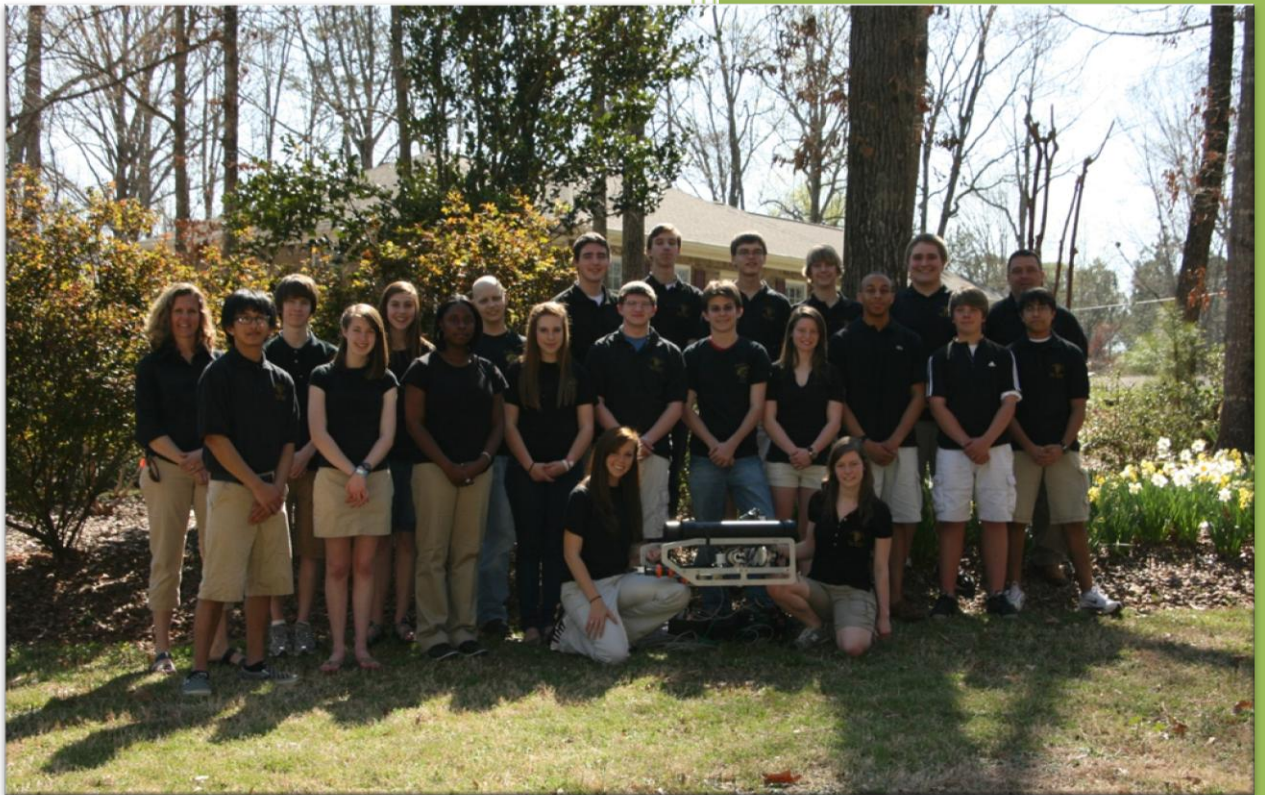


# 2010

## Carrollton High School ROV Team



Class of 2010: David Kathe (Gaming/Design Development), Bennett Stedwell (Mechatronics)

Class of 2011: Matthew Cline (Chemical Engineering), Caroline Cooper (Environmental Science), Patrick Dost (Marine Biology), Kaj Hansen (Physics), Melissa Hutcheson (Engineering), Rebecca Hutcheson (Biology/Medicine), Russell Ives (Aerospace Engineering), Ryan Kendall (Public Relations), Bo Lovvorn (Engineering), Phyllistine McCrary (Astrophysics), Jayanta Ray (Engineering), Aaron Rucker (Software Engineering), Karl Sanchez (Aerospace Engineering), Justin Whitaker (Aerospace Engineering), Quinn van Zanten (Mechanical Engineering)

Class of 2013: Lucy Edgar (Biblical Studies), Joseph Hendricks (Engineering), Sam Jarrell (Engineering), Kelcy Newton (Environmental Sciences), Carter Smith (Marine Biology)

# *Ragnarok*

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Team Member Molding the Pourable Foam



