University of North Carolina at Charlotte
Charlotte, North Carolina
Explorer Class

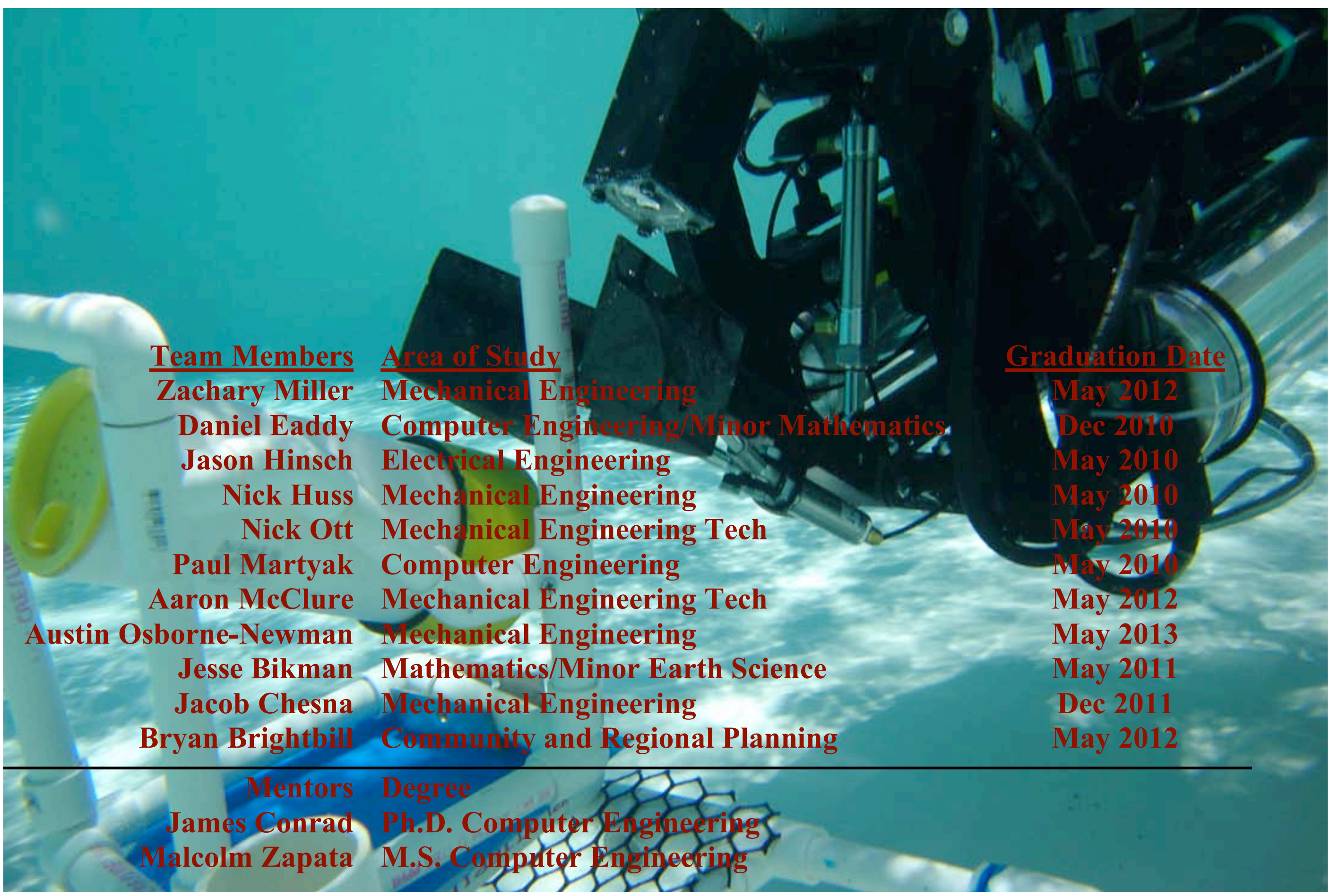
ROV NORM II

NAVIGATIONAL OPEN-WATER ROBOTICS MACHINE

TECHNICAL REPORT

2010 MATE International ROV Competition

ROVs in Treacherous Terrain
Hilo, Hawaii



Team Members	Area of Study	Graduation Date
Zachary Miller	Mechanical Engineering	May 2012
Daniel Eaddy	Computer Engineering/Minor Mathematics	Dec 2010
Jason Hinsch	Electrical Engineering	May 2010
Nick Huss	Mechanical Engineering	May 2010
Nick Ott	Mechanical Engineering Tech	May 2010
Paul Martyak	Computer Engineering	May 2010
Aaron McClure	Mechanical Engineering Tech	May 2012
Austin Osborne-Newman	Mechanical Engineering	May 2013
Jesse Bikman	Mathematics/Minor Earth Science	May 2011
Jacob Chesna	Mechanical Engineering	Dec 2011
Bryan Brightbill	Community and Regional Planning	May 2012

Mentors	Degree
James Conrad	Ph.D. Computer Engineering
Malcolm Zapata	M.S. Computer Engineering

Completed Photo of ROV NORM II (Photo by Bryan Brightbill)

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ABSTRACT

This technical report describes the Remotely Operated Vehicle (ROV) NORM (Navigational Open-Water Robotics Machine) II , built by the University of North Carolina at Charlotte to compete in the 2010 MATE ROV Competition. The purpose of this ROV is to explore the Loihi seamount by deploying instruments, taking sensor readings, plotting data, and collecting samples of geologic features and organisms that inhabit the volcano's surroundings. NORM is built out of positively buoyant sheet PVC and aluminum and has a mass of 15 kg. The major design focal point was on a small, compact design without compromising functionality. NORM is only 38 cm in width, 36 cm in height, and 61 cm long. The ROV has one multifunctional pneumatic manipulator on the front, an agar sampler on the back, and four cameras. The manipulator on the front also has a temperature sensor that extends out of the claw. Two electronic tubes are positioned on bottom of the ROV to keep the otherwise symmetrical frame upright. These features allow the pilot to complete the tasks set by MATE in a timely manner while not damaging the environment of the volcano. To accomplish the design and construction of NORM, the team completed all components and programming. During the process, team members learned how to work with multiple engineering disciplines and build a ROV that incorporated custom-built parts from each discipline.

Figure 1: Charlotte Area Robotics Team 2010

Left to Right: (Back Row) Nick Huss, Aaron McClure, Nick Ott, Austin Osborne-Newman, Malcolm Zapata
(Front Row) Daniel Eaddy, Jason Hinsch, Bryan Brightbill, Zachary Miller
(Not Pictured) Jesse Bikeman, Jacob Chesna, Paul Martyak, Dr. James Conrad.

1.0 Budget/Expense Sheet

Table 1: Total Cost of Materials/Travel

Item	Quantity	Indiviual Cost	Total Cost
Electical Components			220.00
Electrical Housings	2	25.91	51.82
Aluminum Stock			129.46
Rod Ends	6	7.00	42.00
Check Valve	2	15.00	30.00
Bolts & Nuts			30.84
O-Ring Pack	1	15.94	15.94
Air Cylinders			95.95
Electronic Valve	8	20.00	160.00
Air Manifold	1	40.00	40.00
PVC Sheet	1	50.00	50.00
SeaBotix BTD 150 Thruster	4	395.00	1580.00
Color Camera	2	39.99	79.98
Wide Angle Board Camera	1	50.00	50.00
Rapid Prototype Housings	3	30.00	30.00
Lights Camera Action Camera	1	400.00	400.00
Saitek X52 Joystick	1	89.88	89.88
Computer	1	400.00	400.00
Color Quad Camera Splitter	2	55.76	111.52
LCD Screen	2	96.78	193.56
Control Case	1	79.87	79.87
Tether		71.35	71.35
Colored Acrylic		20.05	20.05
Foam	1	46.01	46.01
O-Rings	3	0.41	1.24
Matable Connectors (Reused)	22	10.00	220.00
Matable Connectors (Subconn)	2	86.54	86.54
		Total ROV Cost (USD)	4326.01
Travel Expense	Quantity	Individual Cost	Total Cost
Flights to Hilo	4	850.00	3400.00
Dorm Room/Food	1	1300.00	1300.00
ROV Shipping Cost	2	300.00	600.00

Table 2: Monetary Donations

Contributions	Value (USD)
University of North Carolina at Charlotte Electrical Department	1185.00
University of North Carolina at Charlotte IEEE	1300.00
Charlotte Area Robotics	1500.00
Outer Banks Pastries	3000.00

2.0 DESIGN RATIONALE-TASKS

This section of the report describes the tasks set forth by MATE focusing on underwater volcanoes and the role ROVs play in the science and exploration of them. The team decided that is would be imperative to have a compact ROV and a multiple functioning arm.

