RIVIERA BEACH MARITIME ACADEMY

DIVE DEEP, LIVE LONG, DIE FREE

Riviera Beach, Florida

The Team

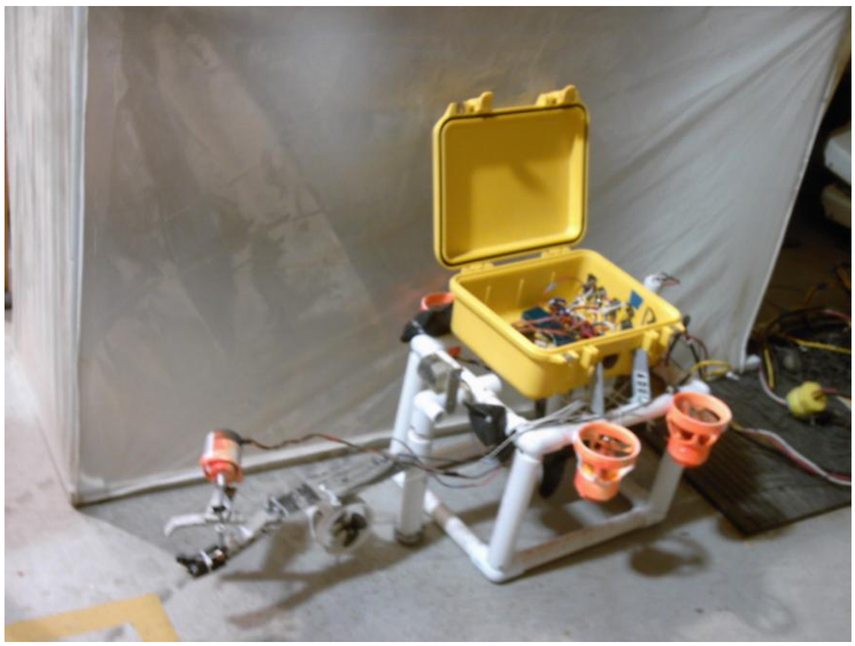
Micaiah Wells – President – Senior
Taylor Katz – Secretary/Treasurer – Junior
Alexander Thompson – Team Member – Senior
Corey Green – Team Member – Junior
Lexxa Katz – Team Member – Junior
Sabrina Bowser – Team Member – Junior
Douglas Drysdale – Team Member – Junior
Gabriel Alejandro – Team Member – Junior
Justin Stanford – Team Member – Sophomore

Mentors

David Sellepack
George Bradbury

Abstract

As a school, this is Riviera Beach Maritime Academy's fourth year coming to the MATE International ROV competition. The ROV was designed to revive a damaged geological observatory, and collect samples of crustaceans, bacterial mats, and a hydrothermal vent. As well as measuring temperatures at said hydrothermal vent. We started off this year with a radically different concept than our final iteration. Unfortunately, the original ROV turned out to be a miserable failure. We ended up scrapping the design and starting anew. As such, this year's final design focused on simplicity and reliability above all else.



The ROV consists of a 'box' constructed out of 1" PVC pipe. Four bilge pump motors provide vertical thrust, and a single bilge pump motor turns the ROV. A single trolling motor underneath the ROV acts as a drive motor. A single claw with a mounted thermal couple is mounted on the bow of the ROV, and is used to collect the crustacean and vent spire, as well as read the temperatures. A length of 1" PVC capped with chicken wire and mounted underneath the claw serves as an agar collection device. Overall, all of our systems are designed to be very simple and reliable. The fewer parts available to fail, the less likely you are to see a failure.

Loihi Seamount

Thirty five kilometers off the southeast coast of Hawaii Island, on the flank of Mauna Loa, lies the submarine pre-shield volcano, Loihi. It is occasionally referred to as the "youngest volcano" in the Hawaiian-Emperor seamount chain, which stretches over 5800 kilometers. Loihi is the Hawaiian translation for "long," and was named for its "elongated morphology." The submarine volcano has two rifts stretching both north and south of the summit.

