OVERBROOK HIGH SCHOOL AQUABOTS
PHILADELPIHA, PENNSYLVANIA

2010 MATE ROV Competition Technical Report

ROV's in Treacherous Terrain: Science Erupts on Loihi, Hawaii's Undersea Volcano

ROV: RESURRECTOR

TEAM MEMBERS

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Freshman

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Sophomore

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Sophomore

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Junior

Patrick Fulton
Junior

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Sophomore

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Senior

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Ms. Vicki Baker

Team Mentors:
University of Pennsylvania Engineering Students
John Baker, Graduate Student at Graduate School of Education (GSE), University of Pennsylvania

Abstract

Remote Underwater Vehicles (ROVs) are unmanned vehicles used in underwater exploration especially in situation where manned vehicles would not suffice—either because of potential risks to the humans on board or the requirements of the vehicle needed for the exploration. The goal of the Overbrook High School Aquabots project was to design an ROV to perform four simulated missions under water for the ranger class division of the 2010 Marine Advanced Technology Education (MATE) ROV competition within 15 minutes. This year, the mission for competition involved collection of various samples, detection of a simulated underwater volcano eruption site, and the simulated resurrection of Hawaiian Underwater Geological Observatory (HUGO). The ROV, named Resurrector was constructed with simplicity, efficiency, and performance in mind. This is reflected in our motor and camera placement, choice of control system, choice of sensors, and choice of object manipulation system. We also factor the needs of the human operator into our design. Design concepts and construction were developed, tested, and improved throughout the time period that was giving. The ROV is capable is completing all four mission assigned in the competition within the allotted time.

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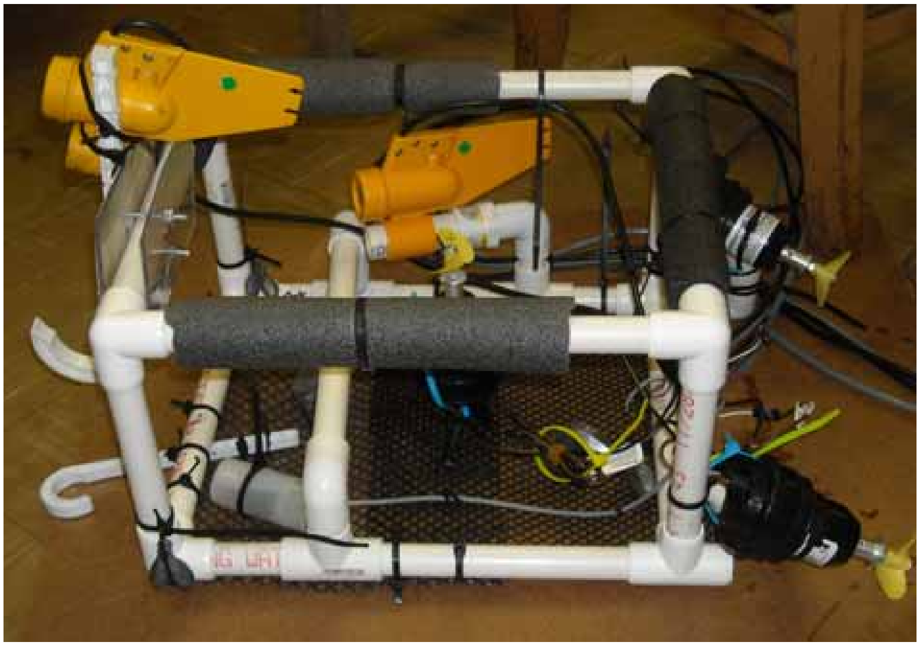
Photographs of ROV: Ressurector



ROV

Project Expense Sheet

Budget

Our team did not have a lot of money so we did some fundraising and we used items that were left over from previous robotics competitions. The budget was developed by looking at what we spent in the past. Our coach had an idea of how much it costs and she bought the materials we thought we needed. There were a number of trips to Radio Shack, Loews and Home Depot.

See next page for detailed expenses.

