CAMS ROV, Ranger Class

OCEANUS NEPTUNUS

CALIFORNIA ACADEMY OF MATHEMATICS &SCIENCE, ROV RANGER CLASS TECHNICAL REPORT.
[1000 EAST VICTORIA STREET. CARSON, CA 90747]

MEMBERS:

Back Row: Mentor Thomas Jett, Matthew Francis-Landau, Jaylen Thompson, Andrew Thompson, Vincent Kee, David Doan, Gabe Acuna

Front Row: Sarah Hafiz, Tommy Arakaki, Josephine Roussell, Anthony Bailey, You Kim

2010 TECH REPORT

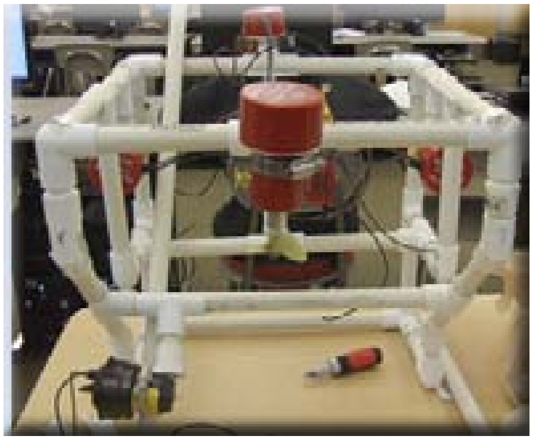
ABSTRACT

This year marks the California Academy of Mathematics and Science (CAMS) fourth year of participation in the Ranger Class of the Remotely Operated Vehicle (ROV) competition. Each year the Marine Advanced Technology Education (MATE) hosts a ROV competition with two classes, Ranger and Explorer. Both competing classes consist of four tasks which require each team to build an ROV that can complete the assigned tasks efficiently and accurately. The tasks in both classes are fundamentally the same. However, the Explorer Class must accomplish each task with minor variations that further challenge the ROV.

Students from 9-12 grade form a team to build the most efficient, dynamic, and creative ROV possible. The team spent numerous afterschool and weekend hours planning, designing, and building the ROV.

The team decided to approach the challenges posed by the competition as two separate sub-teams. The idea behind this seemingly unorthodox approach was to generate a variety of ideas for multiple problems at once. This allowed the team to modify and combine multiple ideas. The finished product is a quadrangle frame with a single slanted side and a simple articulation system that allows the ROV to effectively complete each task.

Overall, the Technical Report contains detailed schematics that document the creation process of the ROV. The report also contains our project's budget, ideas for future references, and troubleshooting methods that could have played to our advantage earlier in the build process.



Above: ROV Oceanus Neptunus

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the Loihi Seamount Rescue System

This year's ROV competition is modeled after the Loihi seamount. The Loihi seamount, an active undersea volcano located 35 kilometers east of the Hawaiian Islands, rises 3000 meters above the sea floor. The Loihi seamount, one of the newest active undersea volcanoes, was formed appromixately 400,000 years ago.

The 2010 ROV Challenge

Loihi seamount was considered inactive until an earthquake swarm occurred. After futher research was conducted, scientists discovered that it is very active. Scientists also found a hydrothermal vent in Pele's pit which is located on the North Slope of the seamount. Temperatures around the vent range is from 30° C to 200° C. Some high temperature vents range from 200° C to 400° C. Also, a bacterial mat can be found near the vents.

Hawaiian Undersea Geological Observatory (HUGO) was installed in 1997 on the summit of Loihi seamount. HUGO is connected with a 40 km long fiber optic cablewhich receives power and sends data. Although damage done by a flood was repaired in 1999, the cable was damaged once again in 2002. HUGO is currently not operable.

This year's ROV mission starts with a disabled HUGO ROV team which must revive the HUGO, the first task of this competition.

For the second task, each R.O.V must collect an organism sample. New crustacean species were found in video footage. Biologists believe that these new species are living in the cave. Now ROV must enter the cave, take a sample, and
bring it back up to surface.

