MARINE ACADEMY OF TECHNOLOGY AND ENVIRONMENTAL SCIENCE
195 CEDAR BRIDGE ROAD, MANAHAWKIN NJ

2010 ROV TECHNICAL REPORT

JET STREAM – TECHNICAL REPORT FOR 2010 MATE ROV INTERNATIONAL COMPETITION – HILO, HAWAII

TEAM MEMBERS

DOUGLAS BAILEY
JUNIOR

WALTER CHURCH
JUNIOR

MATTHEW EISENSCHMIED
JUNIOR

DEVON GONZALEZ
JUNIOR

DANIELLE JUDKA
JUNIOR

EMILY KEPPEN
JUNIOR

JAMES PRIESTLEY
JUNIOR

THOMAS SLAGMOLEN
JUNIOR

JEANNE STAD
JUNIOR

YIFAN ZHANG
JUNIOR

KEVIN QUIGLEY
SOPHOMORE

CHRISTOPHER ETLER
FRESHMAN

DAVID ETLER
FRESHMAN

BRIAN INTILE
FRESHMAN

MATTHEW MOELLER
FRESHMAN

PATRICK OEHME
FRESHMAN

ADVISORS & MENTORS

Karyn Quigley – Advisor

Paul Fennimore - Mentor

OCEAN COUNTY VOCATIONAL TECHNICAL SCHOOLS
MARINE ADVANCED TECHNOLOGY EDUCATION CENTER

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JET STREAM – 2010 MATE ROV INTERNATIONAL COMPETITION

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I - ABSTRACT

Following two consecutive losses at the international level, the Robotics and ROV team at the Marine Academy of Technology and Environmental Science has spent a year in preparation for the 2010 MATE ROV Competition mission simulation, rethinking concepts and designs from the ground up to perform at a competitive level. The resulting fully-operational, submersible, remotely operated vehicle (ROV) is the result of a collaborative effort amongst all team members, under the supervision of the committed advisor, Karyn Quigley, and the knowledgeable mentor, Paul Fennimore. This year, the mission tasks for the competition simulation involved collection of various samples and the resurrection of Hawaiian Underwater Geological Observatory, tasks that the team tackled vigorously in preparation for the competition. Through the collaborative discussion and work of the team and associates, the ROV *Jetstream* was constructed with efficiency and performance in mind, in order to successfully complete the competition simulation. Design concepts and construction were developed, tested and improved throughout the school year, the culminating product of which is presented at the 2010 MATE ROV Internationals in Hilo, Hawaii for competition. Looking forward, the vehicle has been designed with the idea of further use in mind, with an emphasis on preparation for further underwater studies through the school. As an educational epicenter for environmental and marine sciences, MATES sees the completed ROV as a significant investment for further assistance in freshwater studies.

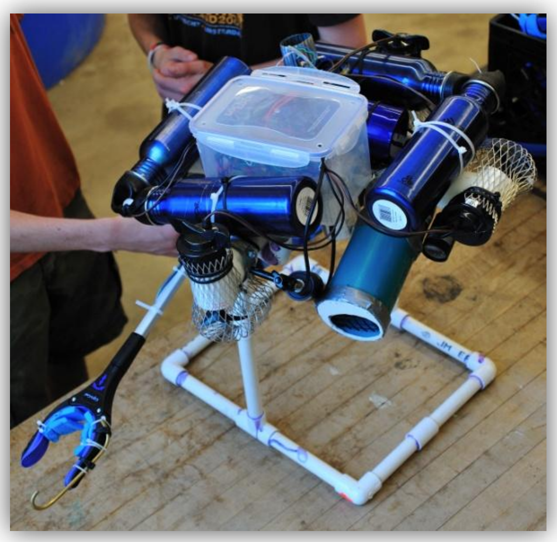

Figure 1 – The completed ROV, undergoing final testing before competition.

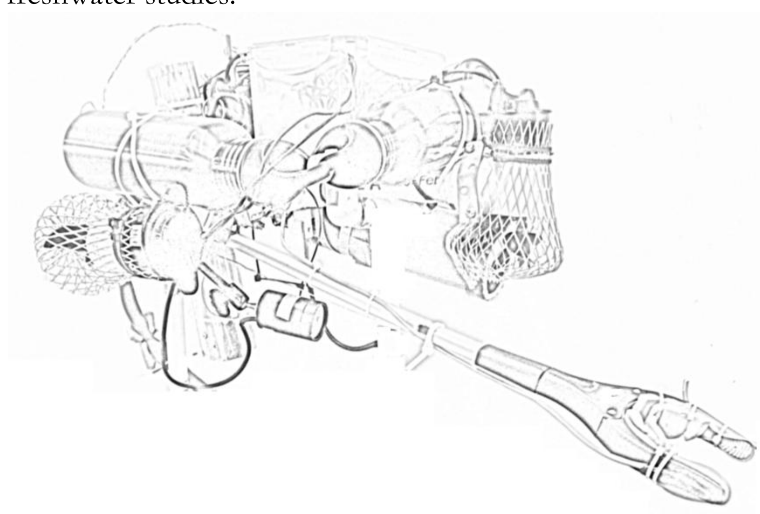

Figure 2 – A scanned sketch of the completed ROV, with most major mechanical systems visible.