OVERBROOK HIGH SCHOOL AQUABOTS
PHILADELPIHA, PENNSYLVANIA

Date	Expense Description	SOURCE	QUANTITY	COST	Balance
2/15/2010	Initial Balance	Fundraising + Donations			$600.00
2/15/2010	Harbor Frieight Cameras	Harbor Frieght	3	$0.00	$600.00
3/1/2010	Pump,bilge, 12vdc	Grainger	3	$0.00	$600.00
3/14/2010	Avy 1x2 5/8 CLR	Staples	1	$28.99	$571.01
3/14/2010	Caremail 10.5x15 P	Staples	1	$1.99	$569.02
3/28/2010	Envirotex Lite 80z	A.C.Moore	1	$13.99	$555.03
4/12/2010	50' VL Audio CABL	Radio Shack	2	$17.98	$537.05
4/12/2010	9V 1Pk Alkaline Enercell	Radio Shack	2	$8.98	$528.07
4/12/2010	C 2 PK Alkaline Enercell	Radio Shack	2	$9.58	$518.49
4/12/2010	PK2 MIN PLG Black	Radio Shack	1	$2.99	$515.50
4/12/2010	PLAS B/HLDR 1-C	Radio Shack	1	$0.99	$514.51
4/12/2010	Pocket SPKR/AMP	Radio Shack	2	$29.98	$484.53
4/21/2010	1/2" Sch40 Coupling 42900	Lowe's	2	$0.42	$484.11
4/21/2010	1/2x6x3/8wall SS Tube Ins	Lowe's	3	$4.92	$479.19
4/21/2010	1"x3/4" Sch40 Tee 46413	Lowe's	1	$1.28	$477.91
4/21/2010	2.8 oz Silicon II K&B CL	Lowe's	1	$3.94	$473.97
4/21/2010	2oz Epoxy Repair Putty	Lowe's	1	$5.48	$468.49
4/21/2010	3/4"x1/2" Sch40 Tee 464	Lowe's	1	$1.16	$467.33
4/21/2010	3"x2' PVC DWV Cellcore	Lowe's	1	$3.62	$463.71
4/21/2010	5/16" ID Vinyl Tubing Per	Lowe's	1	$0.20	$463.51
4/21/2010	75 GPH Statuary Pump	Lowe's	1	$19.97	$443.54
4/25/2010	1/2 PVC Cap	The Home Depot	9	$2.34	$441.20
4/25/2010	8IN BLK TI	The Home Depot	1	$5.99	$435.21
4/25/2010	Angle Gauge	The Home Depot	1	$3.74	$431.47
4/25/2010	BLKCBLITE100	The Home Depot	1	$3.99	$427.48
4/25/2010	Drill Pump	The Home Depot	2	$13.90	$413.58
4/25/2010	DWV J Hook	The Home Depot	2	$1.60	$411.98
4/25/2010	J Hook	The Home Depot	3	$2.61	$409.37
4/25/2010	PVC Cap	The Home Depot	2	$1.58	$407.79
4/25/2010	PVC Cap	The Home Depot	2	$7.54	$400.25
4/25/2010	PVC Cement	The Home Depot	1	$3.76	$396.49
4/27/2010	Bolt J W/NUT 1/4x6"	ACE	1	$1.49	$395.00