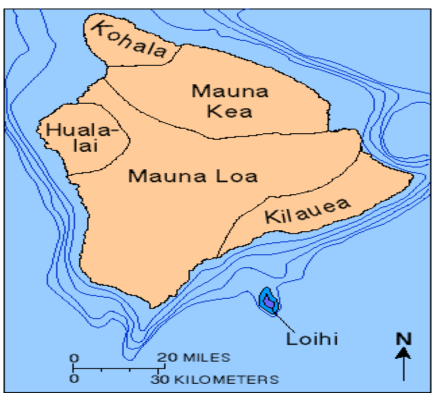


Figure 1: Location and size of Loihi Seamount

Loihi is assumed to have began forming approximately 400,000 years ago, due to a 1978 expedition that supplied 17 dredge samples. The method of testing the rock is called radiometric dating. Radiometric dating is the process of establishing the age of inorganic substances by comparing the concentration of isotopes to the isotopes decaying properties.The oldest sample of rock studied was approximately 300,000 years old. The youngest samples were taken from the eastern section of the seamount, estimating the age of the younger section at approximately 4,000 to 21,000 years old. At this rate of growth, the seamount gains 3.5 millimeters per year.

Before the 1970s, Loihi was believed to be inactive, but a swarm of earthquakes disproved this belief. Scientists studying the seamount revealed Loihi as being a young, active volcano with a combination of new and old lava flows, while venting hydrothermal concoctions at its summit.

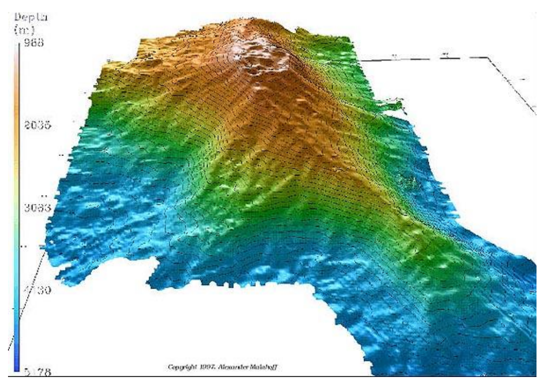


Figure 2: Underwater Morphology of Loihi Seamount

More recently in history, another swarm of earthquakes occurred between July 16th and August 9th of 1996. The swarm was considered to be the largest series in amount of earthquakes and intensity, with over 40 of the spasms at 4.0 and a single earthquake at 5.0.

The University of Hawaii scientists that studied the seamount following this seismic swarm have found evidence of there being a volcanic eruption during the swarm. In August of 1996, the National Science Foundation funded an expedition led by Frederick Deunnebier to investigate the swarm and the swarm's origin.For the remaining of the year, there were expeditions funded by organizations such as the National Oceanic and Atmospheric Administration (NOAA). These expeditions included a series manned and unmanned submersible dives.

References:

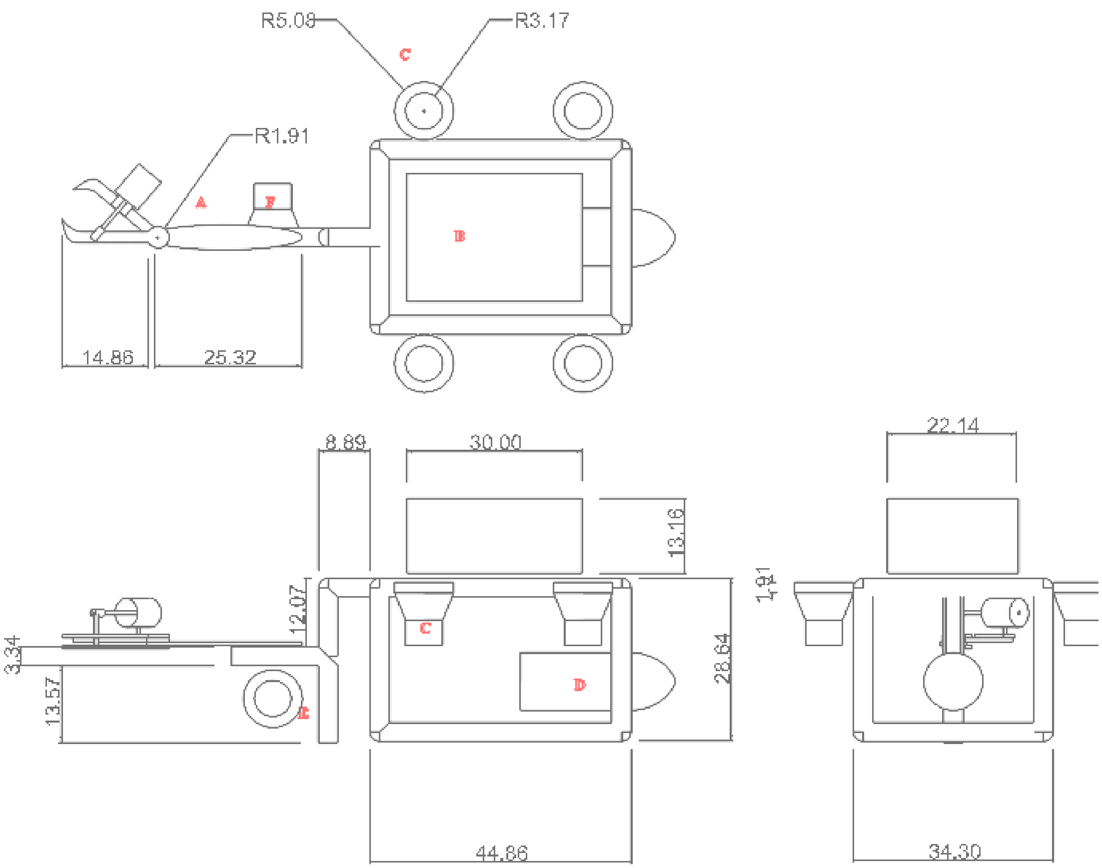
http://www.volcano.si.edu/world/volcano.cfm?vnum=1302-00-

http://www.soest.hawaii.edu/GG/HCV/loihi.html

http://hvo.wr.usgs.gov/volcanoes/loihi/

http://en.wikipedia.org/wiki/Loihi_Seamount

ROV Schematic



A. Claw

B. “Brain” (electronics housing

C. Vertical Thrusters

D. Drive Motor

E. Turning Motor

Design Rationale

Tasks

When doing research for a company or government there is a limited time frame that objectives need to be completed. Many problems can arise and waste precious time and money. The theme of this year's MATE ROV competition is very similar we must complete different tasks in a limited time. So we decided that our ROV should be durable and simple so that if there is a problem it can be fixed fast and continue to the next objective.

Claw

Many of the tasks required objects to be lifted and moved, so we decided to build a claw that could pick up all of these things. An ROV we had used in the past had a claw design that proved to work very well, so we took the basic concept of that design and improved it to be more durable and compact.

The Claw itself has three 'fingers,' two of which lie next to eachother, fixed in place to the arm of the claw. The third finger faces the other two, and is the part that actually opens and closes. Hanging off of this mobile finger, is a bilge pump motor that powers the open-and-close motion of the claw. The bilge pump does this by turning a threaded rod through a chuck connected to the opposite two fingers of the claw. As it does this, pushes or pulls itself away from the fixed fingers by essentially screwing itself into place

We decided to go with the threaded rod approach due to the strength and precision that we would be able to achieve for a relatively low cost. Threading the rod through the chuck works almost like a set of offset gears, turning the high-rpm bilge pump into something that could provide significantly more torque and move at a slower, easier to control, pace.