Team Members Cutting PVC

## Abstract

The 2010 Carrollton High School ROV Team includes twenty-three members, twelve of whom participated last year. Our remotely operated vehicle, *Ragnarok*, is named for the Norse word "Armageddon." Our team designed the vehicle while considering simplicity, maneuverability, and size for the tasks this year. The 2010 mission requires *Ragnarok* to remove the high-rate hydrophone (HRH) from the elevator, identify the rumbling site, and install the HRH at the sound-generating site. Next, *Ragnarok* must retrieve the HRH power/communications connector and insert it into the port on the HUGO junction box, collect three crustaceans from the cave, measure three temperatures, document and analyze the readings, and collect a vent spire. *Ragnarok* must then collect a sample of a bacterial mat and return all collections to the surface. *Ragnarok's* frame is made of 20-24 grade aluminum in a shape resembling a rectangular prism. Support beams run laterally across the top of the ROV to allow easy positioning of tools and thrusters. *Ragnarok's* mechanical arm transmits the HRH and the HRH power/communications connector and collects a spire and crustaceans. Agar collection tubes gather a sufficient amount of agar while a modified aquarium thermometer records temperatures from the chimney vents. Passive foam ballast tanks allow *Ragnarok* to maintain neutral buoyancy. Dipolar switches connected through the tether provide pilots with control of the vehicle. The CHS ROV Team has collaborated with many helpful adults and technicians and has created a vehicle capable of efficiently completing all the missions.



CHS ROV *Ragnarok*  
2010

*Ragnarok*



# Budget

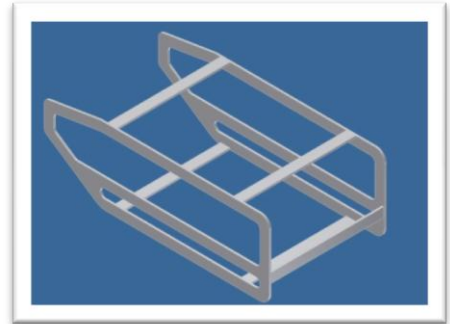
Date	Deposit/ Expense	Description	Vendor	Quantity	Amount	Balance
9/15/2009		Open Account				\$1,822.47
12/8/2009	Expense	task props	Lowe's	N/A	\$87.00	\$1,735.47
2/4/2010	Expense	armatron	Ebay	1	\$40.00	\$1,695.47
2/10/2010	Expense	pourable foam	Plastic Depot	2	\$78.00	\$1,617.47
2/19/2010	Expense	clamps	Lowe's	8	\$15.52	\$1,601.95
2/19/2010	Expense	banana plugs	Radio Shack	5	\$27.24	\$1,574.71
2/22/2010	Expense	switches	Car Quest Auto	6	\$50.16	\$1,524.55
2/23/2010	Expense	ABS sheets	Sign Depot	1	\$25.00	\$1,499.55
2/23/2010	Donation	aluminum frame	APM Inc.	1	\$200.00	\$1,499.55
3/5/2010	Expense	manipulator arm	Amazon	1	\$200.00	\$1,299.55
3/5/2010	Expense	hex bolts	Lowe's	12	\$3.53	\$1,296.02
3/9/2010	Expense	bilge pumps	Walmart	2	\$74.81	\$1,221.21
3/16/2010	Expense	respirator	Home Depot	1	\$32.07	\$1,189.14
3/19/2010	Expense	o-ring and s cap	Home Depot	1	\$3.65	\$1,185.49
3/19/2010	Expense	1/2" PVC cap	Home Depot	1	\$1.16	\$1,184.33
3/29/2010	Expense	project box	Radio Shack	1	\$5.34	\$1,178.99
3/29/2010	Expense	3" ABS cap	Lowe's	2	\$9.91	\$1,169.08
3/30/2010	Expense	hydrophone	Cetacean Research	1	\$390.00	\$779.08
3/31/2010	Expense	foam for tether	Home Depot	4	\$4.00	\$775.08
4/2/2010	Expense	pipe insulation	Home Depot	4	\$4.15	\$770.93
4/2/2010	Expense	crystalline probe	Probe Central	1	\$69.00	\$701.93
4/4/2010	Expense	adaptor	Radio Shack	1	\$8.50	\$693.43
5/14/2010	Expense	Camera	Lights, Camera, Action		\$1,364.00	-\$670.57
5/17/2010	Expense	Motors (agar collector)		2	\$140.00	-\$810.57
5/18/2010	Expense	Motors (manipulator)		2	\$295.00	-\$1,105.57
5/20/2010	Expense	plexiglass			\$10.00	-\$1,115.57
5/21/2010	Expense	Gravel Vacuums		2	\$18.00	-\$1,133.57
<b>Total Expense</b>						-\$1,133.57
	Donation		Brett Polk		\$500.00	-\$633.57
	Donation		Ken Kagiya		\$100.00	-\$533.57
	Donation		Tanner ER		\$1,000.00	\$466.43
	Donation		API		\$500.00	\$966.43
	Donation		Phyllis Skinner		\$250.00	\$1,216.43
	Donation		Dana and Mary Ann Ives		\$140.00	\$1,356.43
<b>Total:</b>						\$1,356.43

