The company learned late in the assembly process that the 1” series nut do not drop in. It was necessary to partially disassemble the frame in order to add nuts. This reduced the convenience of using this system. The solution was to purchase extra nuts and insert spares for future modifications.

The compact configuration of this ROV design is a little too tight, making it hard to access components. The company did model the assembly in CAD, but didn’t perform accessibility checks. Processes were put in place to pre-assemble components before installing into the frame.

7. LESSONS LEARNED

7.1 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. Scheduling meetings was becoming a challenge as the year progressed. Some members of the team were having difficulty finding a compatible meeting time so many members were missing out on the more frequent team meetings. It was decided something had to happen in order to fix this inequity.

The team learned communication was the key to overcoming this dilemma. Communicating through e-mail and text message, to remind every member of their responsibilities, was used to keep the project on schedule. An assignment checklist was maintained and progress was updated daily. Copies were distributed throughout the team on a regular basis. The team tracked attendance at every meeting.

Since, during pool missions, we are allowed only six team members on the pool deck, the team determined that the level of effort of each member would play a significant role in selecting which member would participate.

The team learned that written checklists and protocols were of 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 team's capability to function as a coherent group.

7.2 Thruster Problems

A week before the competition, a team member noticed thrusters were spinning inconsistently and stopping, reducing the thrust that was needed to perform certain mission tasks. Among the problems that we were having, there was shorting between the wires inside the motor, and some were taking on water due to improper sealing of the fasteners. The team decided to risk using the thrusters during the regional competition, which resulted in a poor performance of the second mission run. After the regional competition the team discussed options, whether to buy new thrusters that are more efficient, or to improve the current design. Due to lack of funding, they decided to refurbish the thrusters used at the regional competition.

8. FUTURE IMPROVEMENTS

8.1 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 volume of the ROV had reduced maneuverability. Adjustments were made, but the team decided that more modifications would be beneficial.

Scaling down the volume of the ROV floatation and ballast, to make it more streamlined, should be considered. A more hydrodynamic shape would also help.

Incorporating some type of programmable logic controller into the ROV's controls, 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.

8.2 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.

9. TEAMWORK

The Europa ROV is the result of successful collaboration, which required excellent project management skills. Having seven team members in the company required 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 prototype ROV in a short period of time.

A milestone schedule, action item list, and a project checklist were developed to track the project. In addition, project roles and responsibilities 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 significant amount of each member's time because of minimal mentor participation, and because each component was hand 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 club meetings to work on design modifications and strategies was necessary to insure that ROV Europa would be ultimately finished on time. In addition, the technical report was created and written with contributions from each team member's area of expertise.

10. Ocean Observing systems

Much of the information about the ocean we know today has come from a vast variety of ocean bottom observing instruments. Since divers have time restraints, are limited to shallow depths because of pressure, and have limited air supply, they have a limited observation window. Ocean bottom observing systems can bare the load of extreme water pressure and may run for years on one battery. Going where a diver would never be able to go, these instruments sit on the sea floor for extended periods of time taking measurements of currents, temperatures, light, hydrothermal activity, seismic events, salinity, turbidity and much more. As the extent of our knowledge about the ocean increases, the need for divers decreases and more complex and high tech observing instruments are required. Instruments such as ocean bottom seismometers (OBS), acoustic Doppler current profilers (ADCP), and hydrothermal vent thermometers are used. These complex instruments are designed to function in extreme environments. The OBS sits on the sea floor under immense pressure and records data that is used locate the source of seismic events as well as the geophysics and geology of the sea floor and deeper crust. ADCP's transmit and receive sound signals, much like sonar, to investigate the magnitude of water columns and what direction they are traveling. Although the costs of ADCP's are relatively high, they have no mechanical parts subject to bio-fouling, and can observe up to one thousand meters of water column. Thermometers for hydrothermal vents, the ocean-observing instrument that must work under the most extreme conditions, must be able to record accurately temperatures of more than 340^{o}C (700^{o}F). As bizarre as it may seem to focus on a hydrothermal vent, life around these vent communities is 10,000 to 100,000 times denser than the surrounding water that is 0^{O} C and below.