Thrusters

There are a total of 6 thrusters mounted on the ROV to control movement. Located within the frame is a single trolling motor as the ROV's main propulsion used for forward and reverse movements. The trolling motor is situated through the frame and fastened in place with epoxy and screws. Although there are three coils in the motor that can be fired to increase power, only one is used, as any more would be unnecessary.

Vertical movement is provided by four bilge pump motors situated in an array around the outside of the top level of the frame. These motors are mounted into a homemade shroud consisting of a 4" to 2.5" PVC reducer with porting cut into the side. They're mounted in the shrouds with a layer of 3M 5200 marine sealant. The shrouds serve several purposes, working as a safety feature, protecting the blades, and providing a convenient method of mounting the motors to the ROV's frame. 2 screws through the outside edge of the shroud are enough to hold the motors down.

The last thruster is constructed in the same manner as the vertical thrusters, the difference being that it is mounted on the underside of the claw's arm facing perpendicular to the ROV's centerline so that when put in forward or reverse the motor will turn the entire ROV. This was done in order to make the control system more ergonomic. One joystick on our controller covers forward, reverse, left, and right, while the other(without a spring in the joystick) controls vertical thrust, and opening and closing the claw.

Cameras

In order to provide vision we waterproofed and used three cameras. We placed the cameras in a container and coated the cameras with silicone to seal the body away from the lens. Five minute epoxy was used to hold the cameras down while we poured a clear acrylic into the container. After 24 hours it cured and the cameras were effectively waterproofed. We positioned one camera on the front of the ROV for navigation and tasks involving the claw. The second was mounted within the frame in order to view the agar collection pipe. The final camera is rear-facing and located on the back of the ROV so the pilot can navigate in reverse.

Frame

The final design of our ROV focused on pure simplicity. We had a lot of issues with the complexity of our previous design, and we only had a week to build everything.

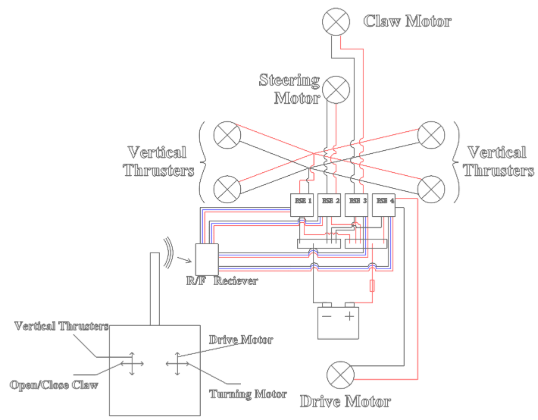
Our frame consisted of a 43x34x32cm Box made out of 1” PVC pipe. Forward Thrust comes from a single Minn-Kota trolling motor facing backwards and mounted on the underside of the ROV. Vertical thrust is provided by four bilge pump motors mounted on the top four corners of the main frame. The ROV is turned by a single bilge pump motor mounted on underneath and perpendicular to the claw. Electronics were housed in a Pelican™ 1500 waterproof case.

We built the frame out of PVC piping due to its low cost, light weight, and commercial availability. The sizing was our attempt to make the ROV as small as possible, while still using remaining parts left over from our previous ROV.

The trolling motor was somewhat difficult to mount. Originally we planned on mounting it facing forward, in the ‘normal’ fashion, but in order to do that, we would have had to put obscene amounts of floatation hanging off the back of the ROV, which would have made it larger and more cumbersome; the exact opposite of what we wanted. So instead, we mounted it backwards, putting the majority of the weight directly underneath the electronics box.

In order to mount the trolling motor, we put a 4-way PVC connector on the rear-top section of the PVC frame, and put the trolling motor’s shaft through two of the four connectors. This was all cemented into place with epoxy and kwiksteel. This was the simplest method of mounting that we could think of, and it provided a stable mount for the motor.