II - BUDGET / EXPENSE SHEET

Date	Description	Quantity	Amount	Total
10/23/09	McMaster Carr - sealed linear solenoid continuous pull, 12 VDC 1" stroke, 60 OZ force	1	$36.86	$36.86
10/23/09	Lowes - 1/4-20NYLN INSRT LCK NUT	1	$3.67	$3.67
10/23/09	Lowes - SS Carriage Bolts 1/4-20X	1	$6.57	$6.57
10/26/09	Sears - EVO 6FC MI MDS	1	$16.04	$16.04
10/26/09	Lowes - #20 Clamp 2 PK	1	$21.06	$21.06
10/26/09	Lowes - JH Grip'n grab	1	$1.96	$1.96
10/26/09	Lowes - FG strings - #222	1	$5.32	$5.32
10/26/09	Lowes - 1/6x 1-5/16 hitch pin clip	1	$0.78	$0.78
10/26/09	#28 clamp 2 PK	1	$2.11	$2.11
10/20/09	Home Depot - Bat 145CCAL	1	$21.39	$21.39
10/20/09	Home Depot - Core Batt deposit	1	$10.70	$10.70
1/21/10	Home Depot - PVC40 Pipe	4	$4.12	$4.12
1/21/10	Home Depot - Screws	1	$3.57	$3.57
1/21/10	Home Depot - 1/2M Adapter	15	$4.65	$4.65
1/21/10	Home Depot - 1/2PVC CPLG	1	$0.21	$0.21
1/21/10	Home Depot - 1/2 PVC 90EL	4	$1.00	$1.00
1/21/10	Home Depot - 1/2 PVC EL45	2	$1.00	$1.00
1/27/10	Home Depot - 2 PVC cap	1	$1.10	$1.10
1/27/10	Home Depot - 3/4 PVC bush	16	$0.35	$5.60
1/27/10	Home Depot - 1/2 PVC Cross	1	$1.15	$1.15
1/27/10	Home Depot - Homer Bucket	1	$2.34	$2.34
2/3/10	McMaster Carr - PC board mount relay, Dpdt 5 amps, 12 VDC, 8 pinsc	4	$6.69	$26.76
2/3/10	McMaster Carr - PC board mount relay, Spdt 10 amps, 12 VDC, 5 pinsc	6	$5.84	$35.06
2/4/10	Lowes - 0 2"X5 PVC Pipe Solid	1	$2.87	$2.87
2/4/10	Lowes - 1 1/2" Elbow	1	$1.16	$1.16
2/4/10	Lowes - 1/2" Adapter	1	$2.79	$2.79
2/4/10	Lowes - 1/2" Elbow	16	$1.13	$18.08
2/4/10	Lowes - 1/2" Adapter	6	$0.31	$1.86
4/6/10	Home Depot - Liquid Tape	1	$5.99	$5.99
4/6/10	Home Depot - Toggle Bolt	1	$1.92	$1.92
4/6/10	Home Depot - Tubing	1	$1.95	$1.95
4/6/10	Home Depot - Tubing	1	$1.79	$1.79
4/6/10	Home Depot - HS But 22	1	$3.99	$3.99
4/12/10	McMaster-Carr - pencil grab soldering iron	1	$13.69	$13.69
4/12/10	McMaster-Carr - PC board mnt relay	3	$5.34	$16.02
4/12/10	McMaster-Carr - Gen purpose uncoated Jobber's drill set	1	$55.48	$55.48
4/13/10	Home Depot - 10" 50T	1	$39.97	$39.97

4/13/10	Home Depot - RYBI Saw	1	$119.00	$119.00
4/30/10	McMaster Carr - Expandable Mesh Sleeving	1	$29.69	$29.69
5/4/10	Home Depot - OLD 1G Low	1	$1.28	$1.28
5/4/10	Home Depot - Toggle Bolt	1	$1.92	$1.92
5/4/10	Home Depot - Toggle Bolt	1	$1.92	$1.92
5/4/10	Home Depot - PVC Clamp	1	$0.50	$0.50
5/4/10	Home Depot - Spring Assort	1	$3.97	$3.97
5/4/10	Home Depot - SS Clamp	2	$1.30	$2.60
5/4/10	Home Depot - SS Clamp	2	$1.45	$2.90
5/4/10	Home Depot - 2 Port WP Black	1	$1.67	$1.67
5/4/10	Home Depot - SD Con 12	1	$5.99	$5.99
5/4/10	Home Depot - SD But 12	1	$5.99	$5.99
5/4/10	Home Depot - HS But 22	1	$3.99	$3.99
5/4/10	Home Depot - Spring Clamp	1	$0.99	$0.99
5/4/10	Radio Shack - Buzzer	1	$3.49	$3.49
5/4/10	Radio Shack - 2.5OZ Solder .032	1	$5.99	$5.99
5/4/10	Home Depot - BI DR Rod TP	1	$2.84	$2.84
5/4/10	Walmart - Water Bottles	4	$5.00	$20.00
5/17/10	Home Depot - Ring	1	$2.38	$2.38
5/17/10	Home Depot - 3x4 Strainer	1	$2.35	$2.35
5/18/10	Home Depot - Poly. Foam	1	$5.98	$5.98
5/18/10	Home Depot - 3x4 Strainer	4	$2.35	$9.40
5/18/10	Home Depot - 5pk Tape	1	$2.49	$2.49
5/18/10	Home Depot - Mega Cuff	1	$3.88	$3.88
5/18/10	Home Depot - Cable Ties	1	$1.90	$1.90
5/18/10	Home Depot - Cable Ties	2	$1.30	$2.60
5/18/10	Home Depot - Cable Ties	1	$3.49	$3.49
-----------	--Total--			$629.78
Funding	***Source***			***Amount***
Donation	Nancy Given – For t-shirt fundraiser			$40.00
Discount	Dave Valero			$60.00
Fundraiser	Misc. Fundraising Activities: T-shirt sale, Bagel sale, etc.			$75.00
Award	Gift card won at 2009 MATE International Competition			$100.00
Donation	OCVTS District Funding			$354.78

Donations and discounts were supplied through the generous efforts of Nancy Given and Dave Valero. Further funding was supplied through fundraising activities at the school, such as a t-shirt sale, bagel sales, and other activities. The remainder of the funding was supplied on a per-purchase basis via the Ocean County Vocational Technical District. Pool access was generously supplied through the Toms River Fitness Center.