11. REFLECTIONS

The ROV Europa is a unique piece of machinery that has put forward many challenges that we, as a team, have learned to overcome. Europa Enterprise's ROV is capable of completing tasks, put forward by its client, with adequacy and thoroughness. Designing and manufacturing this mechanism has brought the team members closer together.

As individual team members, we all have found aspects of this project where we can excel in. In working on the ROV, our group has discovered that we are capable of working together with little difficulty. 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 as well. Moreover, the MATE Center's goal of giving students the opportunity to enhance their entrepreneurial skills has been quite beneficial to us. We have broadened our networking skills by reaching out to other businesses and organizations, in a professional manner in search for funds and sponsorship.

The MATE Center's competition has inspired us all to expand our knowledge in science and technology. We have found that the skills developed in participating in the competition can be used in our daily lives. 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.

12. ACKNOWLEDGMENTS

Europa 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 have Europa.

•**The MATE Center** - Your competition has challenged us to create greater things. Thank you for your inspiration.

• **Mrs. McNeil** - For letting us take over her home for the last 9 months.

• **Production Plating** - Thank you for the anodizing services!

• **Janicki Industries** - who donated the aluminum, water jetting, and the raw float materials. Thank you!

• **Mr. Lee McNeil** - We would like to specificaly 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 mentor.

• **Mr. Cocheba** – Thank you for the donation of the video multiplexer.

• **The Skagit County 4-H Extension** – Thank you for your continued support of our progress.

13. APPENDIX

13.1 Appendix A: Safety Checklist & Protocol

ROV Setup & General Safety:

- When connecting ROV to power, (a) team member(s) must check to ensure correct polarity.
- All controllers, monitors, and equipment must rests securely on command center table.
- Confirm 25 amp fuse is in place and working correctly.
- Power cord plugs must be fully inserted, and out of the way in order to eliminate tripping hazards.
- Keep all parts and hands away from propeller blades when ROV is powered on.
- When servicing electrical components, confirm that power is off and disconnected.
- When testing powered components, make sure before adding power, that there are no conductors that are touching, which could cause short circuiting.
- In the case of an emergency, flip green emergency shutoff switch located on the control console to cut power to ROV.
- Keep any metal devices, cords and connectors away from battery terminal to avoid short circuiting & sparking.

13.2 Appendix B: Detailed Material Expense Report

Category / Item #:	Qty:	Item Description:	Mfg. P/N:	Source:	Donated:	Unit Cost:	Total:
Frame & Bouyancy							
1	4	1" X 1" Black T-Slotted Extrusion	1010-Black	80/20 Inc		$4.64	$18.56
2	4	1" X 1" Black T-Slotted Extrusion	1010-Black	80/20 Inc		$3.84	$15.36
3	8	1" X 1" Black T-Slotted Extrusion	1010-Black	80/20 Inc		$1.60	$12.80
4	1	1" X 2" Black T-Slotted Extrusion	1020-Black	80/20 Inc		$6.58	$6.58
5	1	1" X 2" Black T-Slotted Extrusion	1020-Black	80/20 Inc		$4.23	$4.23
6	2	1" X 2" Black T-Slotted Extrusion	1020-Black	80/20 Inc		$2.59	$5.18
7	1	1" X 1" Black T-Slotted Extrusion	1010-Black	80/20 Inc		$5.72	$5.72
8	24	Black-10 S 4 Hole inside corner bracket	4115-Black	80/20 Inc		$4.96	$119.04
9	8	Black-10 S 3 Hole Joining Strip	4118-Black	80/20 Inc		$5.21	$41.68
10	8	Black-10 S 3 Hole inside corner bracket	4176-Black	80/20 Inc		$4.76	$38.08
11	28	Black-10 S to 15 S 2 Hole trans inside corner bracket	4503-Black	80/20 Inc		$4.26	$119.28
12	200	Socket Head Cap Screw		80/20 Inc		$0.35	$70.00
13	4	Teather/camera assembly mounts		Janicki Industries	$400.00	$0.00	$0.00
14	1	High Density Polyurethane Foam Block		Janicki Industries	$250.00	$0.00	$0.00
15	10	Primer / Hi-vis Green / Clear Spray Paint		Ace Hardware		$6.59	$65.90
16	2	3 Lb Steel Trim Weight		Sea-tech salvaged	$50.00	$0.00	$0.00
17	2	Stainless steel drop-in nuts (100 / bag)				$95.00	$190.00
				Sub-total:	$650.00	Sub-total:	$522.41
Propulsion							
1	12	Water Jetted Alluminum Motor Mounts		Janicki Industries	$360.00	$0.00	$0.00
2	6	Kort Nozzles		Janicki Industries	$2,100.00	$0.00	$0.00
3	6	Sevlyor 12 VDC / 12-Lbf Thrust Trolling Motors		Sea-tech salvaged	$500.00		$0.00
4	6	Four Blade Propellers				$13.99	$83.94
5	18	Bolt o-rings				0.32	5.76
				Sub-total:	$2,960.00	Sub-total:	$89.70
Cameras & Sensors							
1	1	Wide angle board camera 460 lines	PC823XS	Super Circuits		$79.99	$79.99