2.1 TASK #1 RESURRECT HUGO

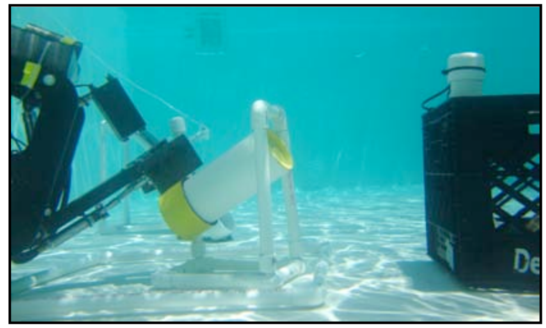


Figure 2: ROV NORM II dropping HRH at site

The first mission that the ROV will have to perform is to locate an area of rumbling, release the HRH from the elevator by removing two pins and place it at the rumbling site. After that is complete, the port on HUGO's junction box must be opened and the HRH connector must be installed to begin transmitting data. The ROV uses its four-axis manipulator to open HUGO's junction box, release and install the HRH connector. In figure 2, NORM II is using its manipulator to pick the HRH. In figure 3, NORM II is picking up the HRH power/communication.

2.2 TASK #2 COLLECT SAMPLES OF NEW SPECIES OF CRUSTACEAN

This mission is to navigate through a cave and maneuver to its back. Once in position the ROV will collect up to three samples of crustaceans. After the ROV has secured these samples, the ROV will then navigate back through the cave. The three samples will then be returned to the surface to verify that it is a new species and documented for science. The team spread the cameras across the ROV: front, back and side, to help navigate through the cave. The crustaceans will be picked up with the manipulator on the front on the ROV and then placed in a basket that was brought down by the ROV. This will eliminate the need for the ROV to make multiple trips inside the cave and risk damaging the environment. Lights were also added to help the visibility inside the cave.

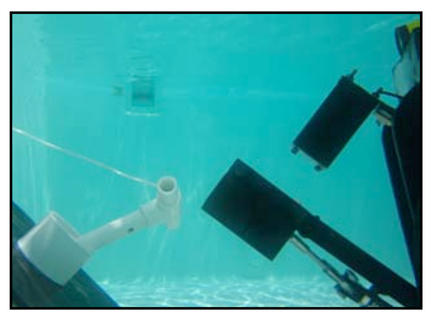


Figure 3: ROV NORM II grabbing HRH power/communication

2.3 TASK #3 SAMPLE A NEW VENT SITE

The third mission is to measure the venting fluid at three different heights on the chimney then create a graph of the different measured temperatures vs the chimney height. NORM must then collect a vent spire from the base of the chimney and return it to the surface. To minimize the overall size of NORM, the temperature probe extends out of manipulator. The temperature readings will be sent via RS232 to the surface computer were a readout will be displayed. After the data is collected, a vent spire will be collected by the manipulator and returned to the surface.

2.4 TASK #4 SAMPLE A BACTERIAL MAT

The last tasks consists of collecting a specific volume of bacterial mat and returning the sample to the surface. The ROV has a camera placed above the agar sampler orientated straight down. This camera will allow the pilot to lower the ROV directly into the sample and not damage the surroundings. The sampler has a ball check value on the top. This valve will ensure the water can escape the sampler, and when the ROV obtains the sample, it will not fall out because of the pressure that has built up.

3.0 DESIGN RATIONALE- SUBSYSTEMS

This section describes the individual subsystems that make up ROV NORM II. The team designed all of the individual components using computer-aided design (CAD), this allowed our team to have a 3-D model of NORM before starting construction. CAD helped show our team how the electrical, computer and mechanical components all work together on NORM II.

3.1 SAFETY PRECAUTIONS

Our team put in numerous safety precautions during the designing and building phases. When first researching thrusters, propeller shrouds were a must priority. Without these wires, hands and/or props could get caught in the propellers and cause major damage. Another safety precaution put into effect was a leak detect in the electric housings, if water was able to reach the inside of the housing the electronics would shut off. This would prevent the electronics from running while emerged in water. A safety check list was created to ensure team members or the ROV was not harmed in testing. This checklist can be found in Appendix D. The team also individually checked each component for waterproof seals before mounting on the frame. This ensured that each component had at least two water testes. Safety was a main priority in designing ROV NORM II.

3.2 FRAME DESIGN

The team established that one important goal in exploring underwater volcanoes was to not disturb the surroundings. Before the shape of the frame was determined, the team initially desired that the frame be made of a material that would render the robot as neutrally buoyant as possible; therefore, reducing the necessity to add a significant amount of positively buoyant material and reducing the complexity of the electrical system required to control thruster reactions for the counter balance of buoyancy effects. After great debate over what material to use for the ROVs frame—either PVC or aluminum—it was eventually decided that a combination of both would be used. PVC was selected for the two main vertical sides and aluminum was for bracing between the sides for strength and to act as an easier mounting surface for the payload tools. The perfect amount of aluminum bracing was determined so that the frame was neutrally buoyant. The width between the two PVC sheets was minimized to help keep the size of the ROV to a minimum. Two underwater housings were positioned at the top of the frame to ensure that NORM remains upright. One tube contains all of the bottom side electronics while the other tube holds the manifold and pneumatic values for the payload tools. This separation was done to minimize the size of the two housings.

3.2.1 Density of Material Testing

To test for buoyancy, the team needed to know the exact density of the PVC material which made up most of the frame. A nominal density of PVC plastic was given to be 0.55 g/cm^3. A specified volume of PVC was cut to be 10 cm x 10 cm x 1.9 cm. The block was then weighed, which resulted in a mass on the digital scale 95g. The measurements were then utilized in the equation for density,

$$D = \frac{m}{V} \qquad (1)$$

The density of the material was determined to be 0.5 g/cm^3. The material was less dense than water, therefore, it was concluded that the material was positively buoyant.

3.3 THRUSTERS

One of the most important decisions for a remotely operated vehicle is how the vehicle will achieve motion, also known as propulsion. The debate over what kind of thrusters to use was a big one. The major factors that influenced our final decision were power, cost, and the viability to manufacture some ourselves. We ruled out the small, cheap thrusters because of the amount needed to achieve the power our team was looking for. The final decision was made based on the amount of other parts our team was going to design and make in-house. The Seabotix BTD150 thrusters have the power our team was looking for and the compact design that had been pursued in our own design. The thrusters run at 19 V, only use 4 amps and weigh 350 grams in water. The team is in the process of designing our own thrusters for next years competition.

3.3.1 Thruster Testing

It was important that each thruster be tested before it was mounted on the ROV. In order to test a thruster, it had to be attached to a low friction track that limited the thruster to forward and reverse travel only. Then, the thruster was linked to a thrust gage. The test set up was lowered into a small tank filled with water. The thruster was then connected to a serial circuit made of car batteries. Readings on the force gage were recorded for various input voltages. Results are tabulated in Table 3.

Table 3: Team Tested Voltage vs Thrust

Voltage (VDC)	Thruster 1 (kg)	Thruster 2 (kg)	Thruster 3 (kg)	Thruster 4 (kg)
12	0.77	0.78	0.81	0.78
24	1.89	1.85	1.83	1.81

These results coincide with the curve provided by SeaBotix, which are in Figure 4.