III - ELECTRICAL SCHEMATIC

The positive line from the battery splits into several separate directions. The primary force of energy is split and goes directly to the ROV via the tether from the control box. The power section of the tether has its own 2 plugs, one for each of the two 12 gauge wires; one for positive, one for negative. The power is then separated to the objects and powers the use of relays as switches. The rest of the electricity from the battery remains in the control box, as the positive lines are split into eight to ten different directions. Eight of those lines are attached to their own switches. Each of the joysticks on the control box has four switches and is wired identically, outside of the motors they control. The relays are activated through an Ethernet cable with a customized wiring set-up for optimal usage and simplified set-up. All of the 8 wires for the motor relays go through a single Ethernet cable so that there is no cross connections whereas the other auxiliary functions go down their own Ethernet cable.

Figure 3 – The relays exposed in their plastic container, mounted at the top of the ROV.

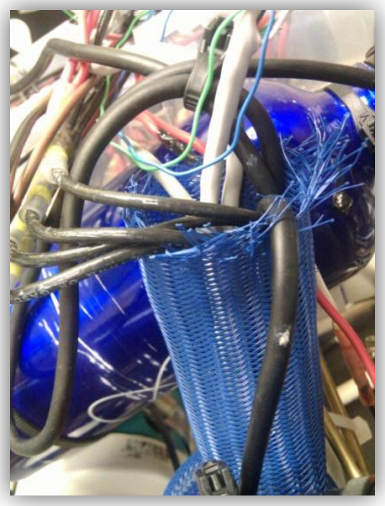

Figure 4 – CAT 5 cables and camera wires exiting the tether on the vehicle, routed to their corresponding systems.

The vertical stick from the box controls the two horizontal motors. When the controller is pushed forward, it completes a circuit down to the primary relay (See Diagram below). The relay that this activates allows power from the primary power line to go through to the other two relays that are set to common on. These common on relays are then redirected to two Double Pole Double Throw relays that are set into a forward (conditional) position. This direct flow of power lets the ROV move forward. If the stick is pushed forward and to the right, power is sent down to a second stream that goes alongside it. This power goes into the two secondary relays that switch from the default setting to off. This shuts off the right motor while leaving the left one on. The left motor will cause the ROV to move to the right (See Diagram below). By moving the joystick to the left, only the left motor will shut off while the right stays on, moving the ROV left. When the joystick is pulled backwards towards the user, the power is split into two directions. The power goes down to the DPDT which reverses the incoming polarity. The split is also set to go through a diode into the forward control which allows the motors to receive power. Therefore, when the controller moves backwards, the motors move backwards as well. If the controls were activated backwards and either to the left or to the right, the same rules for turning apply; backwards to the left or right will move the ROV backwards and to the left or right.

The side-stick of the control box controls the two vertical motors. The same rules apply to this set of switches and relays, save positioning. When the stick is moved up, it powers the relays and makes both of the vertical motors activate and go up. Pushing it up and away from the user causes the front vertical motor to stay on; up and towards the user keeps the back motor on. When the stick is pushed down, both motors go down. The same rules apply to switching from the back and forward vertical motors.