Wiring and Electronics



With the flooding of our previous control box fresh on our minds, we decided to return to a control design that had worked wonderfully in the past. Although considerably lighter than past machines, This year's model was still fairly heavy, with a 4kg trolling motor centered under the ROV and a not-so-light claw hanging off the front, we needed a good deal of floatation. A model 1400 Pelican™ case served our needs wonderfully; we had used the same case in the past with success, so we knew it would be reliable. Plus it would provide a more than enough floatation.

Control of the ROV is done through four ESC's (Electronic Speed Controllers). An ESC is an electronic circuit designed to (surprisingly) control speed in an electric motor. Unlike other methods of controlling speed control, an ESC will constantly allow full voltage and amperage to the motor. Rather than regulating voltage, they send 'pulses' of electricity to the motors, controlling the speed by increasing the length of these pulses.

We are using ESC's because they allow for a much more… ergonomic control system than we would be able to achieve through our team's limited programming experience. The ESC's plug directly into an RF receiver, and can be controlled through a commercially available model airplane controller. RF signals are transmitted to the receiver through a serial cable, which basically functions as an extended antenna of sorts.

Looking into the actual wiring of the parts, we had 2 primary goals

1. Keeping everything as simple as possible. Less parts in the system means fewer chances for something to go wrong.

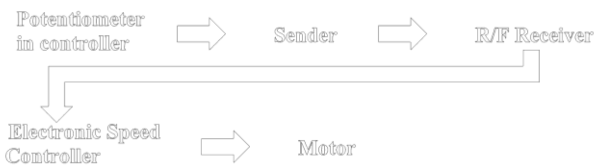
2. Avoid leaking. I suppose this would be a given, however, it still shaped our design process.

To get wires into the box without letting water in with them, we used machine screws tapped through the plastic of the box. On each side of the plastic, we had a rubber seal and a washer, providing a watertight seal. Ring connectors were crimped onto the wires both inside and outside of the box, and those were placed on the bolts.

Even with this watertight system, we wanted to keep the number of holes in the box to a minimum. So rather than having 2 battery cables for each individual ESC, we put 2 power strips inside the box, one positive, and one negative. The power strips were connected directly to the power source, and the ESC's received their power from those strips.

Software & Control

Originally we were going to use a PLC (Programmable Logic Controller) running a PBASIC program to control our ROV. The PLC would have been connected to a laptop through a serial cable and controlled via keyboard commands.



Commands would be entered through a debug window. Motors would have been controlled by 2 relays each. One relay was a simple on/off switch, hitting the appropriate key would simply turn the relay on, which would in turn switch the motor on. Activating the second relay would reverse the electric current flowing to the motor, and thus put the motor in reverse.

Unfortunately, the serial cable we ordered had an issue and it wasn't transmitting a signal. On top of that, the PLC sustained water damage during a test run and was put out of commission. In response we had to redesign our control system.

We replaced the computer and PLC system with a model airplane RF controller and waterproof ESC's. Each 'joystick' in the controller manipulates a potentiometer. These potentiometers send signals to an RF sender in the controller, which transmits this signal through an RF cable to an RF receiver within the brain of the ROV. The ESC's are wired to the RF receiver and interpret it to regulate the speed of the motors that they control.

Challenges

Unfortunately, this year's ROV club was faced with a large host of problems. Not the least of which was the complete and utter failure of our original design. At the regional competition, we hadn't even put the ROV in the water yet, it wasn't balanced for floatation, it was uncontrollable, and, to cap it all off, it sprung a leak and most of our electronics got fried. Pretty much all of the problems with our original design can be traced to a combination of procrastination, lack of communication, and not analyzing design choices thoroughly enough.

Our original concept was based off of issues we ran into last year in keeping the ROV stable while we were trying to perform precise operations. So this year we went into the design process wanting to have a stable platform which we could use without having to worry about keeping the ROV steady. Looking at this year's missions, we saw that almost all of the tasks required a manipulator of some sort, agar collection being the exception.