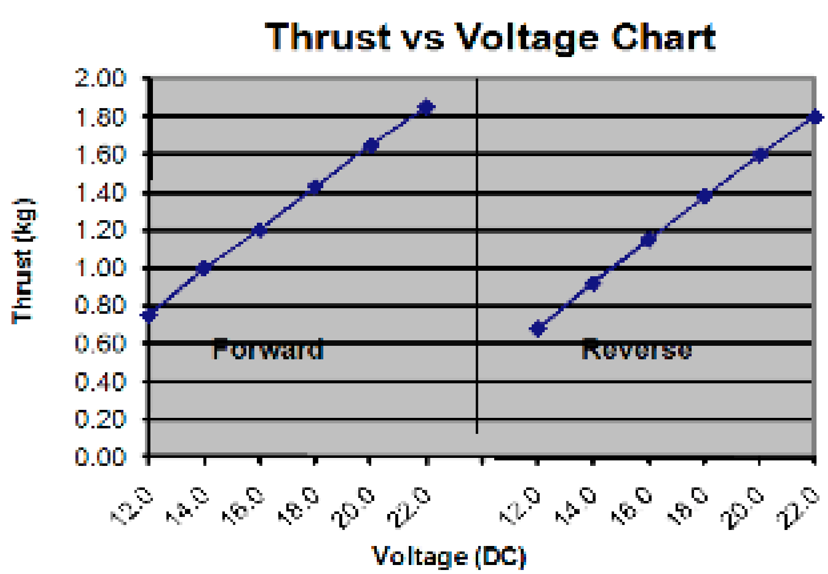


Figure 4: Seabotix Voltage vs. Thruster Graph

3.4 PAYLOAD TOOLS

3.4.1 Manipulator

In order to grab and move the objects put forth by MATE in tasks 1, 2 and 3; the ROV was equipped with a mechanical arm and pincers. The mechanical arm has 4 axes of rotation, which employs two pneumatic actuators for critical movement. An actuator placed vertically along the front of the frame, mounted from the top of the frame to the base of the arm, directs the arm to move up and down without changing position of the ROV. Another actuator, mounted to both the arm and the frame, allows the arm to swing left and right without changing the position of the ROV. The pincers at the end of the arm are opened and closed by a single pneumatic actuator. The actuator is connected to two rods, which are each connected to one of the pincers. As the actuator stroke extends, the pincers open.

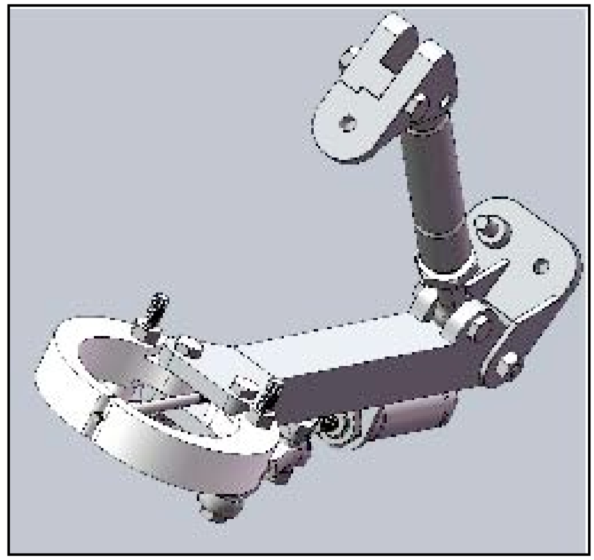


Figure 5: Solidworks Drawing of Manipulator

3.4.2 Agar Sampler

Another competition requirement called for the sampling of a bacterial mat substance. MATE chose to use agar to simulate the bacterial mat. Agar is a gelatinous substance made from seaweed. It solidifies between 32 and 40 ˚C, while melting begins at approximately 85˚C. In order to remove a sample of agar, two designs were proposed based on the principal that the agar would remain mostly solidified throughout the process. The first design was very similar to a post-hold digger concept. It would employ two pneumatic actuators. One actuator would extend the tool from within the frame, while the other controlled cylindrical jaws that would be inserted into the agar, rotated nearly 90˚, and closed, bringing the sample of agar to the surface. The second design relied heavily on a vacuum concept. In effect, a cylinder with sharpened edges would be lowered over the agar, pushed into the agar, and then a piston-cylinder configuration would draw an air vacuum on the agar inside the cylinder. Research of vacuum valves produced the discovery of what is called a check ball valve. Located at the top of the cylinder, the check ball valve would allow water to escape the cylinder as it is pressed into the agar. Then, when the cylinder is lifted from the agar sampling station, the check ball valve would close, creating suction on the agar within the cylinder. An advantage of the suction-cylinder agar sampler was the elimination of a pneumatic actuator, which resulted in lower cost. The team designed the agar sampler cylinder so that the volume within the cylinder would be within the range that MATE credits maximum points for; see Figure 3 for a picture of the agar sampler. The arrow seen in the image indicates the check valve described previously.

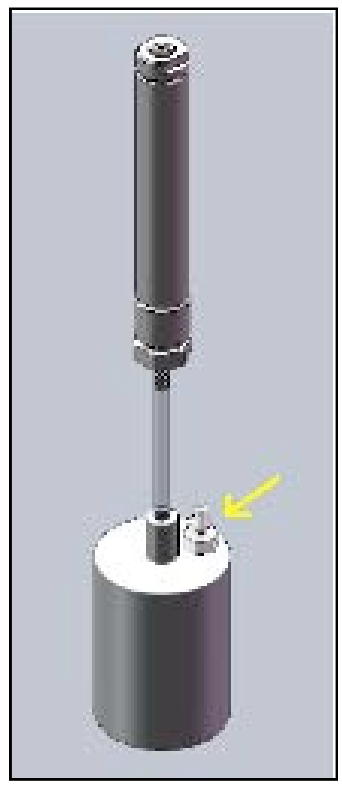


Figure 6: Agar Sampler

3.5 TETHER

The tether is the lifeline of the ROV; it provides the ROV with power, communication and air for the payload tools. Our team contacted several companies to help design a tether to be neutrally buoyant and have the number of conductors we needed. Our team decided that the cost of the tether could be used somewhere else and a team made tether was then constructed instead. Our team-made tether consists of one .3175 cm (1/8 in) OD airline, four 26 AWG twisted pairs, two 12 AWG power wires, and two 22 AWG wires. Three of the twisted pairs are used for the cameras and the last is used for frequency processing. The other two 22 AWG wires are for communication from the ROV to the surface, via RS232. Only two 12 gauge wires shall be present within the tether for power. This size wire was determined through a rough approximation of the largest possible load expected to be drawn by NORM. Given four thrusters rated at 4.25A each, three cameras rated at 200mA each, and about another 200mA for the rest of the electronics, it would not be expected to see a load much greater than 18A at any given time. As determined by the NEC (1), 12 gauge copper wire is safe for up to a load of 20A. In practice, all four motors would never be driven at full speed at any given time; therefore this size wire is a very conservative value. For efficiency purposes, it was determined that the full 48V provided should be fed down the tether. The tether is wrapped in nylon wrapping to keep all of the conductors together. The nylon not only keeps the tether together but also protects it from the harsh seamount floor.

3.6 UNDERWATER HOUSINGS

From the beginning, our team decided to have two underwater housings, this would help keep the whole ROV size down, which kept to our overall goal. The dual housings also lead to a symmetrical ROV and kept the weight evenly distributed from side to side. The housings were constructed from acrylic tubes and aluminum end caps. One of the housings was to hold the manifold and solenoids for the pneumatic controlled payload tools. The other housing holds the team designed and built electronics. Figure 7 shows the solenoid/manifold housing.