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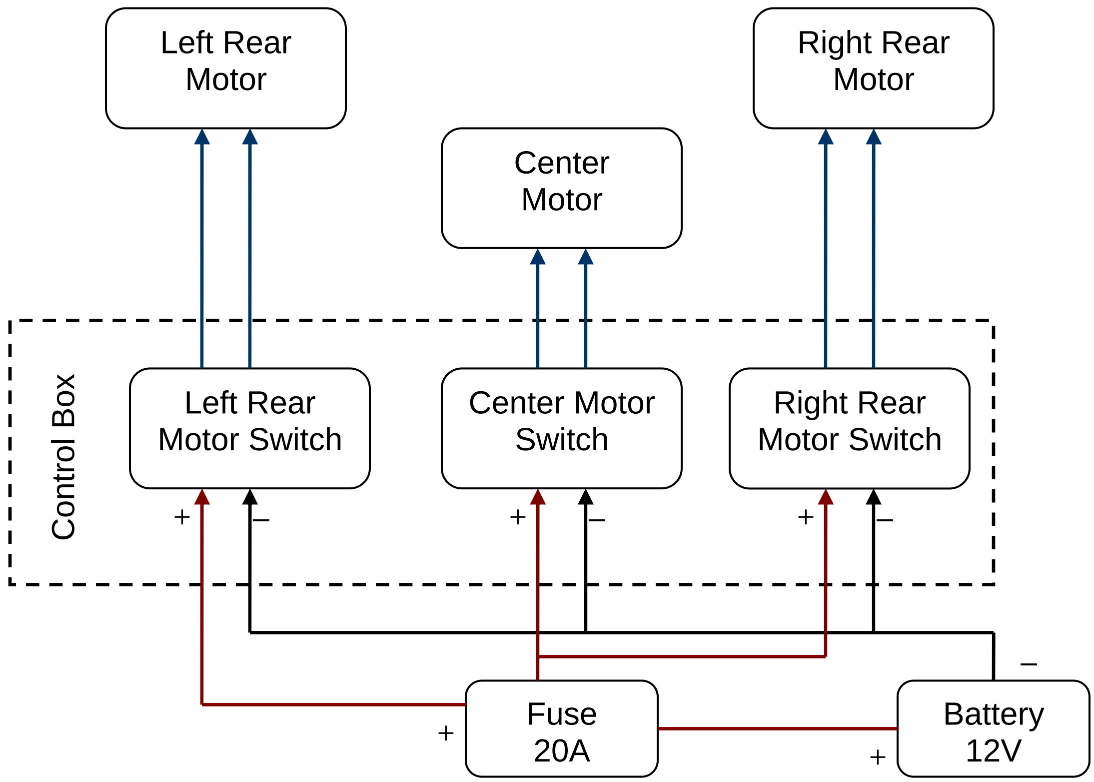
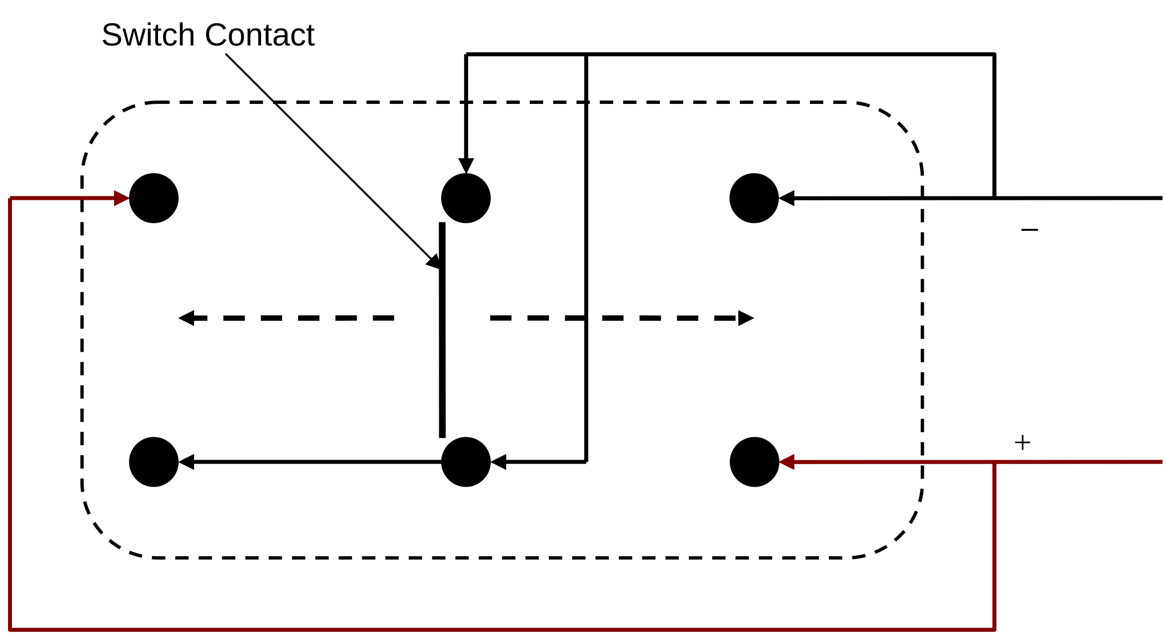
Date	Expense Description	SOURCE	QUANTITY	COST	Balance
4/27/2010	Bolt U ZN1-3/8X3.75X5/16	ACE	1	$2.29	$392.71
4/27/2010	Chain	ACE	1	$1.49	$391.22
4/27/2010	Clamp Hose 3/8" TO 7/8" SS	ACE	2	$2.58	$388.64
4/27/2010	Connect MALEFAUCET	ACE	2	$6.98	$381.66
4/27/2010	Rope Braid Poly 3/16x50	ACE	1	$5.99	$375.67
4/27/2010	Tubing Vinyl5/8IDx3/4" OD	ACE	3	$2.37	$373.30
4/27/2010	PVC Fitting-3 Way Connector for 1/2" pipe	International Greenhouse company	10	$1.15	$372.15
4/27/2010	PVC Fitting-4 Way Connector for 1/2" pipe	International Greenhouse company	10	$1.55	$370.60
4/27/2010	PVC Fitting-5 Way Connector for 1/2" pipe	International Greenhouse company	2	$4.15	$366.45
4/27/2010	3.6KAZ PIEZO BUZR	Radio Shack	1	$1.49	$364.96
4/27/2010	PK3 20A Blade FUS	Radio Shack	1	$1.99	$362.97
4/27/2010	PK5 9V BAT Clips	Radio Shack	1	$1.99	$360.98
5/1/2010	8OZTROLLBA/N	Dick's Sporting Goods	4	$23.16	$337.82