Task number three simulates a new vent site. The ROV must find the temperature of the new vent, imitated by the PVC pipes, collecting geographical samples which will be a piece of PVC pipe.

The final task mimics the bacterial mat. Agar represents the mat on the sea floor.

The ROV must remove a fixed amount of agar from the cup, imitating the deep sea environment as much as possible.

team STRATEGY

Strategies such as stating missions, identifying challenges, troubleshooting, and budgeting are important. They allow the team to not only maximize points but also to minimize the costs and time spent on the ROV.

Features to Accomplish Missions (Payloads)

The payload tools are the key to the success of the mission. There are three samples we need to collect: the bacterial mat represented by agar, the crustaceans, and the vent spires. We created a unique payload tool for each sample.

To retrieve the bacterial sample, we use a pneumatic piston to push a ½" PVC tube into the agar. The tube is surrounded by a casing that has a spring door at the bottom. When the pneumatic piston is activated, the tube extends and pushes the door open. The tube is injected into the agar and the agar is forced into the tube. Once full, we release the piston and the tube is retracted, closing the doors. The tube can hold up to 175 milliliters of agar, the maximum amount allowed.

We must collect at least three crustaceans to receive the maximum score for the cave task. The crustaceans are inside the cave on the back wall, on the ground, and on the side walls. On the bottom section of the ROV, we created a rotating 35 centimeter long brush made out of ½" PVC pipe. The brush sweeps the crustaceans into a chicken wire container.

The vent spire is attached to the bottom of the temperature vent. We must grab and remove the spire to earn 20 points. Our objective is to use two PVC pipes to close on the spire to bring up to the surface. We use a pneumatic piston to push the two pipes together using approximately 275.8 kilo-Pascal's. A rubber material around the PVC allows better traction to hold objects without slipping.

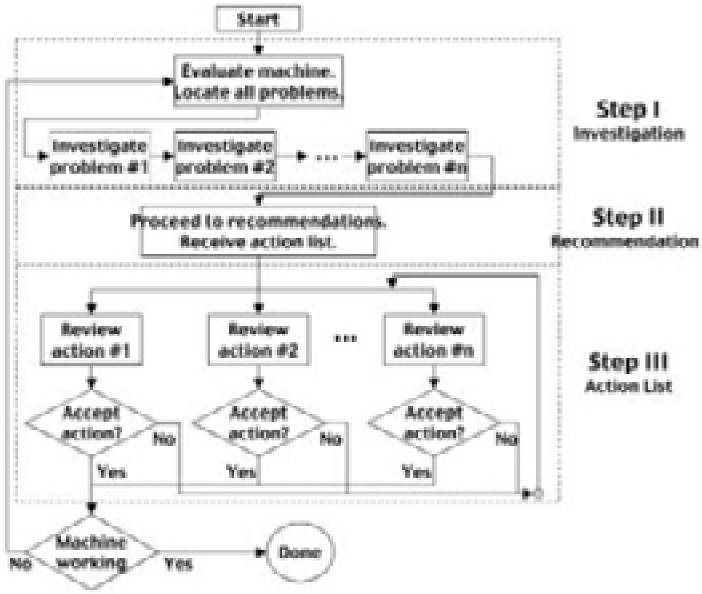
Challenges

The main challenge Oceanus Neptunus faced was working with a team of rookie members. The 2010 team was comprised of all new members excluding the two advisers. New members had to overcome many obstacles. Also, the new members did not understand the importance of reading the manual, delaying the design process. Overall, the team devoted too much time to designing the ROV and not enough time to building and testing it. However, the team constantly kept ideas flowing. In the future, the team would like to expand on all of its ideas.

CAMS ROV overcame this challenge by working together to keep each member on task. Demonstrating teamwork, our team used its ideas to fit constraints. Our team overcame its challenges by working together and using logical thinking to solve problems.