# Design Rationale

**Frame:** *Ragnarok's* frame is composed of 20-24 grade aluminum. Team members created the frame design using the CADD program *Inventor* and constructed the frame to the resulting specifications. Select team members, with the assistance of Mr. Art Powers, cut the frame at Advanced Precision Manufacturing, Incorporated. The frame is 60.96 cm long, 30.48 cm wide, and 20.32 cm high. *Ragnarok's*



Final Frame Design



Original Frame Design

shape is a tapered rectangular prism; this shape allows the ROV to be more hydrodynamic. Because the edges of the ROV are rounded, water is able to move more smoothly across the top, making the ROV faster. Located at the center of the ROV, a sheet of expanded metal supports the arm and other tools. The expanded metal allows the ROV to move up and down with less resistance.

**Propulsion:** *Ragnarok* houses five thrusters. By replacing impellers with propellers, the team transformed ordinary bilge pumps into fully functional thrusters. Each thruster provides four amps of power and propels approximately 4,542.5 liters per hour (LPH). Three of the thrusters are mounted in a horizontal row above the sheet of expanded metal on a metal beam across the frame; this positioning allows a full range of motion for the ROV and permits the vehicle to travel forward, backward, and in both lateral directions. The other two thrusters are mounted directly to the expanded metal for vertical motion in the water. The converted bilge pumps give *Ragnarok* the ability to travel with ease and precision.



Thrusters

**Thermometer:** In order to measure the vent temperatures, *Ragnarok* features a modified aquarium thermometer. The original wire was cut and spliced to the tether, and the temperature readout screen was then attached to the corresponding end of the wires on the pilot's end of the tether.

**Cameras:** *Ragnarok* is equipped with two cameras. The first camera (the top camera) is attached to an 11.2 cm aluminum rail mounted above the ROV and helps the pilot steer to complete the tasks. The second camera (the belly camera) is mounted on the right underside of



**Belly Camera**

*Ragnarok* and allows the pilot to navigate while collecting the agar. The belly camera has six white LED (Light-Emitting Diode) lights; the top camera is an infrared LED camera. The lights installed in the cameras allow the pilot to see in dimly lit areas of the pool.



**Top Camera**

**Manipulator Arm:** The team elected to purchase a kit from IWO, Incorporated; the team assembled and then heavily modified this arm. Members waterproofed the device and replaced the original 6 volt motors with 12 volt motors. The arm has an individual control box and is managed by the co-pilot. The arm itself is 25 cm long, 6 cm in diameter, and the grabbing mechanism is 8 cm wide. The base of the arm rotates 350 degrees, and the end clamps together to grasp



**Arm Control Box**

objects. The manipulator arm is used to remove the pin from the HRH, transfer the HRH, maneuver the HRH power /communications connector into the HUGO junction port, and collect the crustaceans and one spire. The manipulator arm is mounted on a 15.4 cm piece of aluminum positioned in the center of the ROV and is secured using two hose clamps.



**Manipulator Arm**

**Agar Collection Tubes:** *Ragnarok's* system for collecting agar is comprised of two refurbished gravel vacuums. The agar collection tubes are 5 cm in diameter and 8 cm in length. Each tube is mounted on a 5.08 cm gear driven by a center gear, which is turned by a 12-volt brushless motor. As the tubes turn, they dig into the agar and force agar into the tubes. The water is pushed out through a one way valve at the top of the tube, creating suction that holds the agar inside of the tube.



**Agar Tubes Gear Mounting**





Control Box with Terminal Box

**Control Box:** The control system is comprised of three black boxes: one contains the control switches for the thrusters, one contains the control switches for the manipulator arm, and one houses the terminals. Five dipolar switches, one toggle and four momentary, control the thrusters. Two momentary switches control the manipulator arm. The team opted to use momentary switches because they allow the pilot to make finer control adjustments by negating the need to return each toggle switch to the neutral position after each movement. Two battery leads, one positive and one negative, connect to the terminals. Leads then branch out to the control switches from the terminals. A 25-amp inline fuse on the positive lead coming from the battery protects the circuitry from shorts. The terminal system organizes the wiring and makes it easier to diagnose any problems.