With that in mind, we developed a concept that, in theory, would provide a stable platform for a large manipulator that could perform everything that was required of it. And we came up with a rather… interesting design. The structure of the ROV consisted of a 40x40x50cm PVC frame. Attached to a crossbar on the top of this frame, we had a claw that had 3 separate axes and could fold into the center of the ROV for transport. The claw would ordinarily only use 2 of the 3 axes, and then the third would extend when we needed to test the temperature of the vent spires using a thermal couple at the end of the claw.

There were 4 vertical thrusters made out of bilge pump motors on the top corners of the frame, and 2 trolling motors hanging from a piece of plywood running across the Frame's midsection. And the control systems were housed in a watertight pelican box (Affectionately dubbed 'the brain').

Although not the *best* idea in the world, the original concept was somewhat sound. The problems occurred when trying to turn that concept into a reality. When I came up with the original concept and drew out a rough draft in Rhino, I didn't include a method of mounting the brain, nor a method of mounting the trolling motors. Neither of these design issues were addressed until the ROV was already under construction. The person in charge of designing the claw failed to include how the various bilge pump motors would be attached to the claw, and that too, was developed 'on the fly.' We didn't calculate the weight of the claw or motors for purposes of balancing everything out.

Once we had everything together, we cut and re-spliced a serial cable in order to run it into the brain, sealed it in place, and realized we put it in backwards. So we hurried to our local radio shack to get some male-male and female-female adapters and reversed it, but unfortunately, after everything, the serial cable didn't work. We never did pinpoint the problem, but we believe that the adapters reversed all of the pins.

After that little mishap, we pulled an all-nighter at a hotel the night before our regionals, redesigning the wiring of the ROV, changing the program and a few other modifications. Even after all that, we still failed miserably. Luckily, Erica Moulten decided to grant us grace and allow us one additional week to get the ROV ready to qualify.

So we scrapped the original design and managed to build a functional ROV in two weeks, when our original took over two months.

Lessons learned

As infuriating as all these issues were, we had no one but ourselves to blame. We devoted a large amount of time building simulations on the Blender animation program, but we focused all of these simulations on whether or not the parts would fit and move together in a functional manner, and whether or not they would be able to perform the tasks they were designed to do. But we did not do any work whatsoever in regards to balancing, or movement.

In our design process, entirely too much time was put discussing theories and concepts of the ROV, without thinking through what actually needed to be done to make those concepts work. That, combined with a team-wide tendency to procrastinate and goof off rather than diligently working, led to frantic last-minute work, most of which was spent trying to fix obvious design issues that we should have noticed months before.

Overall, on a technical level, we learned some very important lessons about the design process. Everything needs to be planned out to the smallest detail before construction begins to avoid confusion. More research needs to be done regarding materials, weight, and balancing. And you can't always rely on theoretical hypothesis to say, "It will work."

Beyond the technical, however, I believe the team learned much, much more. We learned the value of communication, letting eachother know where we were on our individual portions of the project. We also learned precisely how *not* to manage our time properly

(Team Photo)

Future Improvements

Due to time constraints, this year we were unable to devote adequate time to the design process. As a result, our ROV threw an unsuspected curveball at us when it came time to test our buoyancy. In previous years, we had always needed to add significant amounts of flotation to our designs. And although our robot was much lighter than previous years, it still was fairly heavy so we assumed we would have to do the same. But, to our surprise, when we dropped it in the water we discovered that it had several pounds of positive buoyancy.

We were able to add some dive weights to correct this problem, but in the future, we'd like to make it a goal get as close to neutral buoyancy as possible without needing to artificially increase weight or floatation.

Another minor issue that cropped up involved our control systems. In their current incarnation, we use a model airplane controller. The right joystick controls forward/reverse movement, as well as turning left and right. Moving the left joystick forwards and backwards controls the vertical thrusters, and moving it left or right will open and close the claw. Although the system is functional, it can cause some issues. Opening or closing the claw can cause inadvertent vertical movements which can keep you from being able to grab the intended target with the claw.