Troubleshooting

Oceanus Neptunus eliminated most of its problems through a systematic examination. By proposing plans, presenting alternate ideas , and asking "Does it accomplish the task? Does it comprise other systems? Can we improve this idea?", the team eliminated most design problems.



Above: Troubleshooting Method Diagram

A major issue did arise over the size of the frame. As a first year ROV Ranger group, unfamiliar with the Metric System, the team designed the frame to fit with a 60cm X 60cm X 100cm rectangular prism. After materials were purchased and the frame was constructed, the team realized that it was too large for the proposed articulation system. The team decided a 40cm X 40cm X 40 cm would be sufficient. Our second design problem was buoyancy. Since buoyancy is difficult to predict, our team decided to overcompensate for the weight of the ROV and weigh down the corners until the ROV reached neutral buoyancy.

Budget

PARTS STRUCTURE

MATERIALS	QTY.	PRICE	TOTAL PRICE
PVC pipe (10 ft.) 0.5"	5	$3.54	$17.00
Two wrie power door lock actuator (donated)	2	$0.00	$0.00
Three-way connectors	8	$1.38	$11.04
45 degree corners	4	$0.38	$1.52
T-connectors	8	$0.26	$2.08
Regular crosses	6	$1.11	$6.66
SUBTOTAL			**$38.30**

CONTROL SYSTEM

MATERIALS	QTY.	PRICE	TOTAL PRICE
18 Gauge Paired Speaker Wire (250 ft.)	1	$39.97	$39.97
12V Victor 884 + 12V Fan (reused)	6	$0.00	$0.00
Arduino nano (donated)	1	$0.00	$0.00
SUBTOTAL			**$39.97**

TETHER

MATERIALS	QTY.	PRICE	TOTAL PRICE
18 Gauge Paired Speaker Wire (250 ft.)	5	$39.97	$199.85
SUBTOTAL			**$199.85**

SENSORS

MATERIALS	QTY.	PRICE	TOTAL PRICE
Cameras/Monitors (reused)	3	$0.00	$0.00
Hydrophone (DIY)	1	$30	$30
Thermometer	1	$10	$10
SUBTOTAL			**$40.00**

PROPULSION

MATERIALS	QTY.	PRICE	TOTAL PRICE
Rule 27D Marine Rule 1100 Marine Bilge Pump (re-used)	7	$0.00	$0.00
Master Airscrew 3-blade Propeller (reused)	7	$0.00	$0.00
Propeller adaptors (reused)	7	$0.00	$0.00
Metal zip ties	6	$0.44	$2.64
SUBTOTAL			**$2.64**

Total expenditures on the six sections of our ROV amounted to **$320.76** for the 2010 Loihi Seamount Rescue System ROV.

the ROV DESIGN Rationale

ROV challenges students to create an ROV that can perform multiple sub-aquatic missions. While designing Oceanus Neptunus, the team had many great ideas about the frame, buoyancy, propulsion, payloads, sensors, electrical systems, and safety.

Vehicle Systems Analysis

The team chose a simple, effective design for its robot. Creating a uncomplicated design would reduce the time spent on programming and simplify the pilot's job.

The ROV has a regular box shaped structure made of PVC. This reduces the robot's weight and cost. The design was also created to reduce drag with an abundance of open space between the PVC pipes with a small surface area.

Frame Design

After reading the design tasks, the team decided to make the ROV significantly smaller than an 80 cm cube so that it could easily fit through the tunnel presented in Task Two. For the frame, the team originally decided to adopt a regular box shaped PVC structure. Unfortunately, it could not support the articulation systems the team had designed. After brainstorming, the team decided that a feasible solution would be to design a frame with a 45 degree angle side that cut through the middle of the frame. This would allow the team to mount the pneumatic claw system alongside the crustacean intake rollers.

Above: ROV Frame

The ROV is constructed entirely of Polyvinyl Chloride (PVC) pipe. PVC was chosen because it is light, relatively inexpensive, durable, and neutrally buoyant (shown below).