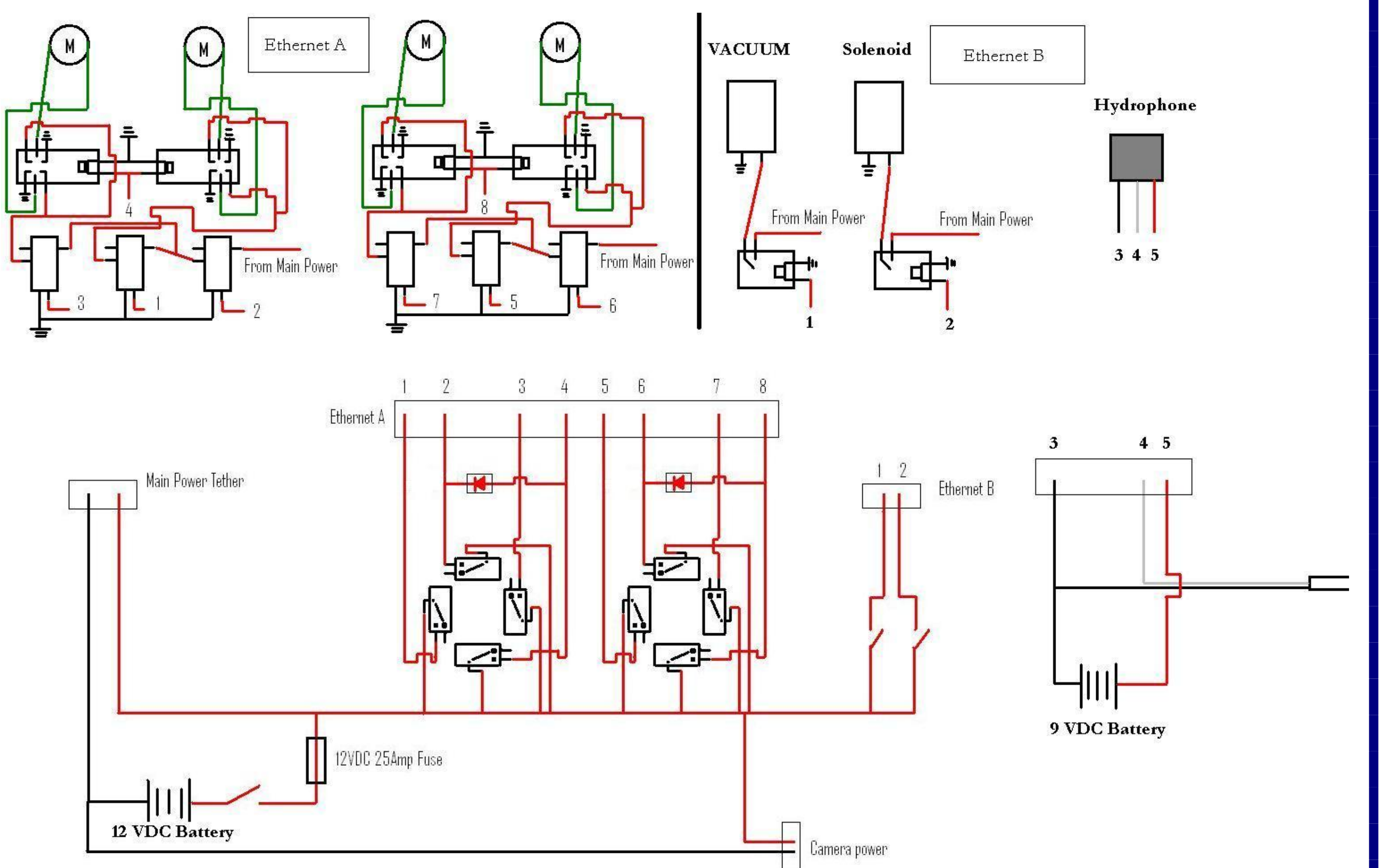

Figure 5: Electrical diagram depicting the wiring and electrical systems for the control box, ROV, and electrical sub-system constituents.

The auxiliary functions of the ROV include the usage of a solenoid powered arm and a 500 GPH bilge pump rigged to work as an underwater vacuum. Each piece of equipment requires minimal power to run and receive their power from the main power lines heading to the ROV. These devices use the remaining two power ends that are inside the control box to activate the relays required to run the apparatus. To use these devices, a small button is attached to the vertically pointed joystick. This button is wired to send power through the auxiliary Ethernet cable to the relay that is associated with the solenoid powered claw. When the relay activates, roughly .8 amps is used from the main power line to power the solenoid claw; this claw is used to grip and move anything related to the missions. Pressing the button once turns the gripper on, which allows the claw to close, and then pressing it again shuts it off and leaves it in an open position. The vacuum is wired to a manual switch on the control box. The vacuum is set up similarly to the gripper when it comes to relay set up, except it only has a simple on/off mechanism instead of having to manipulate it twice with a switch. The vacuum is designed for the sole purpose of collecting the small organisms found in the cave, while the gripper is designed to pickup and gather items.

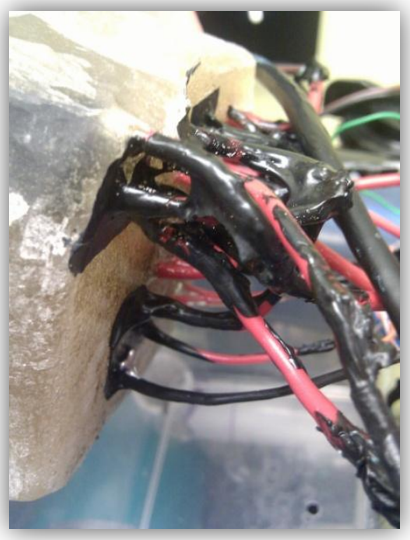

Figure 6 – The top of the relays, water sealed in epoxy with the extruding wires visible.

Although this explanation is in reference to the positive lines, the negative lines share a common design plan. All of the motors and relays and other apparatuses have their negatives led together down at the ROV itself and then sent back up to the control box. Additionally, the positive lines pass through a 25 Amp fuse and out to the positive port on the battery.

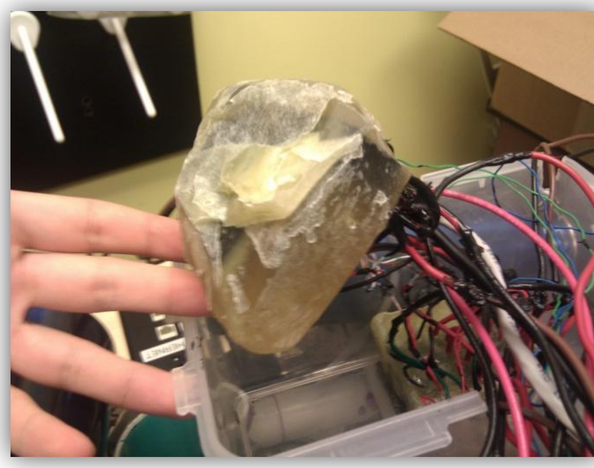

Figure 7 – The bottom of one water sealed relay setup, contained inside the plastic contained mounted on top of the ROV, ensuring little movement of intricate wiring setups during the mission.

IV - DESIGN RATIONALE

FRAME – For the frame, a durable, buoyant, and fairly modular material was needed in order to supply ample support for mission components. Polyvinyl chloride (PVC) was chosen as the base material for construction. As a common construction material, PVC is cost effective and dependable, while the diverse supply of common fittings and attachments allowed customization for the attachment of external systems and mission components. Through the ease of use of PVC, the frame was constructed quickly and efficiently, leaving a highly effective end product. Due to the ease of use and construction of the PVC frame, multiple variations were able to be constructed in rapid succession for efficient design testing.

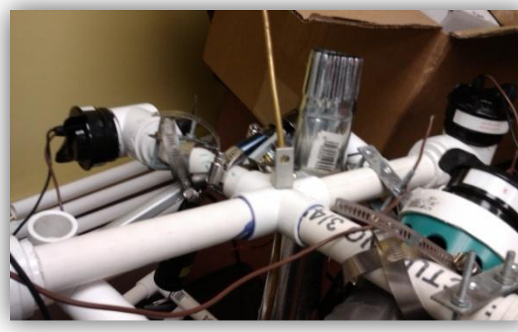

Figure 8 – Top portion of ROV frame with mission props and motors attached.

Propulsion System – For adequate maneuverability during the mission simulation, the propulsion system needed to be light, agile, and efficient. In order to satisfy those requirements, four 1000 GPH bilge pump motors were utilized, split between horizontal and vertical orientation. Through this setup, three degrees of freedom are easily achieved, with movement up and down, forward and backward, and left and right. The motors themselves are controlled through a system of relays in the control box.