**Ballast:** *Ragnarok's* passive ballast system consists of two acrylonitrile butadiene styrene (ABS) ballast tanks. Both tanks are 50 cm in length and 7.62 cm in diameter; they both contain pourable foam. This foam supports 1202.94 kilograms per cubic meter in the water and was purchased from Plastic Depot. Members mixed two reagents together inside the ABS pipe and stirred until the expanding foam reached the top of the pipe. The excess foam was shaved off and the ABS pipes were capped and sealed using ABS glue. Though sealing the tanks helps prevent water from seeping inside, the foam will still maintain the ROV's buoyancy in the event of a leak. The ballast tanks' lateral positioning on *Ragnarok* allows for maximum efficiency when traveling through the water. Team members bolted four hose clamps directly to the frame to hold the ballasts in place. Choosing a passive ballast system eliminates the need for the pilot to manipulate more than one component.



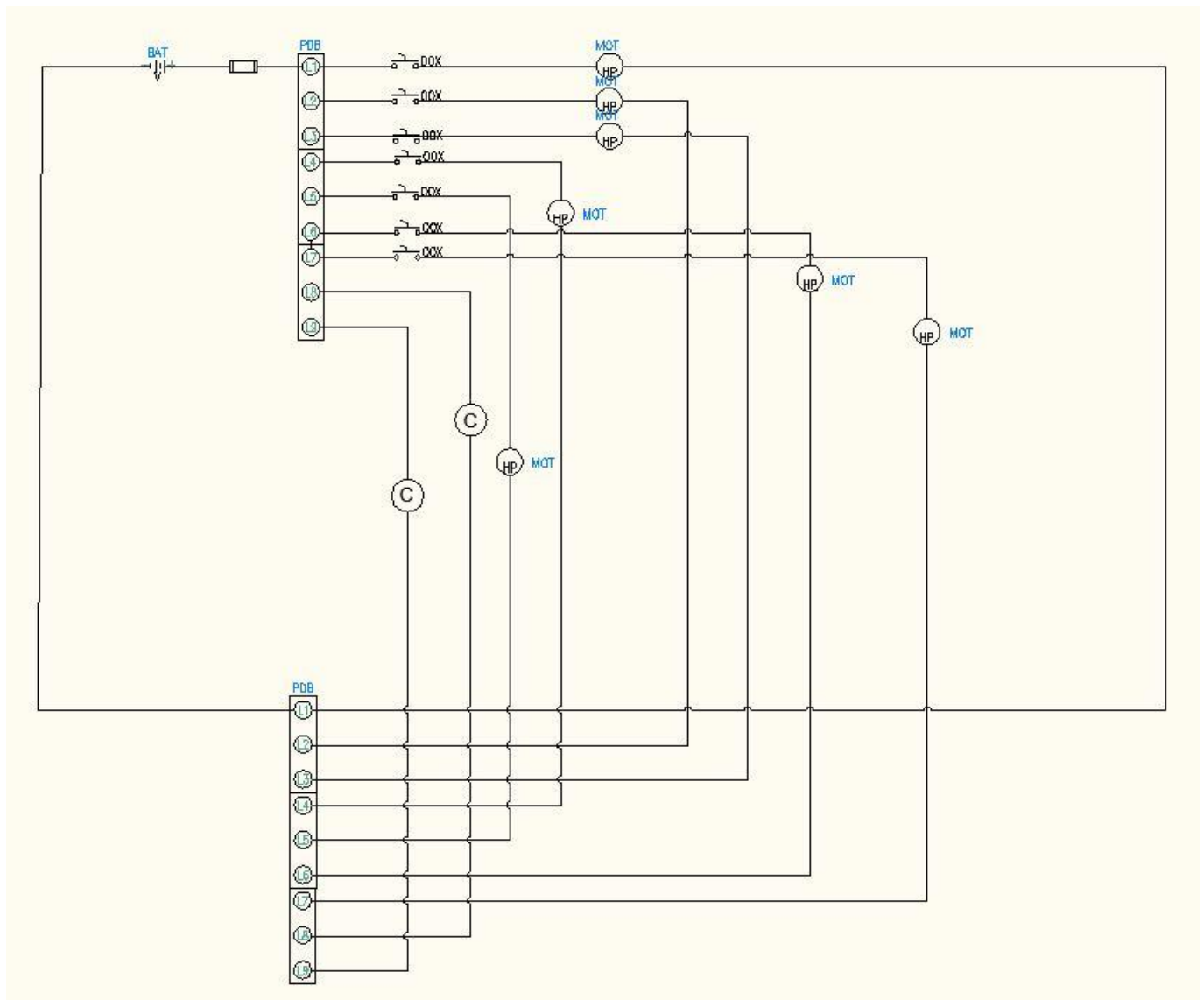
Passive Ballast System

**Hydrophone:** The hydrophone, purchased from Cetacean Research, detects seismic activity. It is attached to a 13 cm aluminum plate and bolted to the frame in front of the right ballast tank. The co-pilot listens for any seismic activity through headphones connected to the hydrophone. The co-pilot informs the pilot which site is generating the seismic activity, and the pilot navigates the ROV to that site.