In the future, we would prefer a more… ergonomic control system. Perhaps we could re-attempt having everything controlled through a PLC, using a computer as a control interface. Or we could design our own control box with additional axes to use for control.

Finally, I personally am not too thrilled about our choice of material this time around. PVC pipes are cheap and easy to work with, but they also can put some rather harsh limitations on ones design. One thing that I would like to see, would be to take note of our mentor's M.U.D. wrestling robot and build something out of fiberglass or a similar composite.

Overall, we have a good design. But it most certainly isn't perfect and could use some improvements. Even if we don't build off of the same concept in the future, we can learn from issues we ran into in this year, and apply what we learned to future designs.

Reflections

Micaiah Wells

Position: President

Overall, this has been an enjoyable experience, and somewhat educational as well. I found all of the time I spent working with friends very rewarding, even though we didn't work as… efficiently as we could have. If I were to return to participate in the future I would do my best to think things through a bit more thoroughly, as well as do better to finish things *before* the deadline, rather than right up to it.

Taylor Katz

Position: Secretary and Treasurer

Point of View on R.O.V: Learned that if you procrastinate you will get little done correctly so take your time and make sure you finish when supposed to. Wish we were ready for everything in the beginning and fully focused.

I would improve on working together to put ideas in. Thinks we don't really listen to each other and that we take ideas from only one person, sometimes it's not fair but it's what we need to make the ROV working. Maybe next year we'll improve on the team actually being a team.

Gabriel Alejandro

Position: Team Member

I enjoyed getting to experience working with others to build the ROV. If I were to do this again, I would put more time into everything and work faster.

Alexander Thomson

Position: Team Member

I enjoyed the ability to work with so many great mind and experience teamwork and innovation to complete our goal. If I were to do this again, I wouldn't procrastinate.

Douglas Drysdale
Position: Team Member

My experiences you say? Well, during this experience I have learned to rationalize designs and work as a team with my fellow studentes if. I were to do this again…. I would focus on being more time oriented.

Lexxa Katz
Position: Team Member

I have been in this club for over three years and have enjoyed the m very much. Ive learned things I never thought I Could and I have done hands-on things with creating the ROV that I never thought I could do. Building the ROV has been quite an experience; we've had a couple rough spots on the way though. Joining ROV has brought me closer to people that I now call friends and I can gladly call my ROV leaders/teachers friends as well. Overall, I enjoyed the experience and of I were to do anything differently, I would invest more time into working on the ROV.

Sabrina Bowser
Position: Team Member

My most rewarding experience in the ROV club was our time spent traveling and the opportunity to meet new people. If I could change anything, I would have used our time more wisely, as well as properly test and design the ROV to fit requirements or restrictions.

Budget Sheet

Quantity	Item#	Description		Unit Price	Total amount
1		Analog Sound Level meter			
		mcmelectronics.com/product/VELLEMAN-SA-		$43.99	$55.98
1		3-Camera Anaconda Color Video Kit			
		http://www.x10.com/cameras/sc18a_s.html		129.99	$129.99
1		Enviro Tex Lite	#NAME?		
		shopcraftworld.com/view_cart.asp?catid=		8.39	$8.39
1		Silicon Aquarium Sealant			
		walmart.com/ip/Silicone-Aquariu-Sealant-		$5.50	$6.47
		Clear-3-oz-Fish-Aquatic-Pets/363511			
1	7541A76	Quick Drying Epoxy		$4.44	$4.44
10	4188T411	Plastic Mixing container			
		http://www.mcmaster.com/#4188t411/=61ntdn		$0.93	$9.30
4		1000 GPH Bilge pump			
		Amazon.com/gp/cart/view.html/ref=ox_huc			
		_edit_car		$30.44	$121.76
1		Pelican case		$28.00	$28.00
			TOTAL		364.33

Acknowledgements

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Mate Center for providing us with this excellent opportunity

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