Mission Specs – In order to complete the tasks specified in the mission simulation, several components were constructed and attached to the ROV. Again, light and simplistic solutions to the tasks at hand were used, to ensure reliability and performance. The hydrophone was made from a microphone protected in non-conductive vegetable oil, used during the mission to detect sound from the various stacks. The gripping arm is modified from a reaching aid, and enables the ROV to pick up and move various items.

Figure 9 – The ROV under construction. Note mission components such as the grabber and vacuum.

The hooks are made from bent bronze rods, one mounted at the bottom of the vehicle for lifting the HRH, and another fashioned onto the claw for easier manipulation of the elevator pins. The core sampler is made of a piece of sheet metal rolled into a cylinder and is used to retrieve the agar solution. The gripper proved ineffective and unwieldy for retrieving the crustaceans; therefore, a vacuum was designed, consisting of a 500 GPH bilge pump motor at the end of a PVC pipe, with a mesh barrier at the end to prevent contact between any organisms and the motor. This enables collection of all three crustaceans without having to visit the surface, as would be required if using the claw.

Buoyancy System – The buoyancy system needed to keep the ROV at consistent neutral buoyancy to ensure optimal conditions for navigation and mission completion. To satisfy this requirement, the system was constructed from recycled metal water bottles. The weight of the volume of water displaced is proportional to the amount of buoyancy generated. The solid metal bottles presented an advantage, as their volume does not change over the range of pressures in the pool. For the tether, small pieces of foam were cut and attached to minimize drag from the tether in the water.

Camera Systems – For the competition mission simulation, the ROV required ample surveying capabilities of the surrounding area to aid in navigation and mission completion. In order to adequately view the environment, the ROV encompassed 3 cameras in its design, specially chosen for their ability to illuminate dark areas using infrared light. This automatically makes the darker portions of the frame easier to see than that visible within the normal spectrum. The cameras are connected to a video processor through the tether, which displays each feed individually through a four way split screen on the television monitor via an RCA connection.

Control Systems – The layout of the control box needed to be simplistic and easy to use, as to alleviate the need to focus on technical aspects in order to focus more on completing the mission at hand. To respond to this need, the control box was designed to be simple and straight forward. The top panel includes the main power switch and the propulsion/turn control as well as the vacuum toggle for crustacean retrieval. Additionally, the control box includes the button to activate the gripping arm,

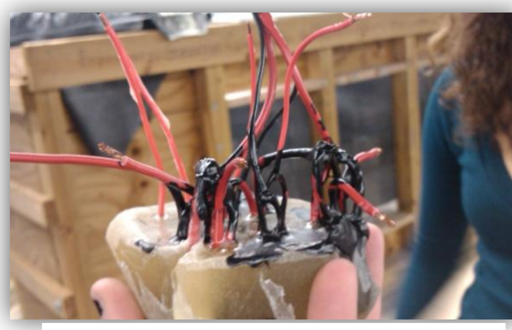

Figure 10 – Closer view on the relay setup, waterproofed in epoxy.

while the left panel contains the up/down control joystick. Each of the control sticks leads to a series of relays that toggle power to each of the motors attached to the ROV based on the intended direction. Finally, the control box is hardwired through the tether to the ROV. By choosing a fully hardwired system, the hassle of software programming and unreliability is avoided, and leads to faster testing and design revisions to reach the optimal setup. After previous failures with more complex software and electronic driven systems, the hardwired setup was an excellent and simplistic alternative.

Power Systems – The power for the ROV needed to be managed in a way that stayed within the constraints of the competition requirements while providing enough power to manage all onboard systems. Powered by a 12 VDC battery on the surface, the ROV needed a lightweight and agile solution for carrying the power down to the vehicle; therefore, a single 12 gauge pair was used to power all four motors, minimizing tether size while optimizing performance in the most common drive mode used during the mission. An additional line ran power to all other systems onboard the ROV, while a small portion of the power was distributed at the surfaces to stream tiny currents to the relays in order to switch them on and off. The hydrophone is powered separately, using a 9 volt battery located inside the control box.

V - VEHICLE SYSTEMS

The systems that encompassed in the vehicle design are focused primarily on maneuverability and mission components. The propulsion system is designed using several organized sets of relays to turn the motors on and off. The mission components include the use of a solenoid triggered claw, an independent temperature probe, a bilge pump powered vacuum, a pressure-activated core sampler, an independently powered hydrophone, and a stationary hook. The solenoid and bilge pumps are triggered by the use of their own sets of relays. The Solenoid triggered claw is set up through a button on the control box. Press the button once to activate then again to deactivate. The power from the button goes down the second Ethernet cable to the relay where it triggers the power to the solenoid. The solenoid then pulls the magnetic rod into itself which pulls the claw wire and closes the claw.

The temperature probe consists of a Thermistor thermometer retrofitted for mission purposes. The probe is attached to the end of the ROV's claw, the longest outward extension from the ROV itself. The readout is then recorded by hand at the surface and graphed. The vacuum was built using a recycled 500 GPH bilge pump motor that has been refitted with a propeller. This motor is then mounted to a PVC tube. When activated, the motor spins and draws water in through the large mouthed end and it is expelled through several small holes closer to the motor. This allows for a high degree of suction to power a vacuum. The vacuum will be used to collect the simulated creatures at the bottom. In order to prevent the creatures from falling back out, a plastic mesh flap was fitted to the mouth of the vacuum and as a barrier inside the tube. The flap is drawn inwards when the vacuum is on and the creatures are pulled in and stopped by the mesh barrier.