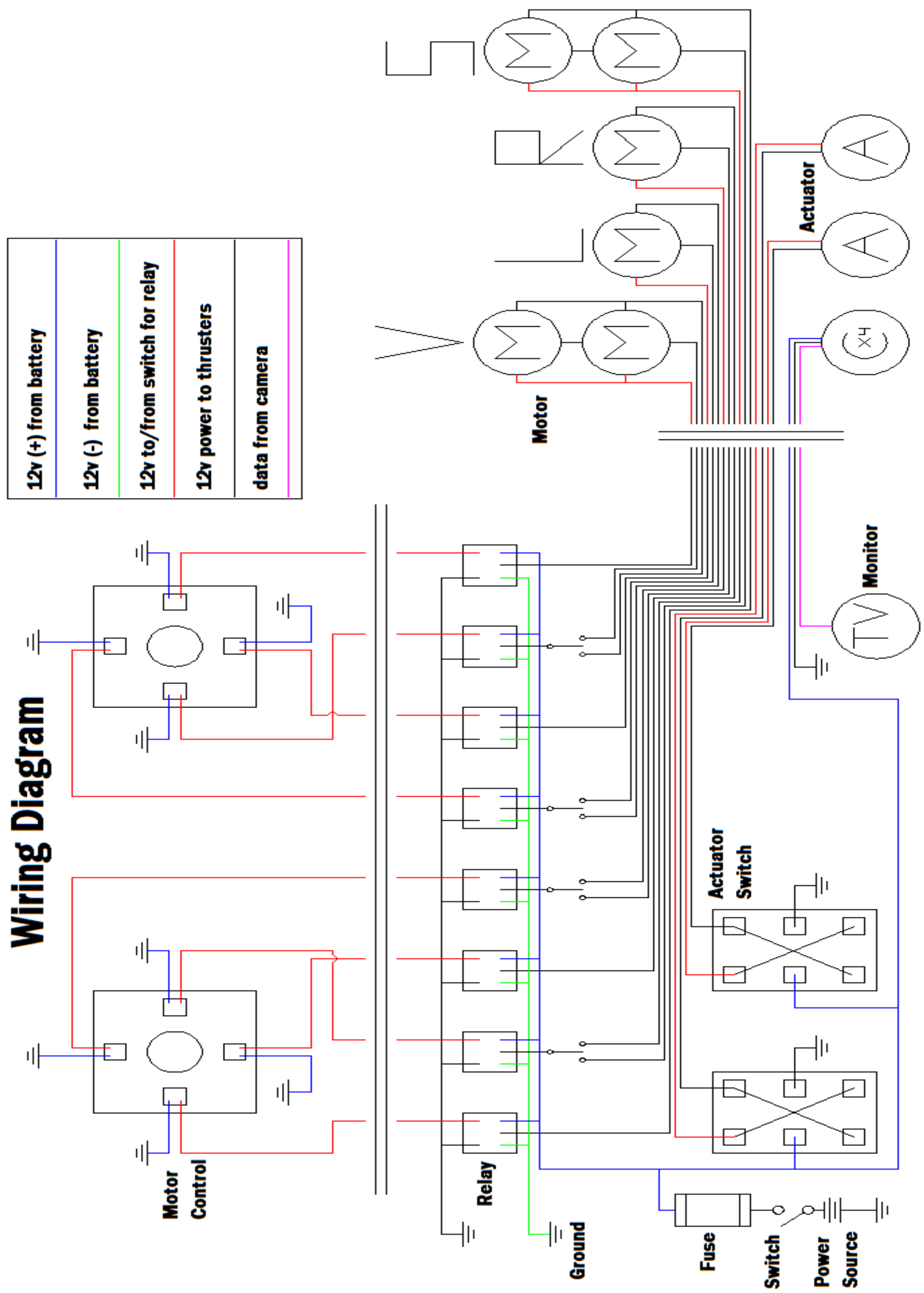
13.2 Appendix B: Detailed Material Expense Report