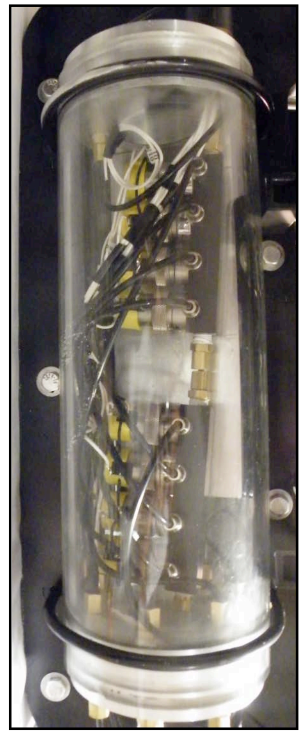


Figure 7: Solenoid Housing (Photo by Daniel Eaddy)

3.7 CAMERAS

Besides the tether, an ROV cannot run without cameras. It is imperative for the pilot to be able to have a good visual of the ROV and its surroundings. Our team thought four cameras would give enough angles of the ROV and its surroundings to accomplish the tasks that needed to be done. One of the cameras is from Light Camera Action salvaged off of last years ROV, this camera would be the main drive camera. The other three cameras were board cameras housed in a rapid prototype housing designed by the team. One of the team made cameras is located on the right side of the ROV. This is to help navigate the right hand turn inside the cave, to make sure the surroundings are not damaged in the close quarters. The two remaining cameras are positioned on the payload tools. All of these locations were chosen for their specific purposes. The Lights Camera Action camera already had a tether attached, so that was not disturbed. The other three cameras were then connected to baluns so that the signal could be converted to a differential signal. This allowed them to be connected to standard twisted pair wires inside of a CAT-5e cable, which allowed the video to be transmitted to the surface. On the surface, the twisted pair was connected to another converter where the four cameras are attached to two different multiplexers to show split screens on two televisions.

3.8 SURFACE CONTROLS

This year's rules required that the ROV be compact and easily shippable, because of this a portable command station was made to house all of the topside electronics, TVs and joysticks. The control box was built out of a hard plastic guitar case. The TVs were mounted in the top half while the electronics and joysticks were mounted in the bottom half. The team kept the tether input on one side and the power input from the battery and the air input on the other side. All inputs and outputs on the control box were made to disconnect to allow for easy shipping and handling. With the requirements having temperature and frequency readings, the team decided to use a laptop computer topside to run the readouts and topside program.

3.9 ELECTRONICS

To keep with the small and compact design of the ROV, all electronics were designed and made by the team. One of the housings has all of the electronics needed for the team to deploy the ROV. These electronics were made on one board to keep the size down and keep the housing organized. The electronics consist of four H-Bridges, Darlington array, power supply regulator, sensors, and video balun. The H-Bridges control the four thrusters using pulse width modulation (PWM). Power regulators are used to convert power down from 48 VDC to 24 VDC for the solenoids and 12 VDC for the cameras. The thrusters are rated to run at 19 VDC, but with PWM the thrusters are kept within their specifications. This is done for better efficiency for both the size of the electronics and the power requirements. For controlling the solenoid valves of the pneumatics, a ULN2803A Darlington array was utilized. This component was ideal for this function as it minimized components while providing a simple interface to the microcontroller. The solenoids were all grounded to the 24V rail and the Darlington array was used to switch the negative terminals of each of the solenoids. The common pin for the Darlington's freewheeling diodes was also connected to the 24V rail. Two types of sensors were used to help determine the orientation and movement of the ROV, accelerometers and gyroscopes. Video baluns were used to convert the video signals onto twisted pairs and sent to the surface. Figure 8 shows the latest board design for ROV NORM. Figure 9 shows the electronic board with the team made h-bridges if the Pololu bridges fail.

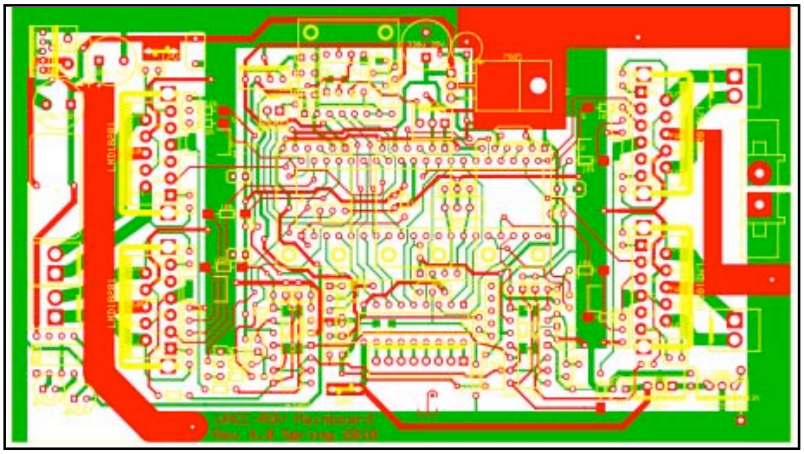


Figure 9: Composition View of Electronics Board

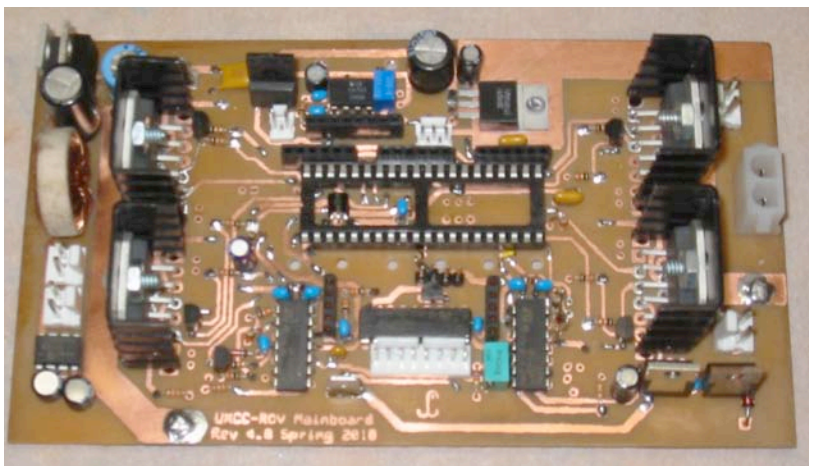
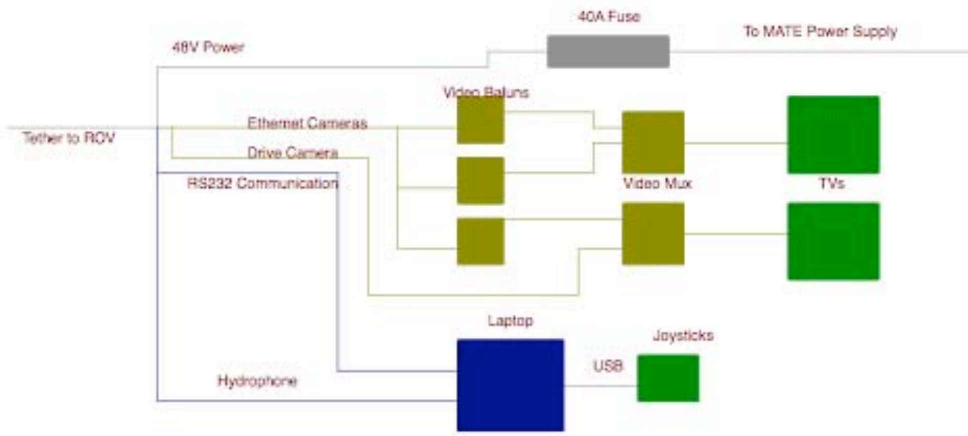
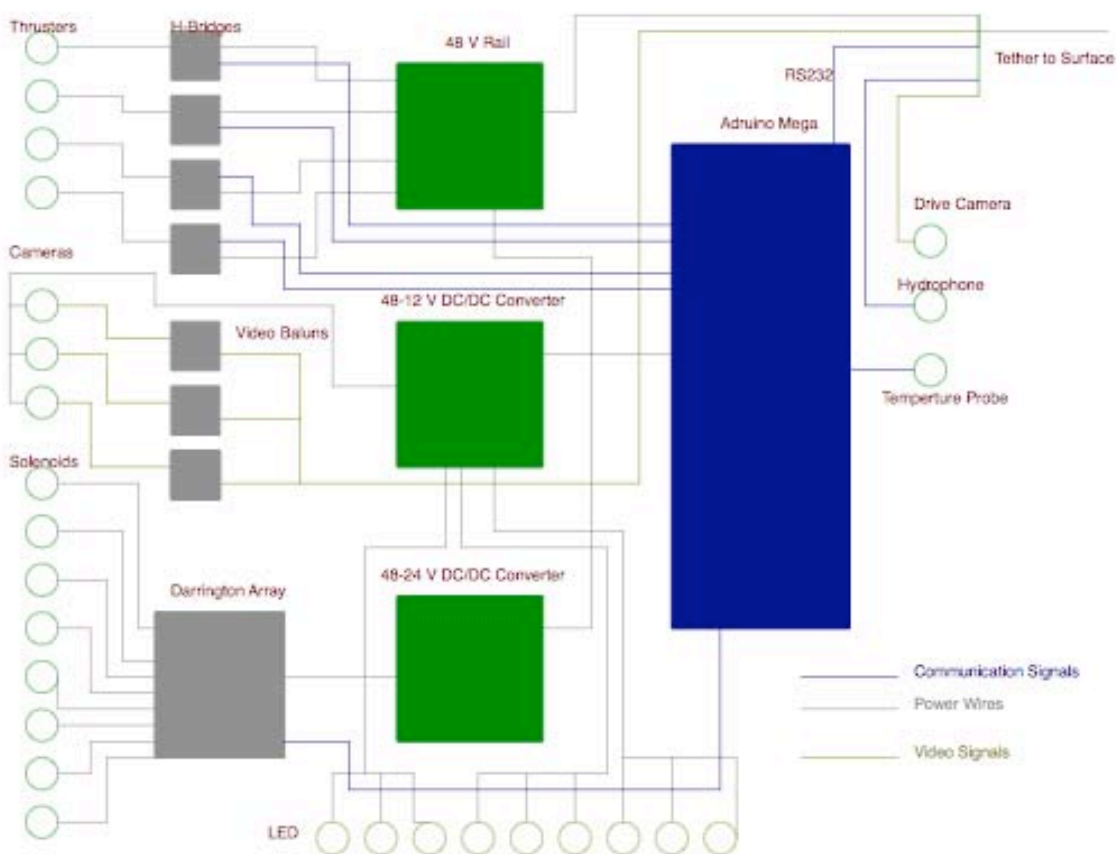