Buoyancy & Center of Gravity

The ROV was designed to be light, lessening the strain on the motors. To provide buoyancy, the team designed two airtight cylindrical tanks mounted on top of the ROV. The team decided that two buoyancy tanks mounted on the sides of the ROV would keep the center of gravity balanced. To make the ROV neutrally buoyant, the team calculated the additional weight needed. Then, the team drilled holes in the PVC pipes to compensate for weight from the water when the robot was submerged. The team decided to drill approximately two holes per PVC pipe for neutral buoyancy. Even after determining the optimum amount of holes, the ROV was still front-heavy and positively buoyant. To correct this problem, the team drilled several additional holes in the back of the ROV. This allowed the back of the ROV to fill slightly faster than the front. CAMS ROV was able to solve its buoyancy and weight distribution problems.

Propulsion Design

Due to budget constraints, our team decided to re-use the Rule 1100 GPH bilge pump motors. The pumps are not intended to propel objects through water. They were modified by removing the impellers and refitting them with propellers, allowing the pump to push water in two directions. For propeller guards, the team mounted large PVC tubes around the propellers.

On the ROV, there are a total of seven bilge pump motors: two bilge pump motors for forwards-backwards movement, two for side-to-side movement, two for up-down movement, and one for the intake roller.

Payloads

For Task 1, the ROV must pull out the cap on the HUGO and the pin holding the HRH. A metal screw protruding from the side of the pneumatic claw hooked through the loop and the ROV was driven backwards, pulling the pins out. To transport the T connector from the elevator to the HUGO, the pneumatic claw closed on the connector. The ROV drove to the HUGO, opening the claw to drop the T connector. In order to transport the HRH to the rocky outcropping, the pneumatic claw opened until it was pushed firmly against the frame of the HRH. The ROV followed the sound using the hydrophone, closing once it arrived at the drop off site.

For Task 2, the ROV drove into the cave towards the crustaceans with the intake roller running. The crustaceans were stored in the chicken wire holding bay until the ROV surfaced after completing Task 4.

For Task 3, the ROV drove over to each of the vents, taking temperatures. After completing the first part of the task, the pneumatic claw closed and gripped a vent spire which would be retrieved from the ROV after the completion of Task 4.

For Task 4, the ROV was positioned over the agar container with the help of the camera. Then, a pneumatic piston pushed the agar collection tube out of its hinged housing while the ROV slowly descended until reaching the bottom of the cup. The pneumatic piston then pulled the agar collection tube back into its closed housing, preventing the loss of agar. Finally, the ROV surfaced.

Sensors

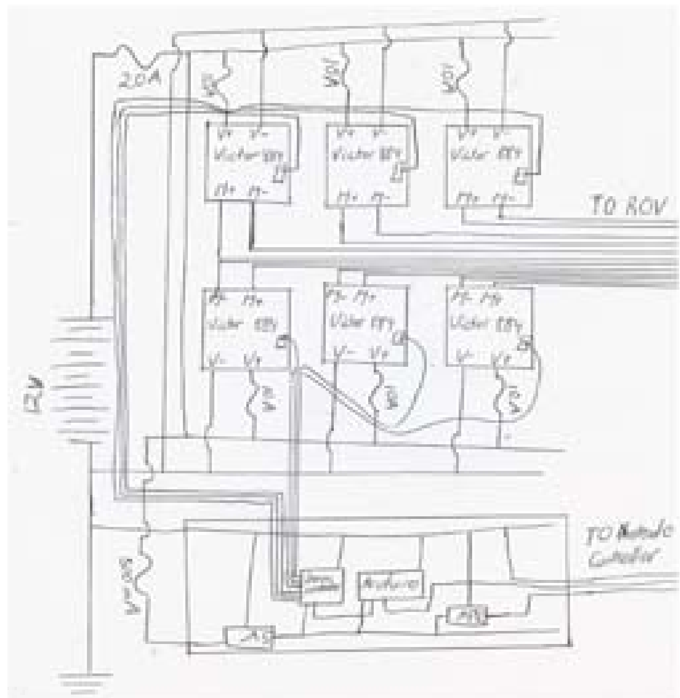
Our ROV uses 3 types of sensors: cameras, hydrophones, and meat thermometers.