Category / Item #:	Qty:	Item Description:	Mfg. P/N:	Source:	Donated:	Unit Cost:	Total:
2	3	380 line board camera	PC303XS	Super Circuits		$39.99	$119.97
3	2	10-32 SS Rivnut	#98005A150	McMaster Carr		$14.42	$28.84
4	2	10-32 SS Thumb Screw	#99607A167	McMaster Carr		$10.97	$21.94
5	2	#10 SS Serated Washer	#91812A427	McMaster Carr		$7.89	$15.78
6	5	3/8" NPT Cord Grip	#2638	Dell City Electric		$0.96	$4.80
7	1	Machined Alluminum Camera End Caps		Janicki Industries	$120.00		$0.00
				Sub-total:	$120.00	Sub-total:	$271.32
Tether							
1	5	BNC to BNC coupler	#70000454	Allied Electronics		$3.95	$19.75
2	2	5 line BNC coaxial cable	#CTL5B-50B	L-Com		$126.00	$252.00
3	1	Acrylic plate		SeaTech	$15.00	$22.19	$22.19
4	5	BNC Solder Bulkhead	#512-1276	Allied Electronics		$3.23	$16.15
5	1	Teather Strain Relief		McMaster Carr		$10.99	$10.99
6	1	Green LED Lights		Auto Zone		$14.99	$14.99
7	1	Urethane Potting compound		AeroMarine		$13.99	$13.99
8	52	Expanded Sleeve		Del City		$0.52	$27.04
				Sub-total:	$15.00	Sub-total:	$310.09
Controls and Console							
1	5	BNC bulkhead fittings		Skagit Whatcom Electronics		$4.99	$24.95
2	5	1' Foot BNC jumper cables		Allied Electronics		$2.75	$13.75
3	5	Right angle BNC adapters		Allied Electronics		$2.87	$14.35
4	1	19" insignia monitor	#19E430A10	Ebay		$152.00	$152.00
5	1	Quad Color Processor	#VM-Q401A	CCTV camera pros		$129.99	$129.99
6	1	.08" non glare acrylic 17"x22"	Clear	Tap Plastics		$15.32	$15.32
7	1	1/8" ABS sheet 18"x24"	Black	Tap Plastics		$15.32	$15.32
8	1	Miscellaneous SS fasteners		Tacoma Screw		$12.45	$12.45
9	1	Control Box	#1500 black	Pelican	$129.00		$0.00
10	1	*Water Jetted Alluminum Parts*		*Janicki Industries*	*$100.00*		$0.00
				Sub-total:	$229.00	Sub-total:	$378.13
Gripper & Mission Tools							