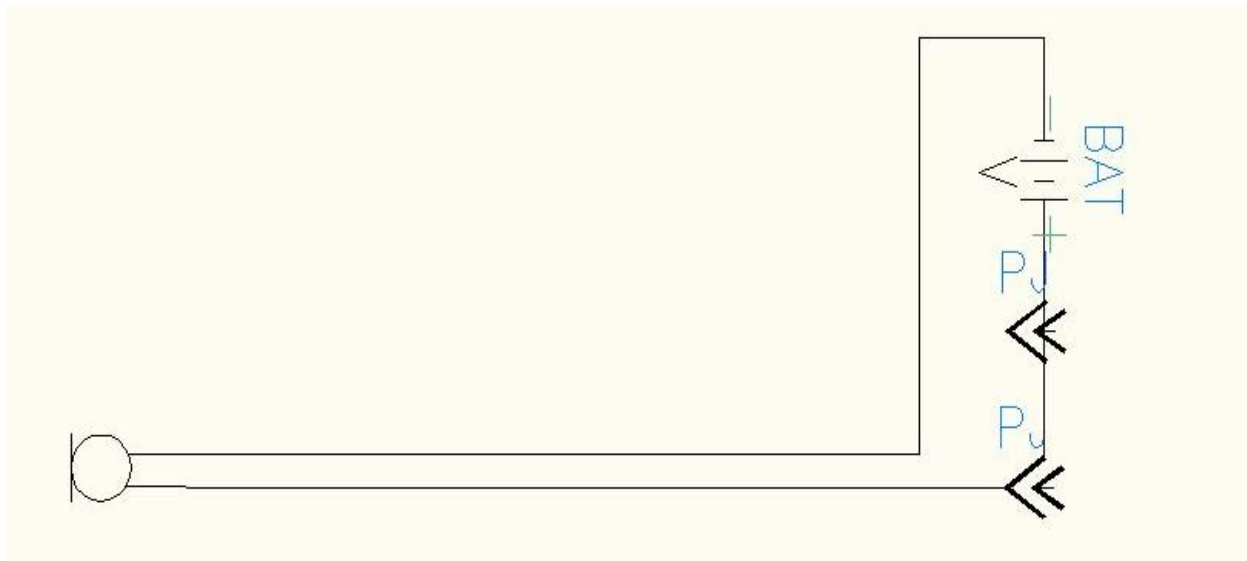
Hydrophone

# Electrical Schematic

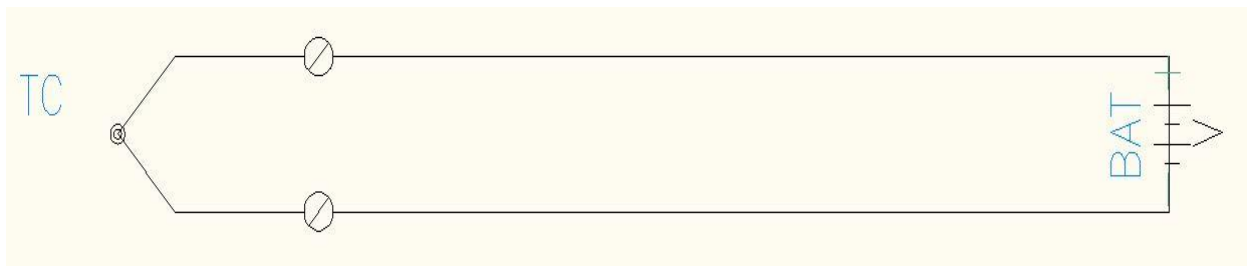


Thruster and Camera Schematic





Hydrophone Schematic



Thermometer Schematic

## Schematic Key

PDB-Terminal

DOX-Dipole Switches

PJ-Power Jack

BAT-Battery

TC-Thermometer

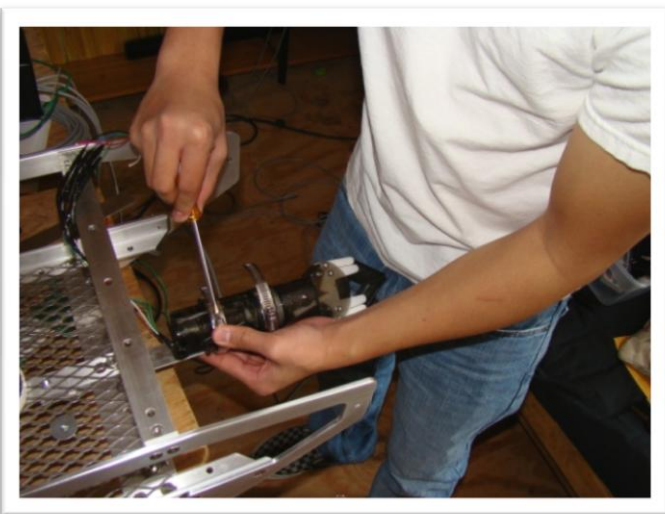
CHS ROV *Ragnarok*  
2010

## Future Improvements

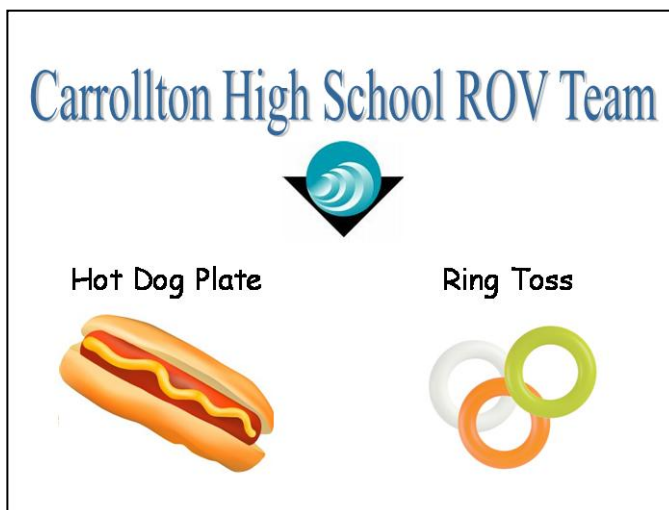
Since last year's regional and international competitions, the Carrollton High School ROV team has faced numerous obstacles. While the construction of *Ragnarok* and the writing of the technical report have gone smoothly, there is always room for improvement. The team has several improvements to make for next year, including better organization, better fundraising methods, and improved streamlining of ideas. Most of our problems this year hinged from a lack of organization. For instance, surplus materials were found that could have been used for this year's ROV; unfortunately, the team had already purchased duplicate materials. The lack of organization also hindered our fundraising efforts. The team raised enough funds to successfully

support our endeavors, but most of these fundraisers were later in the year. Had