5/1/2010	BANK SINKER/N	Dick's Sporting Goods	2	$5.58	$332.24
5/1/2010	Pyramidsin/N	Dick's Sporting Goods	3	$8.37	$323.87
5/15/2010	1/2"x10 ' S40 PVC Pipe PLAI	Lowe's	1	$1.46	$322.41
5/15/2010	14"NAT Cable Ties 100ct(5	Lowe's	1	$9.38	$313.03
5/15/2010	25W Flame Clear 2PK	Lowe's	2	$4.56	$308.47
5/15/2010	3" PVC Test Cap 131 1000	Lowe's	2	$1.18	$307.29
5/15/2010	4" NAT Cable Ties 100ct(5	Lowe's	1	$3.36	$303.93
5/15/2010	4" PVC Test Cap 131 1200	Lowe's	3	$2.55	$301.38
5/15/2010	8" NAT Cable Ties 100ct(5	Lowe's	1	$5.12	$296.26
5/15/2010	Duracell 9V 4PK	Lowe's	1	$9.97	$286.29
5/15/2010	JH Permanent Marker Fine	Lowe's	1	$1.78	$284.51
5/15/2010	Weller 6W Battery Solderi	Lowe's	1	$14.97	$269.54
5/16/2010	1IN Better Binder	Staples	1	$7.49	$262.05
5/16/2010	8.5x11 CO	Staples	1	$4.49	$257.56
5/16/2010	Index Maker 8 Tab	Staples	1	$7.99	$249.57
5/16/2010	Sheet Protectors S	Staples	1	$5.99	$243.58
5/19/2010	Easy Link	Vernier	1	$59.00	$184.58
5/19/2010	Extra Long Temperature Probe	Vernier	1	$72.00	$112.58
5/21/2010	6 Conductor Teather	Houston Wire	1	$75.00	$37.58