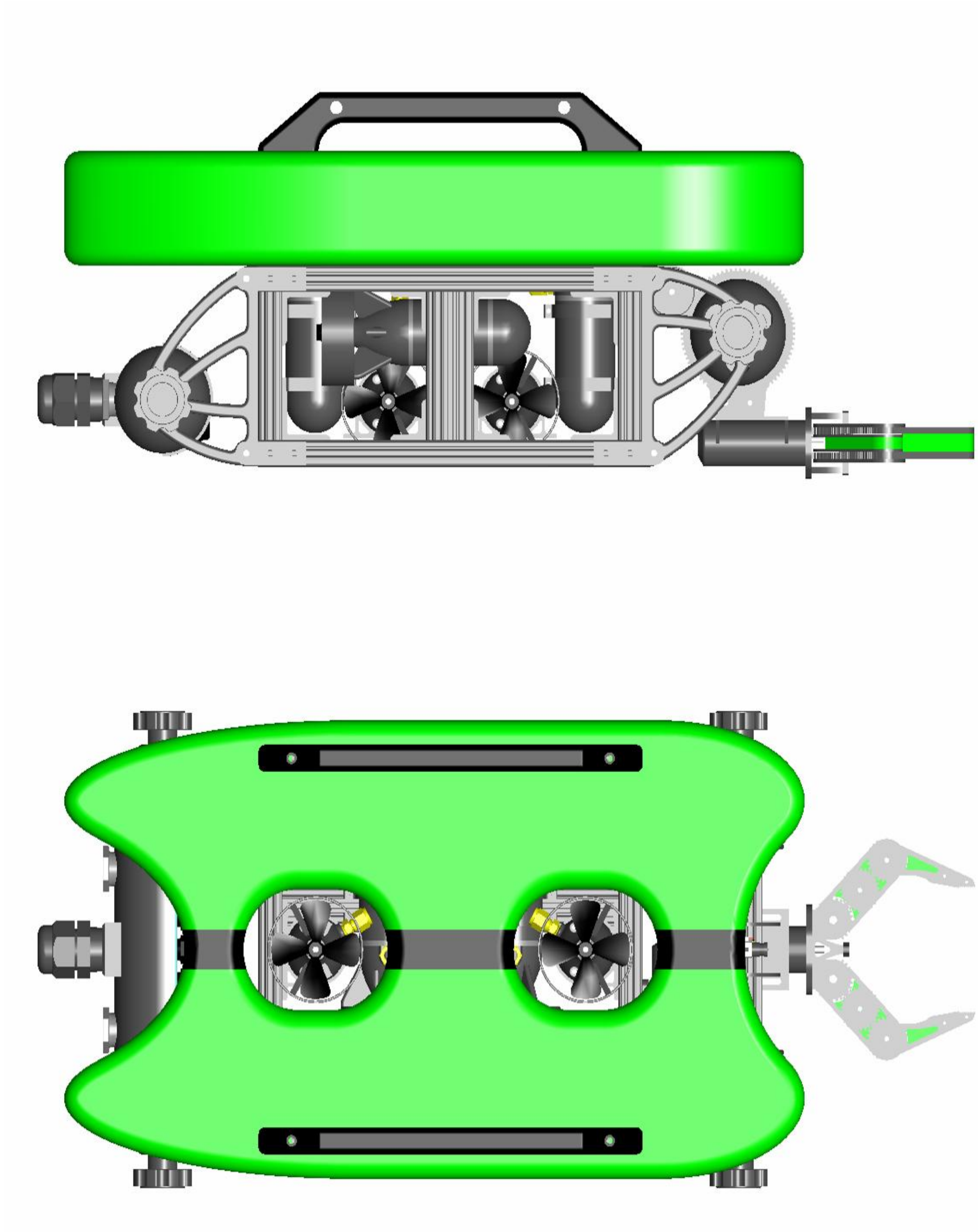
13.2 Appendix B: Detailed Material Expense Report