For sampling the bacterial mat, a core sampler was implemented. The core sampler is pressure activated when the bottom edge is pressed against the bacterial mat. The pressure opens a flap with springs that helps it close when the pressure is released. By pressing the ROV down into the bacterial mat, the core sampler will collect and hold the sample. The hydrophone is built by a very basic microphone system powered via a 9 volt battery. The receiver end is encased in an oil filled container that helps keep the container waterproof, whilst allowing for optimal sound sensing. The output is attached to the control box that is subsequently attached to a set of computer speakers. The hook is a stationary object mounted off of the bottom of the ROV that will be used for the lifting of the heavier objects, while an additional hook was added to the claw for easier manipulation of the elevator pins.

VI - CHALLENGES

As with any competition or task, the team met many challenges throughout the design and testing process that were tackled and overcome with great diligence and efficiency.

One such challenge involved the design of the tether and power distribution. Starting with the previous year's design, the tether was large and obstructive, with individual 16 gauge lines running down to the vehicle to power each motor. This presented a considerable obstacle, as the size of the tether impeded maneuverability, balance, and buoyancy. In order to avoid this problem, the tether and wiring was designed from the ground up, as the motors were rigged and tested with 10, 12, 14, and 16 gauge wires over a 50 foot extension cord to account for voltage drop. The performance was compared between each sample, and an optimal design was devised using a single 12 gauge pair running all four motors through the relays, as compared to the unwieldy individual 16 gauge lines per motor of the previous design. As all four motors are rarely used concurrently, the new design optimized 2 motor operation, the most common driving mode used during the operation of the vehicle. While four motor operation performance was reduced, the tradeoff for an exceptionally lightweight tether and optimized two motor setup was well worth it.

Another mission task met with problematic response was the moving of HUGO. The solenoid powered claw was originally intended to also move the observatory; however, upon testing, it was found to be extremely difficult to get a firm hold on the pins. In response to this challenging dilemma, a light weight and simple solution was devised. A bent bronze rod was attached to one arm of the claw, allowing it to hook onto the pin for easier removal.

VII - TROUBLESHOOTING TECHNIQUES

As with any project, problems arise in a myriad of situations and forms that serve to prove the reliability, performance, and application of any system or design. Most errors and other problems occurred during the construction process, which helped to refine the design. Before implementing systems, they were rigorously tested, such as the implementation of the vacuum; however, small problems arose that required identification and solutions. Prior experience helped identify potentially problematic scenarios, which allowed for adequate preparation and testing when such situations occurred.

Figure 11 – The claw apparatus with attached solenoid, after successful wiring and testing.

One of the more delicate issues during the construction process was the power constraints. Systems were tested continuously until a satisfactory level of power draw was reached that could sufficiently power all devices while maintaining a stable system. Additionally, multiple test runs were necessary to check if the equipment was put into place correctly while maintaining functionality. Throughout the design process, a large majority of the electrical equipment malfunctioned or broke upon mishandling or a mistake in wiring. Repairs were needed frequently to solve these problems and to help further our building process. Numerous trials took place in order to arrive to a final, acceptable product. The relays constantly needed to be remade after breakage, but after several tries a nearly perfect set up was created.

Furthermore, encounters with malfunctioning equipment lead to struggling times. By taking apart the initial set up and going through the procedure repetitively, the flaws were discovered and fixed. For example, the "claw" for the mission did not work upon initial assembly, but after identifying a faulty wire connection, it immediately started functioning correctly. Another issue involved the hydrophone for the mission malfunctioning. The set up and wiring for the hydrophone were correct; yet, no conclusion was able to be drawn. Eventually, minute adjustments were all that was needed to solve the issue. Another example involved placement of the cameras, which required optimization to reduce driver view obstruction during operation.

Another system in considerable need of troubleshooting was the vacuum. Initially, the diameter of the PVC pipe was too small, and the legs of the crustaceans would not fit inside. Additionally, the mesh bag initially implemented to catch crustaceans inside the pipe collapsed in the current generated by the motor. To rectify these problems, the causes were identified, and the design was adjusted accordingly. The vacuum diameter was increased to allow for the crustaceans to fit inside completely. A metal mesh divider was added between the crustacean collection area and the propeller to avoid contact, and the four wire ties that made the hinge in the front were replaced with a single mesh door.

Lastly, another area that saw considerable revisions was the relay setup. Initially designed using Double Pole Double Throw (DPDT) relays to reverse the motors, the setup proved ineffective. The design was in need of troubleshooting, which yielded the discovery of several errors. Forward movement on the joystick resulted in activation of the forward and DPDT relays for reverse, which was incorrect, as pushing forward caused the ROV to move in reverse. The problem was discovered, as the current from the forward and reverse switches on the joystick needed to be connected to the forward relay to power the motors. This caused the current from the forward joystick switch to go down the joystick reverse switch wiring path to the DPDT relays for reverse. A diode was then placed to stop forward on the joystick from activating the DPDT reversing relays, successfully correcting the issue.

A combination of trial and error and mathematical intuition helped in the troubleshooting process for much of the design process. By experimenting countless times until an effective result emerged, the ROV was completed successfully.

VIII - PAYLOAD DESCRIPTION

During the conceptual design process, various systems for payload retrieval, movement, and delivery were presented and discussed. Through extensive testing and revision, a final set of mission tools were deployed for this purpose. The mission details specify the need to carry the HRH to a designated location in the simulation environment, determined by the buzzing sound detected via hydrophone. In order to retrieve, move, and deliver this payload, a brass rod was bent into a hook. The hook formation was highly ideal and flexible, as any portion of the HRH could be hooked on to for movement. The simplicity of design leads to substantial ease of use and quick completion of the mission task. In addition, a bilge pump motor was used in conjunction with a PVC barrel to create a vacuum. This was utilized to capture and contain the crustaceans required to be collected during the mission simulation. Finally, a claw was fashioned using a solenoid and a generic grip extension device in order to grab the PVC pieces on the simulated hydrothermal vent, in addition to auxiliary use during the mission simulation when necessary.

Figure 12 – The claw apparatus, with attached copper hook, used to manipulate various mission elements.