We reused four black and white waterproof cameras which came with one monitor. The cameras were equipped with an LED light, which improved image quality. The ROV also had one camera on top of the ROV to create an overall view. Another camera provided a clear field of view for the intake roller and pneumatic claw. The third camera looked directly at the digital readout of the meat thermometer used for Task 3. The final camera was concentrated on the field of view of the agar container.

The team made a hydrophone using the steps outlined in the electronics section.

Electronics

The electronic parts of the ROV were designed with simplicity in mind. The system had five motors for driving, giving it mutable diminutions of movement. Because of the ROV's complex movement patterns, the team decided that it did not want to make a basic control system with a series of switches. Instead , the team decided to use video game controllers. This system uses a Game Cube controller as the input from the user. A Game Cube controller has two joysticks, each giving a one byte value in each direction which permitted a wide range of control. Another advantage is that Nintendo sells wireless controllers which can be used to "un-tie" the drive from the control station. The Nintendo controller was read by an Arduino Nano V3 after the input from the controller is processed. It was sent to a serial server controller that then generated the six PWM signals which are sent to the Victors 884. The power was individually controlled for each motor through a set of wires that run from the tether to the ROV.



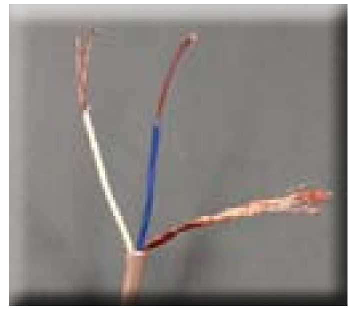
Above: Electrical Schematic Diagram

Two members of our team created an ingenious, cost-efficient hydrophone in order to complete the first task. A bill of materials for the hydrophone is listed below. Additionally, the following directions were the steps taken by Anthony Bailey and You Kim to create the hydrophone.

1	270-092c	Condensor Microphone Element
1	N/A	VEX 2 feet Motor cable
1	274-286a	Two conductors 1/8" mono phone plug
1	Roll 64-2352	Black tape, rubber electrial (NOT PVC tape)
1	N/A	Battery holder, fits 1 "D" plug
1	N/A	D-sized battery

3 feet	N/A	Wire, insulated, #24, 1 foot of orange, white, blue
1	N/A	Soldering Iron and solder
1	N/A	Wire Stripper
1	N/A	Heat Shrink (bigger than the wires)
1	N/A	Small sheet of plastic wrap
2	N/A	Insulated Electrial Wire in green/purple

1) Take the Vex wire and snip off the two connecters so that there is only the wire itself.



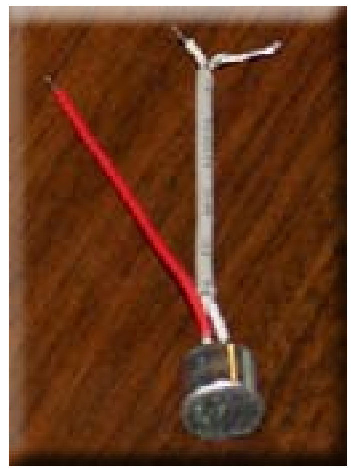
Above: Step Two

2) Separate the three wires (Red from Black from White) on both ends. Then strip each one until about a half inch of wire is exposed.

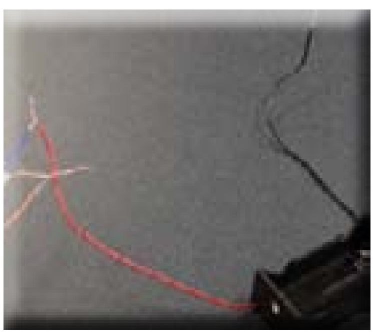
3) Take the Condensed Microphone Element. There should be three wires.