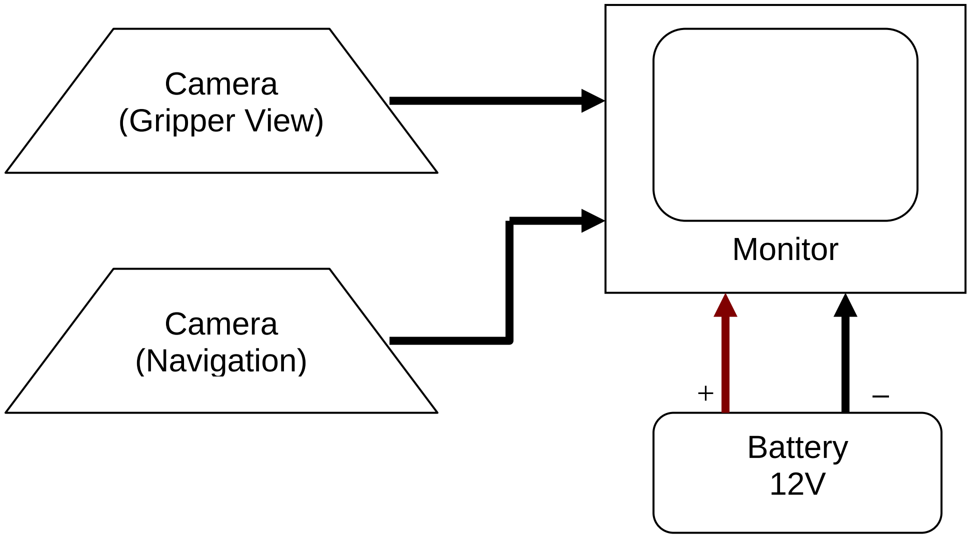
Electrical Schematics



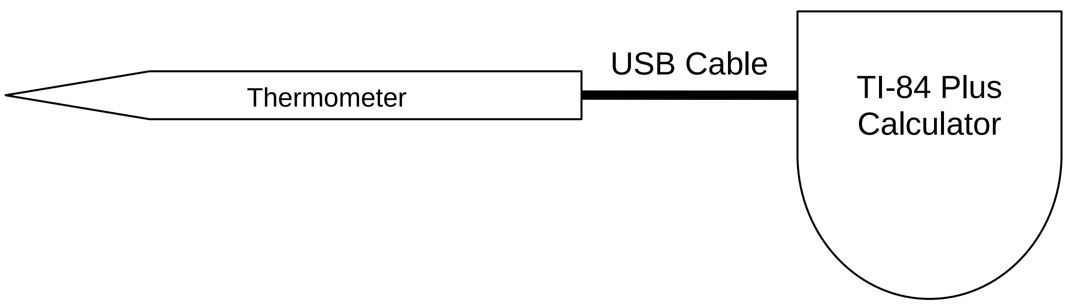
Propulsion System Electrical Schematic



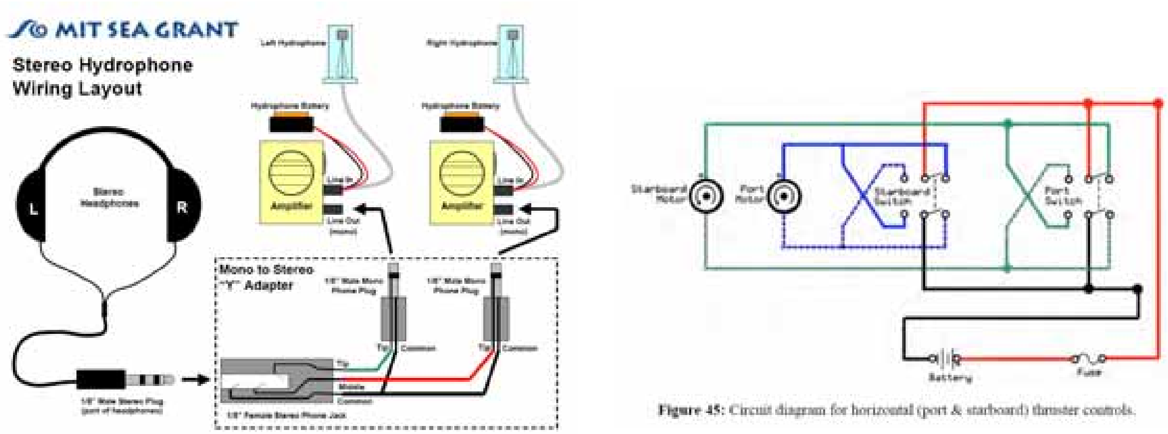
Control Box Switch Schematic



Vision System Electrical Schematic



Thermometer Electrical Schematic



Hydrophone Example Wiring Switches (Source: Sea Perch Grant ROV)

Note: *We used a mono hydrophone which required only one channel from the picture on the right*

Design Rationale

Our team took a methodical approach to designing the robot using the engineering design process. The process consists of 5 steps: (1) Problem Identification, (2) Brainstorming, (3) Idea Refinement (4), Decisions/ Implementation (5) Refinement/re-design. This allowed The resulting ROV is explained below.