fundraisers been conducted earlier in the year, the team could have had a better grasp on the funding situations. Our vehicle did not suffer, but several team members are unable to attend competitions due to the expense, something that could easily be fixed with fundraising. Many promising ideas were presented during the design process, but the team neglected to test many of



Team Member Working on a Prototype



Fall Festival Fundraiser

them. Many times, various team members would share a design prospect for the ROV, and the team would discuss its pros and cons. However, none of these ideas were utilized; most were simply abandoned. Testing more of the team's ideas would ensure that the best designs make it to the final vehicle. This would maximize the efficiency of the ROV and its individual components. With a few simple adjustments, our team could greatly benefit from better overall organization.

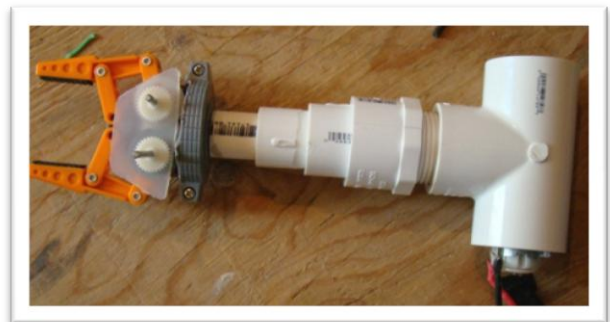
## Challenge



Original Armatron

In order to meet the more diverse demands of the 2010 mission, the team had to design a manipulator that would be able to complete a wider range of tasks. After creating several prototypes, the team decided that a claw would be the most versatile option. Initially, team members attempted to fabricate a custom claw using parts from an Armatron. However, researchers on the team were able to find and purchase a claw that, with modification, would be able to complete all missions.