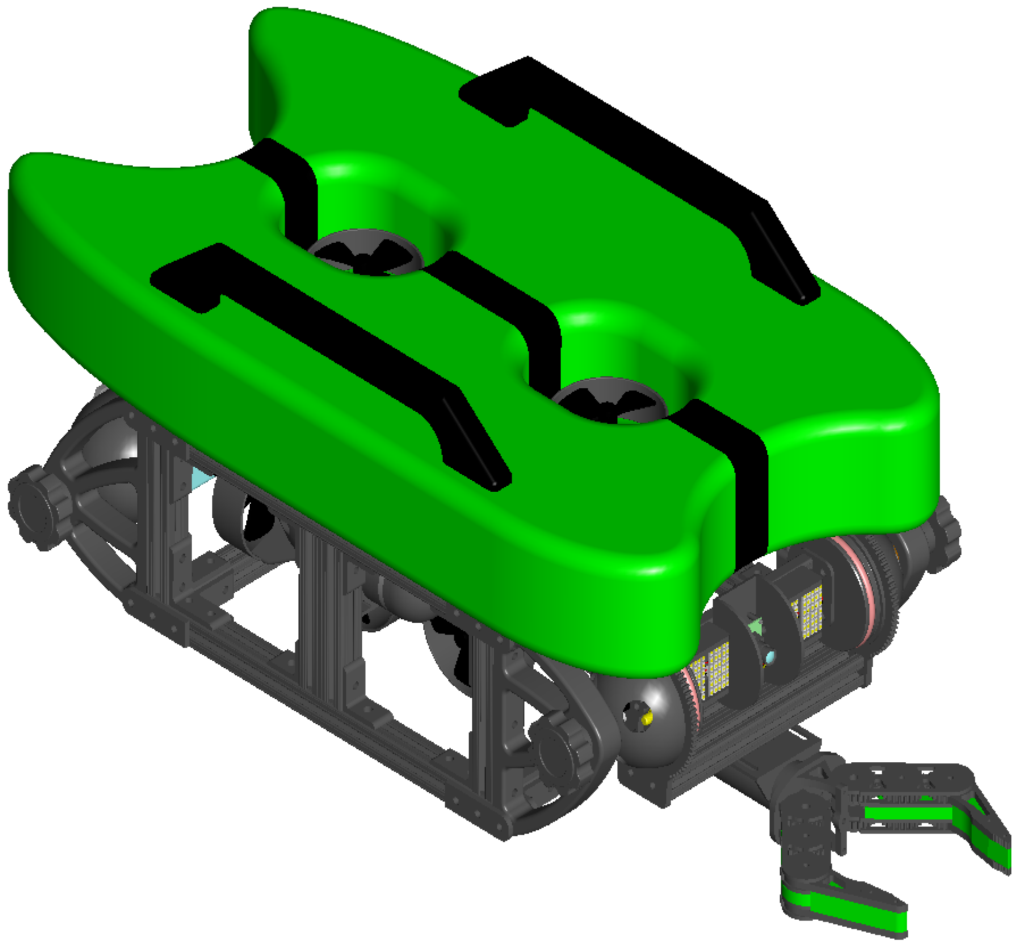
Category / Item #:	Qty:	Item Description:	Mfg. P/N:	Source:	Donated:	Unit Cost:	Total:
1	1	Connector		Lynxpower		$14.99	$14.99
2	1	Miscellaneous SS fasteners		Ace Hardware		$35.00	$35.00
4	1	Gearmotor		Crust Crawler		$32.99	$32.99
5	1	*Water Jetted Alluminum Parts*		*Janicki Industries*	*$650.00*		$0.00
6	4	High Density Polyurethane Foam Parts		scrap		$0.00	$0.00
				Sub-total:	$650.00	Sub-total:	$82.98
Engineering Documentation							
1	1	Poster printing cost		Office Depot		$79.95	$79.95
2	1	Foam-core Board		Office Depot		$14.99	$14.99
3	1	Report Printing		Office Depot		$12.50	$12.50
				Sub-total:	$0.00	Sub-total:	$107.44
Tiltilting Camera / Termination Box							
1	4	4" dia. Hemispherical dome		Sharpe Tubing		$14.99	$59.96
2	2	4" OD x 1/8" wall x 9" long aluminum tube		Online Metals		$43.50	$87.00
4	1	Miscellaneous SS fasteners		Ace Hardware		$35.00	$35.00
5	1	Gearmotor		Crust Crawler		$32.99	$32.99
6	1	*Water Jetted Alluminum Parts*		*Janicki Industries*	*$200.00*		$0.00
7	4	1/2" ID x 11/16" OD x 1/2" long bronze flange bushings		McMaster Carr		$3.45	$13.80
8	4	1/2" ball lock pin assembly		McMaster Carr		11.95	$47.80
				Sub-total:	$200.00	Sub-total:	$276.55
				Estimated Total:	$4,824.00	Total cost:	$2,038.62

13.3 Appendix C: Control Schematic



13.4 Appendix C: Control Schematic





<u>ROV Europa Specifications:</u>
Dimensions- 99cm Length Overall x 45cm Wide x 37cm High
Total Dry Weight- 34.9 kg
Materials- anodized aluminum, urethane foam, cast acrylic tubing, poly-ethylene, stainless steel fasteners, epoxy, lead and gel candle wax
Total Cost- $1400 purchased; $2100 donated
Safety Features- guarded propellers, emergency shut-off switch, no pressurized power systems, encapsulated interconnects.
Features- stable platform, articulated leading edge camera/claw assembly, removable tether, adaptable frame, wide range parallel gripper.