1 Propulsion System

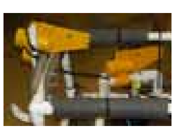
Our propulsion system has three motors. We put two motors in the middle of the back supports, half way up. The motors are pointed straight back so we can move forward, backwards, and left and right. We have a third motor placed in the center of the ROV that makes the robot rise and sink. The three motors are sufficient to allow the ROV movement in all directions of the water (see picture on the right).

Propulsion System

2 Control Box

To control the movement of the ROV, we created a control box with three tri-state switches which controlled the three motors. These switches work by changing the polarity of the electrical current to make the motor spin clockwise or counter clockwise. We decided on using this simple, hardware-only design given the simplicity of our propulsion system.

3 Vision Systems



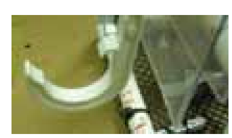
Vision System

We have two cameras. We positioned one camera so we can see the hook and the gripper so that it would be easier for us to see what we picked up and set down. The second camera was for navigation so we could avoid obstacles and identify mission sites.

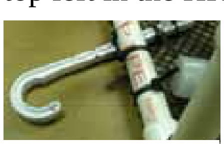
4 Sensors and Object Manipulation Systems

A. Hooks for picking up

We have two hooks. Hook one is on the front of the ROV to the left. This hook was designed to pick up the HRH, and was placed to get at a gap at the top left in the HRH frame. It also made it easier for us to pick up and to collect the samples of the crustaceans off the cave wall. The second hook was placed on the bottom of the front and was rotated to pull the pin out of the HRH and it was also used to collect the crustaceans off the cave wall.



Hook 1



Hook 2

B. Cup/Agar Collector

Early gripper Concept

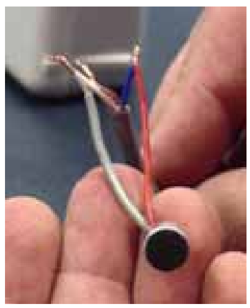
We came up with a gripper that on one side was stationary and the other one was closed and opened with a motor. This allowed us to break through the agar and be able to collect it and keep what was collected and bring it up. This gripper can also pick up the spires in task 3.

C. Thermometer

The way our temperature probe works is by the thermometer is relayed back to a Texas Instruments 84 plus calculator and is powered by the calculator's batteries. We choose this design because we saw it was the easiest to operate and read.

D. Hydrophone

Mounted Hydrophone



Mini Microphone

The team's hydrophone is a microphone wired to an amplifier is powered by a battery. We choose this design because it was cost effective.

Challenges

A challenge the team faced was dealing with buoyancy. Initially, our robot would not float it; it would either sink completely to the bottom or just stay at the top submerged below the water surface. We therefore decided to test different flotation devices. Our first flotation device had air already in it and this made our robot stay at the top of the water all the time. We then tested another flotation device that allowed us to go down into in the water and allowed us to come up to the top; however, we realized in the regional competition that in 13 feet of water, the flotation device compressed due to the pressure of the water so we were not able to come up to the top at all.

Troubleshooting Techniques

Our trouble shooting method involved collaboration and carefully tracing our steps. For instance, we had problems with a motor that wasn't working. First we talked about what we had done around that motor to see if there was a logical way to determine what had gone wrong. Then we looked at the motor and traced the wires to find the problem and fixed the wire. If we had not thought about it we might not have been able to solve the problem.

Lessons Learned

Our team had many lessons. One main lesson that we learned was that objects float differently in chlorine water and than in regular water. In our pre-regional-competition tests, our R.O.V managed to rise and sink easily; however in chlorine water it floated but found it difficult to go down.

Future Improvements

As is the case with undertaking any project, there are some things we thought we did well and other we feel we could have done better. One thing we would change the way we organized our team to undertake the project. We divided ourselves into sub-teams, each responsible for a particular task. However, some sub-teams' (and hence the whole team's) progress was hindered because of the lack of team members at times due to scheduling issues. In the future, we think it would be better to work on the project as whole without strict sub-teams so each part of the project will have people working on it at any given time since we can assign ourselves based on who is available to work on the project on a particular.