Although the above represents the final decisions on mission components for retrieval, movement, and delivery of the various payloads, many other alternatives were devised. One such method involved a dust-pan-like apparatus to scoop up crustaceans; however, this was dismissed after testing revealed that it merely pushed the organisms around, while there was no reliable way to keep the crustaceans onboard after retrieval. Another such alternative brought up in discussion was the use of four claws. Three would be used once to retrieve one crustacean each, while the remaining apparatus would be used when needed. This too was dismissed for its complexity, in addition to the nature of the claws impeding further maneuverability. After extensive testing, discussion, and revision, the chosen mission tools have performed excellently, and insured a high degree of confidence and reliability.

IX - FUTURE IMPROVEMENT

As with any task, challenges are met with innovation, critical thinking, and perseverence, while any obstacles are tackled with diligence and efficiency; however, despite the best efforts of all involved, there will always be room for improvement. Be it revising problematic, older systems, or rethinking concepts from the ground up, improvement is an invaluable tool to fine tune designs and ensure future success.From a technical standpoint, there are many areas that can see improvements and revisions. For example, the control system and motor setup could use an overhaul to adapt a more computerized system. Over the past three years, various designs have been tested and revised; moreover, one such system may see use in next year's competition. Designed around dual cycloidal drives and three vertical thrusters, the motor setup will allow movement with six degrees of freedom, with easier maneuverability through pulse-width modulation and drive-by-wire due to software implementation. Should the same control and motor scheme be used next year, the creation of the relay setups could be better facilitated to create a neater and less error-prone system. Additional areas of improvement include the potential for color video feeds, as well as securing a pool to practice and test in throughout the year.

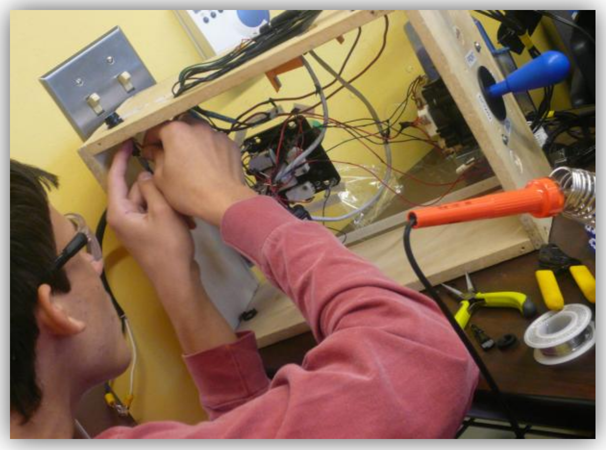

Figure 13 – Another future improvement frequently brought up is the potential move to a computerized control system.

Figure 14 – Dual cycloidal drives, such as this Voith Schnieder Propeller, are capable of controlling all movement with the x,y plane with speed and precision.

X - LESSONS LEARNED

The ROV represents an excellent opportunity to utilize engineering and innovative skills in a working environment. The construction aspect of this project is demonstrated through arduous work and effort. In order to bring the physical pieces of the ROV together, planning and designing must take place beforehand. As the team pushed onward to assemble what started as an idea into a fully functional machine, the success they wished to obtain was finally within their grasp. It was an endless struggle for everyone, including the advisors who refused to let the team give up and kept the team motivated. The long hours and demanding work was also an eye opener into the persistence needed to accomplish tasks in the real world.

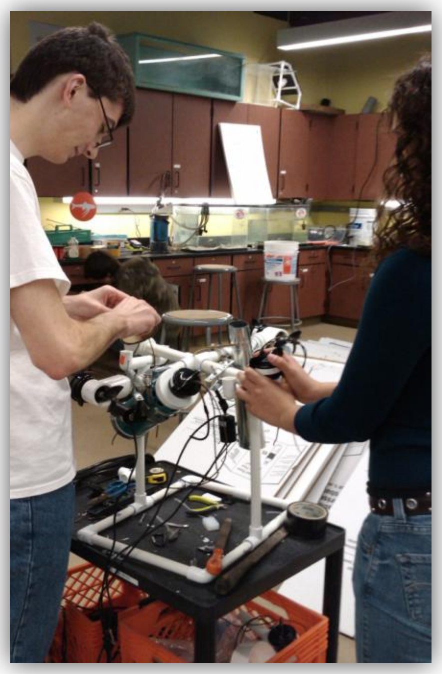

Figure 14 – Team members Emily Keppen and Thomas Slagmolen learn the finer points of teamwork.

The mechanics of engineering, the applications of mathematics, and clever innovation are always available to those who wish to use them. Without a doubt, the fields of engineering involve a plethora of skills and creativity to bring forth a single project. As advised by our leader, "Nothing can be done without first an idea. Nothing can be done without first the skill. Nothing can be done without first the team". This motto has been adopted by the team and has been the drive for all involved. Although individuals may bring forth excellent ideas and designs, only through collaborative efforts can a truly successful project emerge. Although the occasional argument may stir the teammates into question, the collective knowledge and skill of the group aids in overcoming obstacles and enduring the hardest of challenges. This is considerable preparation for real life applications in the fields of science and engineering, where perhaps not all situations can be overcome single handedly. In practical situations that range from developing simple and new methods to creating large scale projects, teamwork is essential for accomplishing these tasks. Small ideas led to innovated ideas which were then finally set into motion to create our ROV. While individual ideas may start out small, a slight push in the right direction and a hardworking team is all that is needed to accomplish anything.