In the design stages, the team decided what missions the arm would complete. The claw would be used in the transportation of the HRH and the HRH power/communications connector, in collecting crustaceans, and in picking up a spire; the agar would be gathered by a separate device.



Modified Manipulator Arm



Final Manipulator Arm

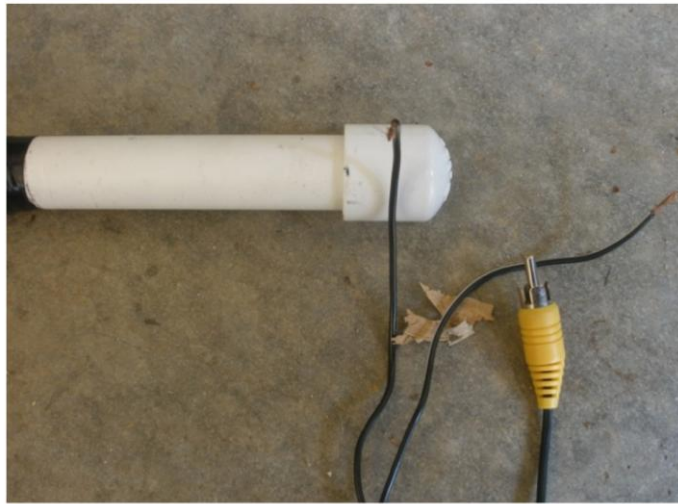
The team encountered several difficulties when constructing the final claw design. The motors included with the purchased claw were 6-volt motors. When used with our 12-volt battery, these motors quickly burned out and had to be replaced. However, the 12-volt motors the team purchased were too large to fit in the housing of the previous motors. The team removed the housing and mounted the new motors to the casing containing the gears. Making these modifications has provided the team with a reliable and efficient claw.



# Troubleshooting

This year, the team has approached all challenges similarly. Whenever a problem arises, the team accurately pinpoints the specific problem, whether it is in the control boxes, the wiring, or the payload tools. Once the team identifies the problem, the team discusses the solutions and employs the most logical option. This process helps to keep the team working together effectively.

At our most recent regional competition, the team encountered some difficulties. During our routine system check, the team discovered a problem with the belly camera. When the camera cord was plugged into the television, the display flickered uncontrollably. The team checked the wires, the terminals, and the camera itself; this allowed us to deduce that the problem was in the junction of the power and the output wires. Between the display and the

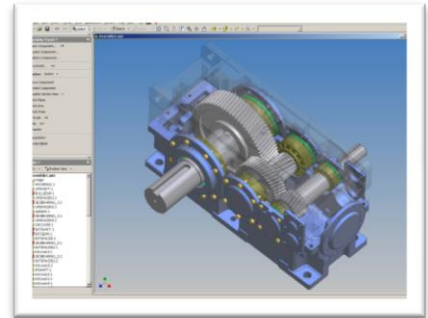


PVC Casing for Soldered Wires

power source, there was originally a circuit board to which all camera wires were soldered. The wires had become disconnected due to a soldering flaw, and information ceased to relay to the display. After some research the team realized the circuit board was unnecessary. The team removed the circuit board and soldered the wires together—the connection to the display was regained. When the second camera was tested, a similar problem occurred. The team repeated the process for the top camera and had a very successful pool run.

# Lessons Learned

At the beginning of this competition year, all members of the Carrollton High School ROV Team began with unique skill sets. Some members were experienced with the handling of mechanical components, while others were skilled researchers and writers. Regardless of our talents as individuals, all members shared a common interest in ROVs and their applications. No individual began this process with all the knowledge required to construct and design an ROV. On the contrary, all of us managed to draw from one another's abilities and further the progress of the group as a whole.



Sample *Inventor* Screen

By learning from fellow team members, the team was able to collectively increase our knowledge of the computer aided elements of the design. At the beginning of the year, less than five members were familiar with these concepts. But during the design process of the frame and an early agar prototype, many members unfamiliar with the CADD program managed to attain a degree of aptitude while also contributing to the design itself.

# Reflections



Team Members Researching

Our team has learned many valuable skills this year. From soldering and wiring a control box to presenting *Ragnarok* to the community, we have grown as a team. This experience has taught us leadership and diligence. One of the many difficulties of having such a large team is the ability to communicate effectively. By way of e-mails, phone trees, and school announcements, the team was able to stay organized so that meetings could run more efficiently. With all of these attributes, the team managed to put together a vehicle of which we can all be proud.