Information about Loihi Seamount

Loihi seamount is an undersea mountain rising more than 3000 meters above the floor of the Pacific Ocean [1]. As the most recently formed structure in this chain of volcanoes, the Loihi Seamount began its formation roughly 400,000 years ago, and remains the only Hawaiian volcano still in its submarine pre-shield stage of development. The Loihi Seamount is located approximately 35km off the southeast coast of the Big Island of Hawaii [2]. The summit area contains three pitcraters, and 11km rift zone. Before 1970 Loihis was thought to be inactive that all changed in 1970 when an "earthquake swarm" of intense, seismic activity sent an expedition team to study the Loihi. Over 4000 earthquakes occur between July 16th and August 9th 1970, Loihi holds the record for the most frequent and intense earthquakes of the Hawaiian volcanoes. These discoveries prompted the invention of new technology such as the Hawaii Undersea Geological Observatory (HUGO), the first underwater observatory providing real time data about visual, chemical and seismic activity to scientists. There is where the Mate ROV competition enters the pictures: the challenges presented during the competition mimic challenges that are currently present at Loihi.

Reflections

We loved the opportunity to use Solidworks to design the gripper part of our robot. We also loved how each task was related to a real life situation or mission. One thing we wished we would have done better was time and project management. We felt rushed to get things done getting close to the regional competition time. One change we would like to suggest on competition organizers' end is how the competition information was organized because we found it difficult and tedious to find the information that we needed while working on the project.

Work Cited

[1] Rubin, K. (2006, January 19). Loihi.SOEST /School of Ocean and Earth Science and Technology. Retrieved May 18, 2010, from http://www.soest.hawaii.edu/GG/HCV

[2] Global Volcanism Program/Loihi/Summary. (n.d). Smithsonian Institution Volcano and Eruption Information. Retrieved May 16, 2010 from http://www.volcano.si.edu/world/volcano.cfm?vnum=1302-00

References

Advanced Sea Perch Stereo Hydrophone
http://seaperch.mit.edu/docs/AdvancedROV/Stereo_Hydrophone.pdf

Hawaii Center for Volcanology, www.soest.hawaii.edu/GG/HCV/loihi.html#general

Hawaii Undersea Research Laboratory at the University of Hawaii at Manoa, www.soest.hawaii.edu/HURL

HUGO, www.soest.hawaii.edu/HUGO/hugo.html

Loihi seamount, http://en.wikipedia.org/wiki/Loihi_Seamount

Mauna Loa, http://en.wikipedia.org/wiki/Mauna_Loa

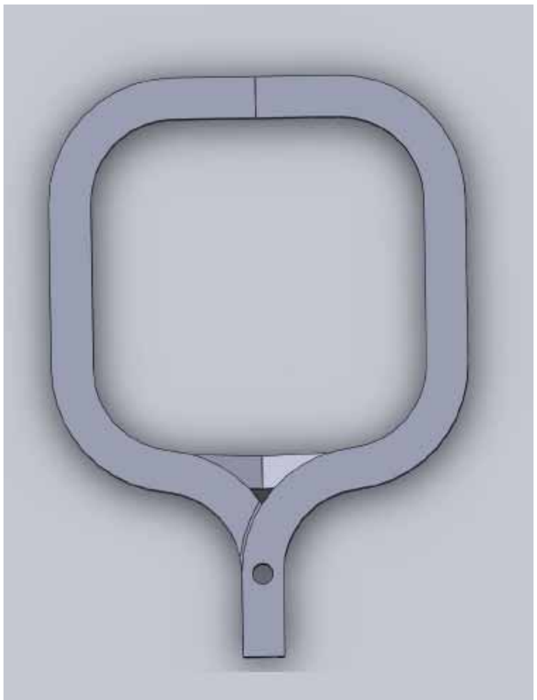
NOAA's Office of Oceanic and Atmospheric Research,
www.oar.noaa.gov/spotlite/archive/spot_loihi.html