4) Strip the wires so that more wire is available to test.

5) Now take one end of the Vex cable. Place the large heat shrink through all three wires and 3 small heat shrinks on each individual wire. On the microphone, place a heat shrink over the red and gray cables. Take another one inch piece, placing it over the two large pieces. Take the Vex Cable and the Microphone Element and twist the wires together. Twist the wires as Follows: Red to Red, White to White, Metal to Black.



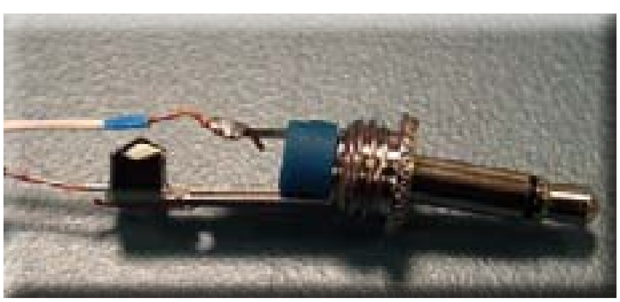
Above: Step Five



Above: Hydrophone at Step Six

6) Strip the black and red wires.

7) Take the other end of the VEX wire and place a large heat shrink over all 3 wires and 3 small heat shrinks over the individ ual wires. Take the two different colored wires and the other end of the VEX wire, twisting together the wires. Match red to red from battery pack, white to purple, and black to green. Remember which wires are connected to the black and white.



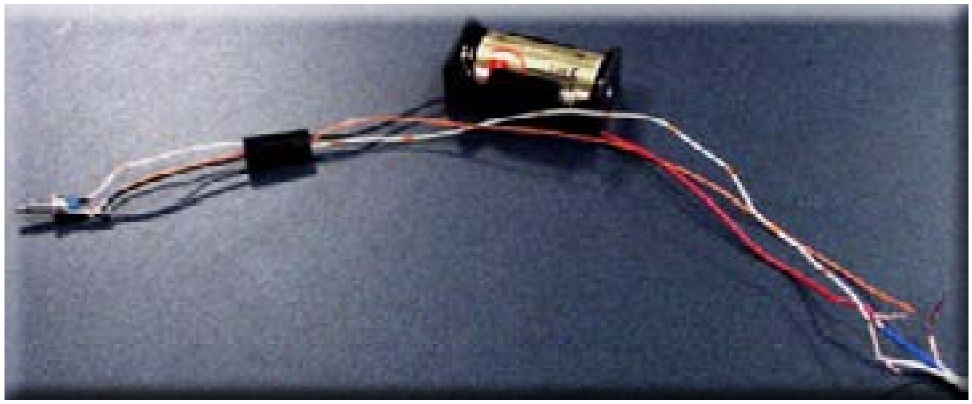
Above: Hydrophone at Step Eight

8) Take the Phone plug and open it, removing the plastic sheath. Take the cylindrical metal piece from the jack and place it through the wires (Black, color, another color). Connect the wires in order: black to the long part of jack, green to the long part of jack, and purple to the small part on the Jack).

9) Once all the wires are connected, plug it into speakers with the battery in the holder and test to see if it works. If not, recheck wiring.

10) Once it works, solder all the connections.

11) Then slide all the heat shrinks onto the open wires (excluding the heat shrinks on the microphone) and apply heat to shrink the shrink. For the VEX Cable, do the small heats shrink first. Shrink the three together by covering them with the larger shrink.



Above: Hydrophone at Step Nine

12) To waterproof the microphone, tear a piece of the plastic wrap and wrap it around the microphone. Then place the first heat shrink over the plastic and slide it as close as possible to the microphone's head. Then shrink the heat shrink.

13) Place another sheet of plastic over the microphone. Use the second heat shrink to seal the plastic. The hydrophone should be complete!