# Loihi Seamount Research

The Loihi Seamount, Hawaii's youngest volcano, is located just off the coast of the big island. The volcano is primarily composed of two vent fields, Pele's and Kapo's vents. These two vent fields, named after the Hawaiian volcano goddess and her sister, are populated with hydrothermal vents. Similar to geysers on the seafloor, these vents were classified as "low temperature" vents with water temperatures of only around 30°C until 1996. At this time, an earthquake drastically changed the nature of these two vent fields. Hydrothermal vent activity intensified, and the vents are no longer classified as low temperature. Many new chimneys, some as large as small trees, have recently recorded temperatures of more than 200° C.

*Pisces V* has been used to examine the seamount that has become such a scientific hotspot in the past twenty years. Scientists aboard *Pisces V* discovered a new vent at the Loihi Seamount which had spawned new hydrothermal chimneys and spires within the course of a year. The tallest chimney, surrounded by spires of varying heights, is the chimney represented in our mission. The pilot maneuvered *Pisces V* as close as possible to the chimney in an attempt to measure the temperature of the venting fluid. Unfortunately, the temperature probe was not able to reach inside the chimney to obtain an accurate measurement.



*Pisces V Underwater*

Courtesy of Mr. Ray Shackelford, Data Department Manager  
of the Hawaii Undersea Research Lab

This year's missions recreate the Loihi Seamount and the surrounding areas. The chimney substitutes the hydrothermal vents, and the cave represents the overhang that has obstructed many of the spires from larger submersibles' paths. The agar portrays mineral samples collected by *Pisces V*. The HUGO in our mission is a direct adaptation of its real-life counterpart. All of these factors combine to realistically recreate the atmosphere *Pisces V* experiences at the Loihi Seamount.



*Ragnarok* has several advantages over *Pisces V*. First, our ROV is much smaller than any manned submersible: while *Pisces V* is 6.096 meters long, *Ragnarok* is only 0.6096 meters long. Also, *Ragnarok*'s arm was specifically built to reach the chimney to collect the spires. These advantages will help us complete the tasks that *Pisces V* could not.



*Pisces V* Being Launched

Courtesy of Mr. Ray Shackelford, Data Department Manager of the Hawaii Undersea

## Acknowledgements

Without the help of our supporters, the team could not have made it this far. As George Herbert once said, “One good mother is worth a hundred schoolmasters.” Our team agrees, but would also like to add fathers into this equation. The ROV parents have provided organization, transportation, and delicious food. Parents from each family have supervised various meetings. Mrs. Ives supplies many ideas and support for the team; she also organizes trips and keeps everyone well informed via email. The team would also like to thank Mr. and Mrs. Dost for their constant hospitality in permitting us to meet in their home.

During the design and build process, many other people have given their time and resources to the CHS ROV Team. The team truly appreciates all those who have helped in any way. First, the team would like to thank our sponsor, Mrs. Kristie Bradford-Hunt. Mrs. Bradford-Hunt allowed the team to use her classroom after school and helped the members keep track of the budget. The team would also like to thank those who helped with the technical report—Dr. Sonja Bagby for setting up the Edu 2.0 account and Dr. O.P. Cooper and Dr. David



Newton for assisting in the revision process.



The team would like to thank Mr. Art Powers and his company, Advanced Precision Manufacturing, Incorporated. His assistance with cutting *Ragnarok's* frame and donation is greatly appreciated. The team would like to thank our coach and mentor, Mr. Jeremy Huff. Mr. Huff always keeps us focused and offers suggestions when the team needs assistance. Most importantly, he always encourages us to do better.

Additionally, there were many companies that donated supplies to the CHS ROV Team. Kroger, Publix, and Wal-Mart donated food supplies for our fall festival fundraiser. R & R Enterprises graciously gave a monetary donation. Also, the team would like to thank the buyers who helped out with the poinsettia sale. The team would also like to thank Gray's Reef National Marine Sanctuary for hosting the regional competition. Lastly, the team would like to thank the MATE Center for giving us the opportunity to participate in this wonderful experience.



CHS ROV *Ragnarok*  
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Shackelford, Ray. (2006, March 2). *The Pisces V and Pisces IV*. Retrieved April 3, 2010 from NOAA, Office of Ocean Exploration and Research from Website: [http://oceanexplorer.noaa.gov/technology/subs/pisces/media/pv\\_launch.html](http://oceanexplorer.noaa.gov/technology/subs/pisces/media/pv_launch.html).