Acknowledgements

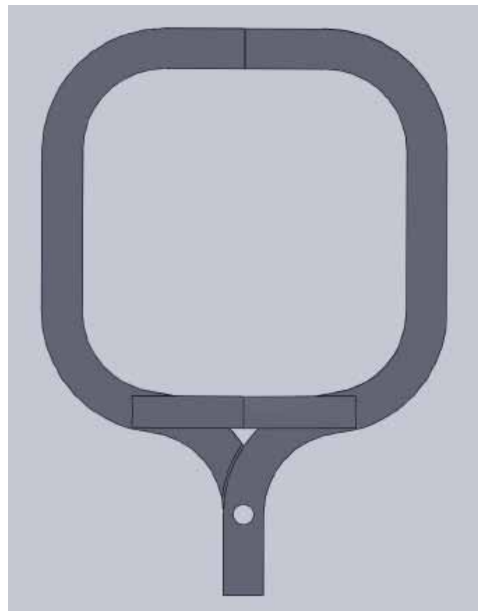
1. University of Pennsylvania - Rebecca Stein, Evan Dvorak, and Philip Asare, our mentors and advisors, for your expertise and dedication to the team members as well as the project.
2. Mr. John Baker - for your generous sponsorship of this project through financial and service contributions
3. Ms. .Morris and the Secondary Robotics Initiative for all of the information and planning
4. Mr. Garcia -for guidance and materials particularly agar
5. Ms. Plappert for lab apparatus especially for gripper
6. The friends and family of the team members, whose support, encouragement and understanding made each team member's dedication and perseverance possible.
7. Villanova University: Thank you for the use of the pool for the competition
8. Staff and other people who supported our team.
9. Maurice Simmons - for being our driver for pizza and snacks.
10. Ms. Baker for your support and dedication as our instructor.
11. The MATE Center. The opportunities you have created are amazing, especially the opportunity for this competition, which has continued to be motivational and inspiring.

Appendix

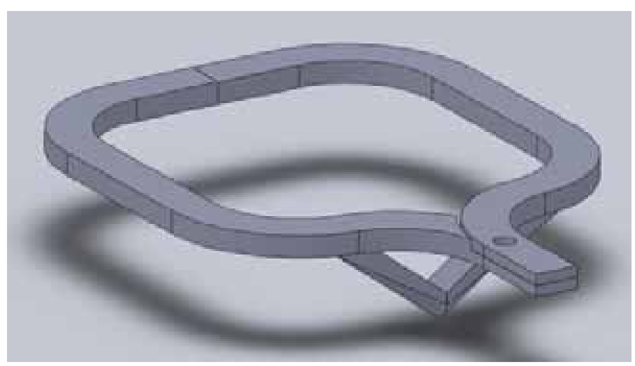
1 SolidWorks Drawing of Early Gripper Designs



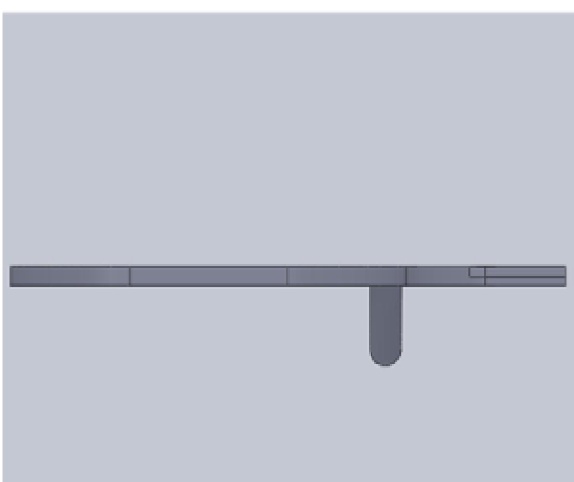
Top View



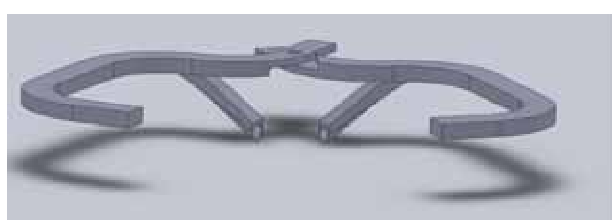
Bottom View



View on an Angle



Side View



View on an Angle - open