Figure 8: Picture of Electronics Board (picture taken by Jason Hinsch)

3.9.1 Topside Electrical Schematic



3.9.2 ROV Electrical Schematic



3.10 Sensors

This years missions required two additional sensors to be onboard the ROV. A temperature and frequency reading had to be taken, within certain accuracies. In task 1, a frequency will be detected and the HRH will be place near the site that is rumbling. In task 4, three temperature readings need to be found at three different chimney heights.

3.10.1 Thermometer

In order to evaluate temperature, as is required in task 3, the team researched temperature reading instruments. Three options for reading temperature were available; they were a thermistor, a thermocouple, or an RTD. The team chose to use a thermistor due to its simplicity and relative accuracy. The thermistor is attached to a rod on a single acting actuator located within the arm. The actuator extends from the arm between the pincers to a length of 7 centimeters. When a temperature reading must be taken, the rod extends between the open pincers, well into the cavity that needs to be checked for temperature.

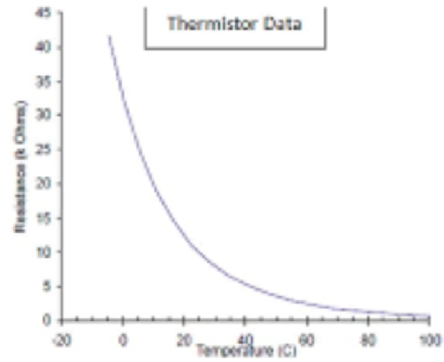


Figure 10: Thermistor Data

3.10.1.1 Termistor Testing

Testing was performed on the thermistor to make sure it provided accurate readings. Three known temperatures were measured with the thermistor and the corresponding resistance value was recorded with the known temperature. See Figure 10 for a plot of the data.

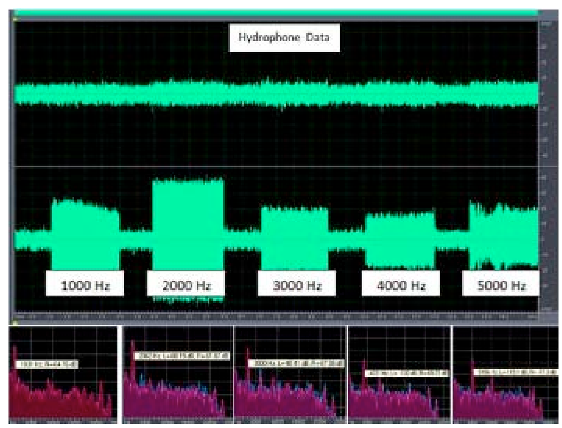


Figure 11: Hydrophone Readout

3.10.2 Hydrophone

In order to accomplish task 1, a hydrophone was attached to the front of the vehicle. The hydrophone then detected sound coming from ahead of its location. The hydrophone was connected with to the surface with a direct line. This allowed for simplification of programming on the surface and the vehicle.

3.10.2.1 Hydrophone Testing

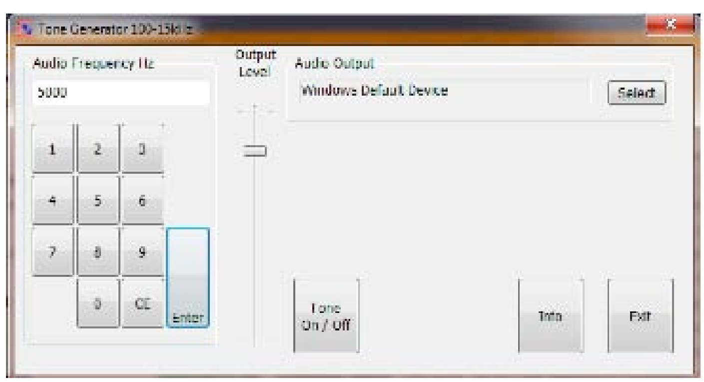


Figure 12: Hydrophone Test Program

Testing was also performed on the sound pick-up. The hydrophone was connected to a twisted pair and run 100ft, to make sure there was no signal loss, to the microphone port on the laptop. The other three twisted pairs were connected to video at the same time to ensure no noise was detected. Using a tone generator, 5 known frequencies were exposed to the pick-up and read to make sure the corresponding frequencies matched. Figure 10 shows an image of the tone generator and Figure 11 shows the hydrophone test data.