XI -LOIHI SEAMOUNT – RELATED INFORMATION

Located off of the southeastern coast of Hawai'i, the Lōʻihi Seamount belongs to the chain of hotspot volcanoes know as the Hawaiian Emperor Seamount chain. As the most recently formed structure in this chain of volcanoes, the Lōʻihi Seamount began its formation roughly 400,000 years ago, and remains the only Hawaiian volcano still in its submarine preshield stage of development. The seamount plays host to a large system of hydrothermal vents which, when combined with the structure's mid-Pacific environment, yields conditions optimal for support of a diverse community of microorganisms and bacterial mats. First unveiled in the late 1980s, the vast and sprawling network of hydrothermal systems at the Lōʻihi Seamount bears a striking resemblance to similar systems found at the mid-ocean ridge, in both composition and temperature profiles.

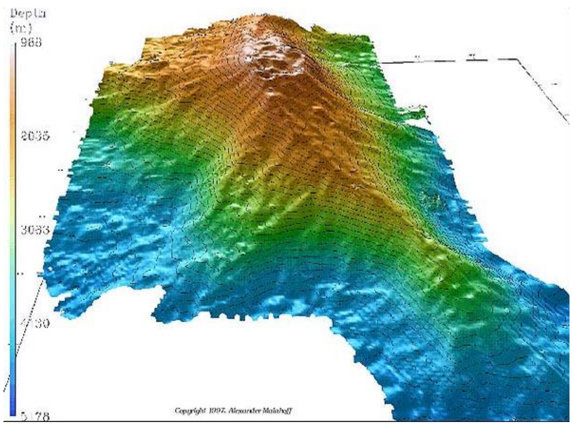

Figure 15 – Map showing underwater elevation of the Loihi Seamount.

As exemplified through the mission simulation, the hydrothermal vent network provides optimal conditions for the development of a myriad of microorganisms, bacterial mats and unique geographical formations. High concentrations of carbon dioxide (CO_2) and iron (Fe) in vent fluids have created a unique environment that allows iron-oxidizing bacteria to thrive. Additionally, the vent system plays host to a large collection of bacterial mats, surrounding and covering many of the vent sites, including a jelly-like microbial mat resembling the simulated bacterial mat in the mission. Exploration and sampling of the environment has resulted in observation of various macroinvertebrates and fish species. The mission used in the competition's simulation is an excellent example of the processes and equipment used in the sampling of underwater formations and structures.

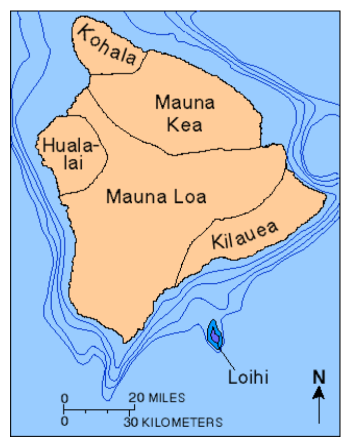

Figure 16 – Map indicating the location of the Loihi seamount in relation to the Hawaiian Islands.

XII - REFLECTIONS

For the 2010 MATES ROV team, the experience was certainly a whirlwind. Looking back, it is nearly impossible to identify the exact time where anything went exceptionally smoothly, at least not until the very end of the project. All hands were on when creating the ROV, and no one ever dared to slack. As each day passed and the deadline approached with seemingly greater speed, it seemed as if everything depended on finishing the project, with the reward of success within the team's grasp. From the very start and from past experiences, the team knew that taking this competition lightly would certainly result in poor results, thus motivation to excel drove the team to delve deeper into its true potential and utilize its collective skills to the limit.

It was a rough start for the team, yet throughout the experience, an inseparable bond was formed. The younger and newer members of the teams were warmly embraced to help create the ROV, and were soon fully entrenched with the rest of the group in the endless pile of work that had to be completed. When frustration occurred, instead of simply casting it aside, the problems were tackled through a collaborative effort, reinforcing teamwork and collective knowledge. With this mentality, the team soon realized how important it was to follow through with a design, and not give up when obstacles were presented. Numerous versions of relays, equipment, and props were created in order to satisfy the need to quality components and construction, culminating in the creation of a fully functional ROV, capable of fulfilling the mission specs and more.

Figure 17 – The 2010 MATES ROV Team, veteran members and a few new faces.

As the objectives come to a close, reflections upon past experiences drew the team together. Looking back, what seemed like small arguments became the backbone of the design, as these discussions presented new ideas and concept variations that were never devised before. Not only did cooperation bring the team's full potential and skill to the forefront of the design and construction process, it resulted in the culminating achievement of a full functional and capable ROV, and a closer appreciation for one another.

XIII - ACKNOWLEDGEMENTS

The members of the Robotics and ROV Club at the Marine Academy of Technology and Environmental Science would like to extend our sincere gratitude in assisting us throughout the year. First and foremost, Ms. Karyn Quigley and Mr. Paul Fennimore deserve the highest appreciation and thanks for the hard work, time, and effort they have put into the vehicle through their thoughtful advice and passionate motivation. Additionally, we would like to extend our thanks and appreciation to Ms. Allison Carroll, Mr. John Wnek, and to the Ocean County Vocational Technical School District for their unwavering support and firm dedication throughout the design, construction, and competitive processes. Additionally, a special thanks to Scott Bentley of Video Ray for supplying the team with a full set of mission props for preparation for the international competition.

Without the financial help from Nancy and Robert Given, Dave Valero, and the OCVTS District Board, this project would have never gotten off the ground, and for this they have our eternal gratitude. The Toms River Fitness also deserves our thanks for allowing us use of their facilities, while additional thanks are extended to Dan Moeller, Jim Priestley, and the Toshiba Foundation for their help and donations. The MATE Center, Secondary Robotics Initiative, School District of Philadelphia, Society of Manufacturing Engineers, Urban STEM Strategy Group, Video Ray, Villanova University's Department of Mechanical Engineering, and all other supporters are held in the highest regard for presenting this opportunity to apply these skills, and for this they have our thanks, for supporting and fostering the development of science and engineering in our education. Knowledge is an invaluable gift, and one that has earned these esteemed associates our most sincere thanks for their endless dedication and drive.

XIV – WORK CITED

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