Safety

The team designed the ROV with safety in mind. Every sharp end was filed down to a smooth surface, from the ends of the chicken wire basket to those of cut PVC pipe. All bilge pump motors have propeller guards to prevent stray hands from becoming mangled. The pneumatics systems have pressure regulators, metal fittings, and pneumatic tubing rated for high psi. The team also used a heat gun to soften tips of cut zip ties on the intake roller.

Team Sustainability

Teamwork and collaboration are crucial when working in a group. Teamwork ensure-team success. Reflections on improvements will guarantee a sustainable ROV team.

Teamwork

Above: Tommy watches You Kim and Anthony Bailey work on the ROV

Every team has a leader. Our team decided that Andrew Thompson would be team leader because he had the most time to devote to ROV. With the leader decided, the team sat down and designed a frame.

The frame had to accommodate the articulation systems and offer visibility and maneuverability for the driver. The ROV team would meet to plan the articulations. Andrew created agendas for each day. When the team reached the build phase, he made a calendar outlining the upcoming months. The team split into two groups. The first sub-team focused on building the frame and attaching motors. The second focused on the technical report. As the due date for the frame came closer, the two teams joined together to finish the technical report.

After completing this task, the team divided again. The build team continued building while the technical report group constructed the display board. Another sub-team formed off of the build team to construct the control and electrical system. This team's planning and foresight proved to be an effective method for promoting teamwork and learning, encouraging new members to become involved in ROV.

Reflections

From participating in the competition to building Oceanus Neptunus, CAMS ROV has learned about the necessary dedication, time management, and preparation for a competition. The team has overcome all odds despite its inexperienced members.

While building Oceanus Neptunus, the team realized that it was a great learning experience. The team agreed that ROV fostered work and communication communication. Though the tasks were difficult, ROV was a life changing experience.

Lessons Learned

Throughout the development of the ROV, the team encountered countless problems, from disorder to idleness. Both of problems were mainly due to the fact that this year's team consisted mainly of new, inexperienced members. Although the returning members were able to familiarize the new members, the rate or progression was somewhat slow: before the regionals, the team worked at a leisurely pace, it wasn't until the week of the competition did the team work diligently. However, that changed after regional's and team was able to work at a more substantial pace. Overall, the team had little trouble creating and decided on which idea to use, but we did have trouble working effectively.

Future Improvements

One main improvement Oceanus Neptunus hopes to improve on next season is team organization and time constraints. The team hopes to become more efficient next year.

The team also needs to be divided into sub-teams that include articulation, electrical, and structure. In addition, the whole team will be more dedicated, balancing ROV meetings with other extracurricular activities.

Though the team is productive, it hopes to find even more motivation and drive. By increasing organization and distributing tasks evenly, the team can have a maximum output. Finishing prototypes sooner will allow for more testing time.

Team Acknowledgements

The CAMS Ranger ROV team would like to thank our teachers, mentors, parents, and classmates for their incredible guidance and support. Special thanks go to the Froschauer family, for allowing us access to their pool for testing, and the ROV Ranger Team Capain Gabriel Acuna, for his outstanding patience, knowledge, and supervision as he mentored our team throughout the season. Our team would also like to thank CAMS PSTO for their $3000 donation to reduce the cost of travel expenses. Last, but certainly not least, we would like to extend our thanks to the Robotics Adminisrtation team (Jon Mitsui, Jessica Chiv, and Jennifer Hung) who volunteered their time and efforts to help our team.

References

"Design Specs & Mission." Welcome to the Marine Advanced Technology Education (MATE) Center. Web. 27 May 2010. <http://www.marinetech.org/rov_competition/construction.php>.

"PVC Pipe | Standard & Custom Extrusions | Schedule 40 & 80 Dimensions." PVC and CPVC Pipe | Duct Systems | Harvel Plastics. Web. 28 May 2010. <http://www.harvel.com/pipepvc-sch40-80-dim.asp>.