3.11 SOFTWARE

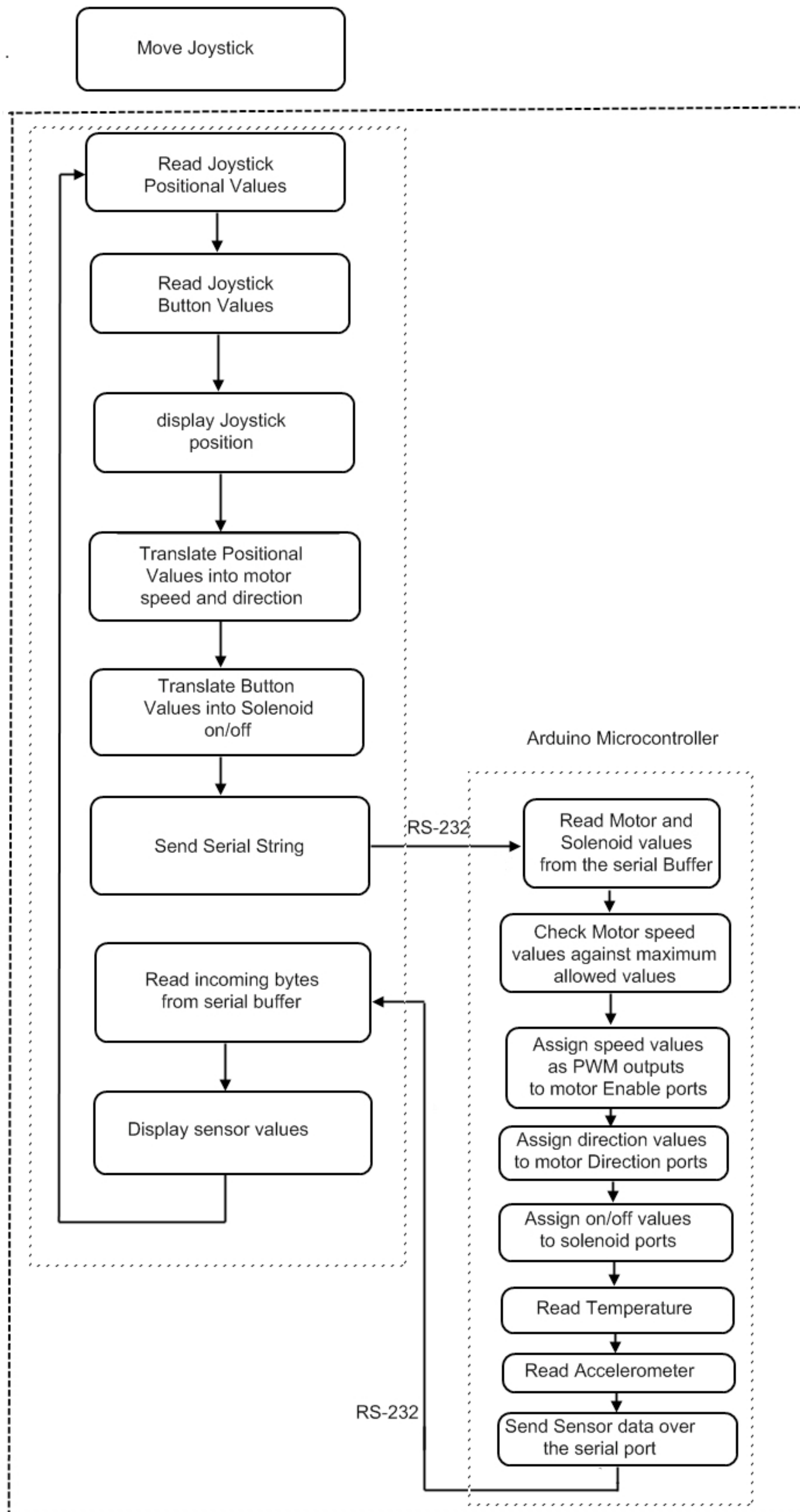
The team debated between a couple of options for a microcontroller. Given that the majority of the work encountered by the onboard microcontroller is in pulse width modulating the motor controllers and in relaying data over a relatively slow serial line, a great amount of computing complexity is unnecessary. The main criterion is that it has enough IO pins for controlling all the motors, actuators, and reading all the sensors with the necessary data interfaces. The team finally narrowed it down to either the PIC16F887 or the Arduino Mega. The Adruino Mega was chosen because of its simplicity of programming. Even though the Adruino was chosen, the team built electronics board was made with a spot to place the PIC. This was done because the PIC had more capabilities and if the team had time to program it late in the game then there would be two systems to control the ROV if one failed.

3.11.1 Joysticks

The Saitek X52 joystick was chosen by the team because of the amount of buttons assessable to the hands. These joysticks would allow the ROV pilot to control every function of the NORM without removing his hands from the joysticks. The right joystick controls the X-Y direction movement plus the multi-functional manipulator and the agar sampler. The left joystick controls rise and descent.

Figure 13: Software Flowchart (right)

Figure 14: Saitek X52 Joystick (above)



4.0 LESSON LEARNED

Over the course of designing, the team made several parts for the actuators that required extensive machinery work. With the team only having one class each of basic machinery skills, the team had to learn the best possible ways to make their creations come to life. After talking to several professors about the machinery in the lab, the team decided to make several parts in two and then weld or screw them together. This allowed the team to refrain from making parts that would take days to complete. After the parts were redesigned the team had to lay out every cut that was going to be made and what machine and tools were going to be needed. The team then learned that once apiece is in the vise on the mill or lathe it needs to stay there until it is complete. This would eliminate having to realign the part to the machine, even if we were off .025 millimeters that could have caused leaks in the electronics housings. Also after working several days a week and several all-nighters each team member learned what the capabilities of the each team member were. This helped us as a whole manage our time better, with knowing which team member had the most knowledge about certain topics. A Google Group was created to help send emails back and forth to members. This allowed our whole team be involved in every discussion by different team groups: mechanical, electrical and computer. Also the team learned Bruce Truckman's five stages of group development to help in the process of completing the ROV. The Forming-storming-norming-performing-adjourning model helps our team in two major aspects of interpersonal relationships and task behaviors. Overall, our team learned how to plan and recreate ideas based on what was physically possible on the machines available to us and learn how to use those machines. We learned the specific capabilities of each team member and how each one likes to work.

5.0 TROUBLESHOOTING TECHNIQUES

With this years ROV focusing on custom made electronics, it gave us many opportunities to develop and sharpen our electrical troubleshooting techniques. Because we designed and built all of the electronics ourselves, we were ready for troubleshooting if the need arose. The first electronics board we designed did not pan out to handle the voltage and current requirements needed by the thrusters. First thoughts were because of the H-Bridges not being able to handle the 5amp requirement of the thrusters. A test of the onboard electronic board was conducted using a current limiting supply. The main voltage was slowly increased to ensure that there were no shorts. At this time it was discovered that the 5V regulator would need a heat sink. Each of the onboard voltage rails was observed on the Oscilloscope to measure their quality. Minimal ripple was observed on all the rails, even the 15V rail. The voltage of the 15V rail was found to be 14.73, right in line with the design equation. An attempt was made to test the H-Bridges using a duty-cycle generator clocked at 480Hz and constructed using two 555 timers. However, no output could be observed. It was thought at first that the over-current protection could be falsely triggering it, preventing the signal propagation. A voltage of 0.90V was observed feeding the logic gates from the comparator. To rule this out, a short was soldered between the comparator output and ground, but to no effect. Ultimately, one of the logic ICs was de-soldered and, after confirming the IC still worked, jumper wires were connected in its place to directly drive the gate drivers. It was here that it was determined that that the FAN7390 would only allow a hi-side pulse after a lo-side pulse had been registered. After two weeks of redesigning, the team decided that this year h-bridges were going to be bought from Pololu. The h-bridges are rated for 60 V and 9 amp, these specifications were plenty high for the thrusters. The entire board would still be custom made but pin outs from the board would go to the h-bridges. In the end this allowed for more room in the housing for extra wire so that the caps could be removed and the board could be worked on.

6.0 CHALLENGE OVERCOME

This years team was comprised of Charlotte Area Robotics members that were underclassmen and seniors in their respected field of study. This gave the team two challenges to overcome: finding certain meeting times where all team members could attend and fulfilling both the MATE and Senior Design requirements.
The Senior Design requirements showed that an initial design had to be submitted by the end of November where in past years a first design was usually decided on by the team by the end of December. Getting the Senior Design requirements done was not as difficult, but more an inconvenience since sizing requirements and sensor requirements were required by MATE this year. Because of this, an initial design was submitted at the end of November and then the team resubmitted a new design at the end of December. The design was then altered a little due to testing after that. Managing the time between all of the team members and relaying all information between different members was tough at the beginning. A Google group was then created; this allowed the team to post when meetings were held and what happened after each meeting. This gave the different engineers a sense of where each group was at in the designing and building phases. This also allowed each member to post datasheets and documents that had been worked on to the website. This system was found to be extremely helpful because it eliminated the use of emailing each person on the team when Google did it for you when a reply was posted to a thread.

7.0 FUTURE IMPROVEMENTS

Our teams overall goal besides the mission theme and requirements was to make a completely team designed robot. One of the only components not made by the team were the thrusters. This year, with time and money conflictions team made thrusters were not possible. After this technical report is submitted designs were being put on the table. Other improvements put forth by the computer engineers deals with the ROV system controls. The incorporation of dynamic measurements systems, or gyroscopes, would greatly improve the stability of the ROV. Dynamic measurements systems would alleviate the demand for driver correction of instabilities on the ROV pertaining to balance. The dynamic measurements systems would cause the ROV to balance or stabilize itself in the event of instability. Another option for further development by the team was in the PIC/microcontroller. The current PIC/microcontroller is used highly in hobbyist activities; therefore, it is not designed for rigorous testing and programming that is involved in the ROV design. Along with an advanced PIC/microcontroller, the logic drive design for the H-Bridges could be optimized.

8.0 RELECTIONS ON THE EXPERIENCE

"This is my third year competing in the MATE International ROV Competition. This experience has given me a great deal of insight into underwater robotics. This year's team lacked the numbers of electrical engineers and being one of the veterans on the team I had to take on some electrical duties. With myself having a more mechanical background, this was going to be tough for me. I took on this challenge and by the end of the several long months I had learned more then I would of in one class. Getting seniors involved in this project was an idea that I previously had after last years competition, to help show seniors different paths that there engineering degrees could take them that UNCC does not really show. With being near a racetrack and not water, cars are a major focus, but this opportunity was too good for some seniors to pass up. Already, several rising seniors have approached me asking how to get involved in this project. With one or time graduating seniors wanting to come back and help be mentors for the project."

-Zachary Miller

9.0 LOIHI SEAMOUNT

Loihi is a seamount—or underwater volcano—located approximately 35 kilometers from the southeast coast of the island of Hawaii. Loihi is part of the Hawaiian-Emperor seamount chain and lies on the flank of Mauna Loa, which is the largest shield volcano known on Earth, shown in Figure 15. Until recently, it was believed that Loihi was simply an extinct seamount from the past, however, after an earthquake swarm in 1970 it was revealed by a research expedition to be a young, active volcano mantled with both new and old lava flows. This evidence leads researchers to believe that Loihi is following the typical pattern of development associated with all Hawaiian volcanoes as it transitions from the preshield to shield volcano stage, shown in Figure 16. The presheild stage of development is characterized by steeper sides and low volcanic activity. As Loihi makes this transition it is expected to eventually create an additional island in the Hawaiian chain somewhere between 10,000 and 100,000 years from present. Loihi is positioned on the seafloor in such a manner that produces a 5 degree slope from its northern to southern bases. This drastically affects its overall height as the northern base is 1,900 meters below sea level, whereas the southern base is as far as 4,755 meters below sea level. Because of this slope, the summit is approximately 931 meters above the seafloor at its northern base and about 3,786 meters at the southern base. This summit is marked by a single depression measuring 2.8 kilometers wide by 3.7 kilometers in length. Three distinct craters, the most recent of which was formed by an earthquake swarm in 1996, mark the southern portion of the seamount. As related to the specific mission themes, Liohi commonly produces hydrothermal vent flumes whose temperature measurements, Mission 3, play a vital role in the continued research of this area. These areas are also a hotspot for both micro and macro-organisms who have also been observed in the past, much like Task 2 in this years competition, shown in Figure 17. Finally, recording and measuring thunder-like noises produced by Loihi by means of a hydrophone have been conducted both in the past and by ROV NORM in Task 1. Accomplishing these tasks as established by MATE is both interesting and realistic as it applies to scientific research that is being conducted currently by means of ROVs and other submersible instrumentation.

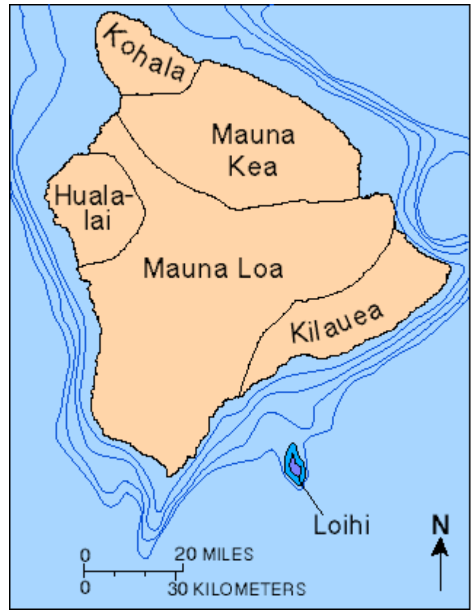


Figure 15: Loihi Seamount Map

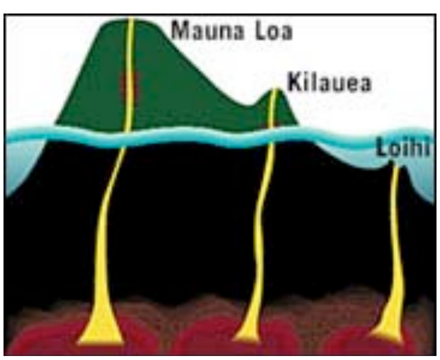


Figure 16: Hawaiian-Emperor Seamount Chain (left)

Figure 17: Hydrothermal Vent Shrimp (right)

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11.0 Acknowledgements

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Company/Organization	Donation
Marine Advanced Technical Education Center	Providing the Opportunity to Learn and Explore
Our Mentors	Dealing with US!
University of North Carolina at Charlotte Motorsports Engineering	Lab Equipment, Welding Supplies, Machinery
University of North Carolina Electrical Engineering Department	Thrusters
SeaBotix	Discount on Thrusters
UNCC IEEE	Travel Expenditures
Outer Banks Pastries	Monetary Donation
T-Shirt World	Competition T-Shirts
NAPA	Supply Discount

Appendix A- Sample Programming Code

Segment of code on the topside showing how the joysticks values are converted into thruster values used by the ROV side.

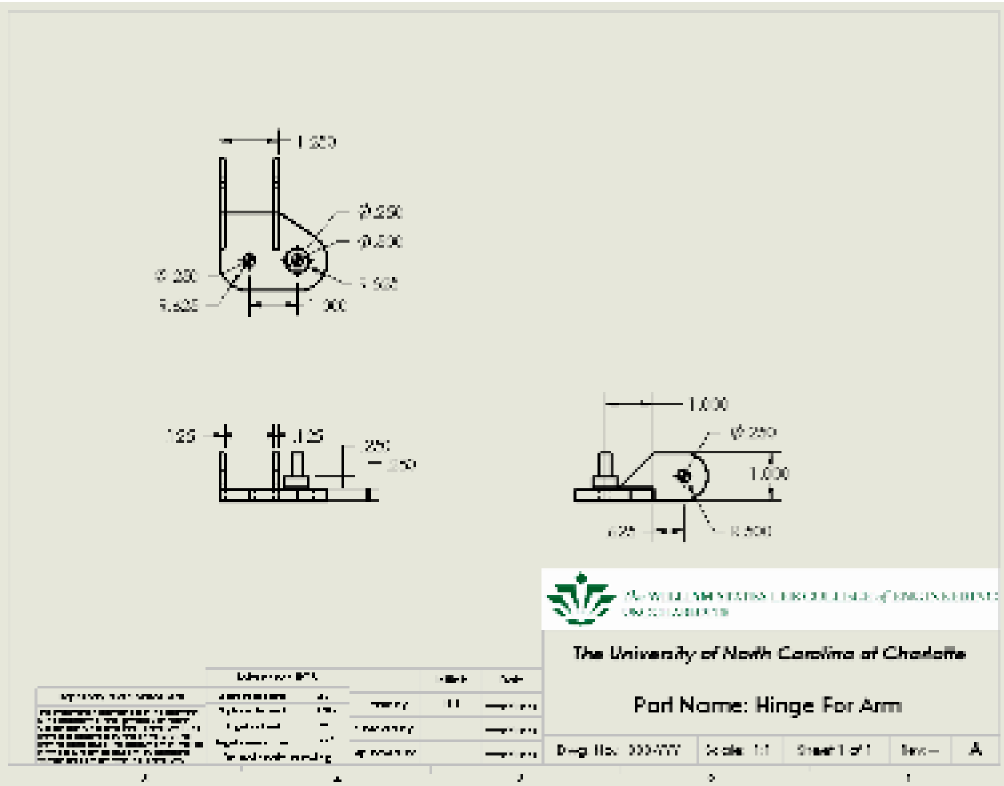
```
/////////////////////////////////////////////////////////////////////
///              4    MOTORS                                  ///////
/////////////////////////////////////////////////////////////////////
   //%%%%% Turn raw joystick values into thruster values %%%%%//
   //Assign Joystick values to 4 motors LFT, RFT, FUP, BUP
if(x<0.0)      {  LFT = int(y*( 1-abs(x) ));  RFT = int(y);     }
else if(x>0.0){  LFT = int(y);     RFT = int(y*( 1-abs(x) ));  }
else if(s<0.0){  LFT = int(s);   RFT = -int(s);                 }
else if(s>0.0){  LFT = -int(s);    RFT = int(s);                }
else           {  LFT = int(y);     RFT = int(y);               }

               {  FUP = int(z);     BUP = int(z);               }
```

Segment of code on the ROV showing the various declarations needed for the motors.

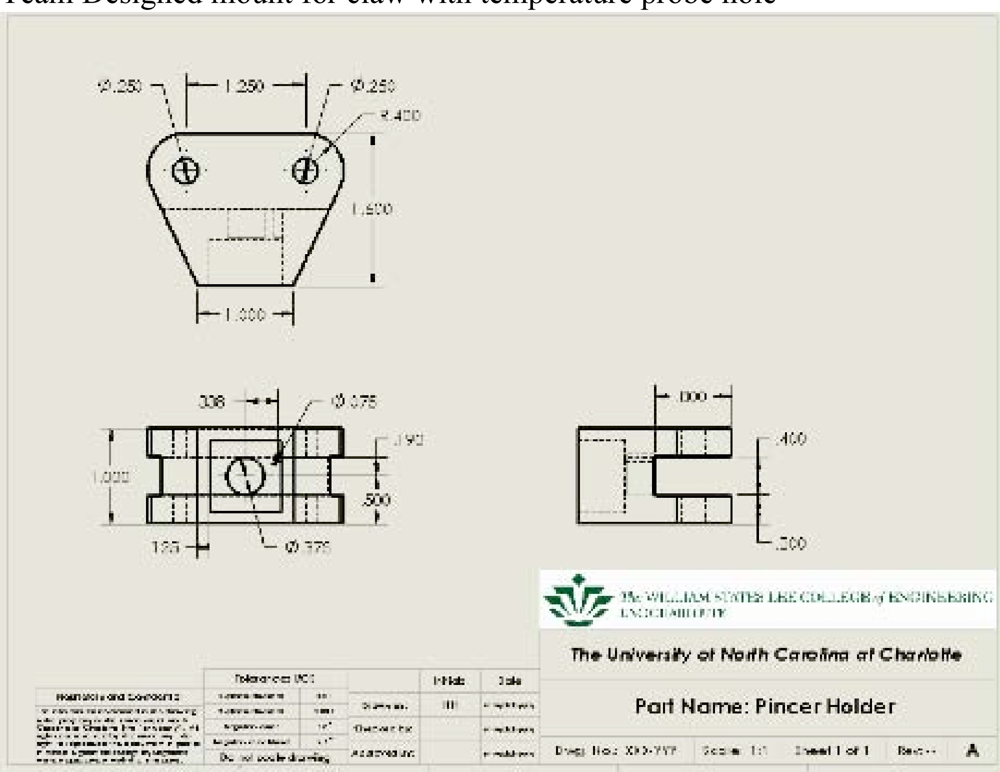
```
//MOTOR 1  LFT
const int m1AnalogPin = 2;
const int m1DigitalPin = 40;
char m1ValString[3];
int  m1Value = 0;
char m1Direction = 'm';
char m1PrevDirection = 'm';
//MOTOR 2  RFT
const int m2AnalogPin = 3;
const int m2DigitalPin = 42;
char m2ValString[3];
int  m2Value = 0;
char m2Direction = 'm';
char m2PrevDirection = 'm';
//MOTOR 3  FUP
const int m3AnalogPin = 4;
const int m3DigitalPin = 44;
char m3ValString[3];
int  m3Value = 0;
char m3Direction = 'm';
char m3PrevDirection = 'm';
//MOTOR 4  BUP
const int m4AnalogPin = 5;
const int m4DigitalPin = 46;
char m4ValString[3];
int  m4Value = 0;
char m4Direction = 'm';
char m4PrevDirection = 'm';
```

Appendix B- Mechanical Drawings

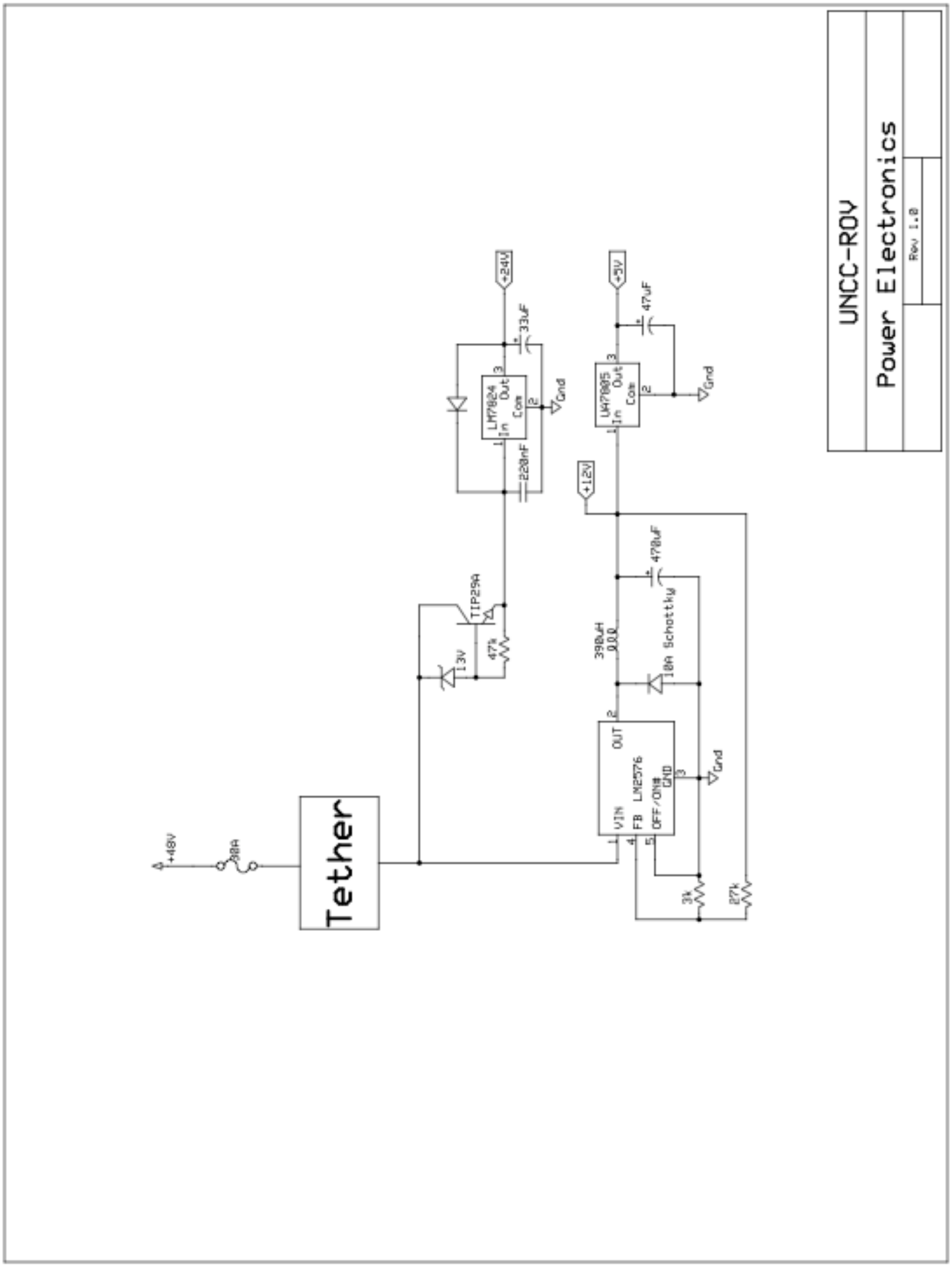
Team designed mount for moving manipulator left and right.



Team Designed mount for claw with temperature probe hole



Appendix C- Power Schematic



Appendix D- Testing Safety Checklist

- ✓ Batteries Hooked in Series
- ✓ Positive and Negative Hooked to the Correct Terminals
- ✓ Fuse is Not Blown
- ✓ All Wires/Air Tubes/Hands/Anything Removed From Moving ROV Parts
- ✓ Tether is Not Tangled or Bunched Up
- ✓ Tether is Connected to Command Station and ROV
- ✓ System Check Complete
- ✓ Test Thrusters, Actuators, Cameras, Sensors
- ✓ Check Pool for Hazardous Areas
- ✓ Clear Poolside for Test
- ✓ Poolside Technicians Grab Lifejackets
- ✓ Being Test!